Joint Review Panel Request for Additional Information Response Package
Addendum 10

Package 5: Surface Water Quality, Hydrology, Hydrogeology, Fish and Fish Habitat, Cumulative Effects, Geotechnical, Reclamation, Wildlife, Land Use and EA Methodology

Benga Mining Limited
Grassy Mountain Coal Project

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SURFACE WATER QUALITY

5.1 Information Request 5.1

Grassy Mountain Coal Project - Updated Environmental Impact Assessment. Consultant Report #5 – Surface Water Quality. (CEAR #42).

Eighth Addendum to the Environmental Impact Assessment. Appendix C-3. (CEAR #89).

Comments from the Government of Canada - Environment and Climate Change Canada submission. IR#7 and IR#9. (CEAR #167).

In Consultant Report #5 (CEAR #42), Benga derived a site-specific guideline for selenium that reflects uptake of selenium in the receiving environment, and is linked to sulphate concentrations, on the basis that sulphate, at higher concentrations reduces selenium toxicity. This site-specific guideline is used as the basis upon which Benga assessed the potential effects of selenium on aquatic organisms in Blairmore Creek. In addition, Appendix C-3 in Addendum 8 (CEAR #89) presented a risk-based evaluation of selenium concentrations in Blairmore Creek.

In its submission to the Panel (CEAR #167), Environment and Climate Change Canada (ECCC) indicated that the pre-operation site-specific risk assessment and guidelines presented by Benga may not represent a relevant indicator of potential impacts to aquatic organisms exposed to selenium during and following mine operations.

With regard to the development of the site-specific guideline, ECCC indicated that it has concerns with the process used to derive the guideline, as well as the data used in its development. For example, ECCC indicated that the approach used for deriving the site-specific selenium guideline is based on DeForest (2017), noting that significant advances have occurred since the publication of the British Columbia (2014) and United States Environmental Protection Agency (EPA) (2016) guidelines. The DeForest et al. (2017) guideline relies on the fish egg selenium guideline of 20 µg/g dw of DeForest et al. (2012), which missed more sensitive toxicity endpoints and did not follow the Canadian protocol (CCME 2007) for deriving water quality guidelines. Furthermore, although the role of sulphate in ameliorating selenium toxicity is known, required data is lacking to enable incorporation of sulphate as a toxicity modifying factor in the US EPA and BC guidelines. In 2017, the Government of Canada published "Screening Assessment of Selenium and its Compounds"[1] and based on available data did not recommend, sulphate-based site-specific predicted no-effects concentrations (PNECs). The Canadian PNECs (or Federal Water Quality Guidelines) for fish egg/ovary and fish tissue are 14.7 and 6.7 µg/g dry weight, respectively. Benga has not made reference to the Canadian screening assessment in the updated EIA or addenda.

ECCC indicated that, globally, there is no jurisdiction that uses sulphate-adjusted selenium guidelines or criteria. Furthermore, ECCC is of the view that Benga's site-

1 Available online: Screening assessment Selenium and its compounds: https://www.canada.ca/en/environment-climate-change/services/evaluating-existing-substances/screening-assessment-selenium.html

specific approach is mainly based on modelling with little or no validation from empirical data. Experimental testing of the relationship between selenium toxicity and sulphate concentrations in water has not been consistently quantified. ECCC highlighted that these empirical relationships for toxicity modifying factors (e.g., hardness, pH, dissolved organic carbon) are the cornerstone of site-specific metal guidelines (e.g., Cd, Co, Mn and Zn).

More specifically, ECCC indicated that they had the following concerns regarding the proposed site- specific guideline and risk assessment:

- the speciation of selenium in the releases from the saturated backfill zones, and ultimately in the receiving waterbody (Blairmore Creek);
- the role of sulphate as a mitigating factor to justify higher water quality criteria for selenium; and
- the high uncertainty induced by the food-web calculation of the exposure and bioavailability to selenium, based on pre-mining conditions.

Benga's approach to the risk assessment presented in Appendix C-3 in Addendum 8 (CEAR #89) is based on three different models and sets of calculations. First, Benga used a food-web model (Presser et al.

2010) for accumulation of selenium with the objective of predicting selenium concentrations in upper trophic level organisms from a series of calculations of site-specific trophic transfer factors. Second, a mitigation factor is calculated to relate sulphate concentration to the bioavailability of selenate in the specific waterbody (DeForest et al. 2017). Finally, a species-specific estimate of fish egg selenium concentration is calculated from concentration of selenium in the fish whole body using United States Environmental Protection Agency data (US EPA, 2017).

ECCC stated that predictions regarding the tolerance of an ecosystem to selenium can be achieved using Presser and Luoma's approach only if initial conditions and, in particular, the speciation of selenium remain the same when the assessment is performed, during mine operations, and after closure.

ECCC noted however that following passage through the saturated backfill zone, selenate may be reduced to selenite and released as selenite. The bioavailability predicted by Presser and Luoma's set of calculations would differ if selenium is present in a significant proportion as selenite. ECCC stated that this is likely to be the case, since the effluent from the backfill zones will contain a significant proportion of selenite. ECCC stated that lotic conditions may eventually transform selenite back into selenate, but this is a slow kinetic process. Consequently over time, the enrichment factor calculated in Blairmore Creek will not remain the same as the one calculated pre-operations. The accumulation pattern would be predicted incorrectly by assuming all selenium is present as selenate, during mine operations and post closure, including bioavailability and accumulation in benthic organisms. ECCC cautioned that if the behaviour of selenium and its speciation have not been correctly characterized, the basis of the risk assessment presented by Benga is flawed.

The justification for a site-specific guideline for selenium, with consideration of the sulphate mitigating effect, is based on the Benga's assumption that selenate is the only species that would be present in Blairmore Creek. While lotic systems, in general, tend to hold a higher proportion of selenate over selenite, at equilibrium, the information provided does not verify this for Blairmore Creek. Furthermore, considering that the reduced form of selenium (i.e. selenite) is produced by the saturated backfill zones, selenite is likely the form that will be released and potentially organo-selenium species such as methylselenide or selenomethionine. Once released, selenium would remain as selenite for a long period of time, unless it is adsorbed onto creek sediments, since dissolved oxygen is not an effective oxidant for selenite. Therefore, ECCC recommends that the risk assessment should assume that the selenium present in the creek, during and after mine operations, is in the form of selenite or organo- selenium such as selenomethionine. Sulphate has a mitigating effect on bioavailability of selenate only, and not selenite or organo-selenium species. ECCC indicated that a pre-operation site-specific water quality guideline for selenium with sulphate as a mitigating factor should not be considered.

Finally, ECCC stated that although the numerous calculations underlying the principles explored in Presser and Luoma's paper are correct, the cumulative uncertainty as a result of the many calculations performed is substantial, resulting in the site-specific risk assessment being highly uncertain. For precautionary reasons, ECCC has recommended that an existing water quality guideline for selenium be used. This precludes the use of US EPA guidelines which are based on a food web-based approach developed primarily in warmer waters and the DeForest et al. (2017) paper, which utilizes a fish egg selenium guideline of 20 µg/g dry weight and excluded the more sensitive white sturgeon data (15.6 µg/g).

Response:

Overall Summary of Comment and Response

The comments associated with this IR primarily express concerns that the approach for developing a site-specific guideline has high uncertainty and is inconsistent with current regulatory guidelines in Canada and other jurisdictions. In response, we note that regulatory guidelines for selenium are purposely conservative to ensure protection of the most sensitive species and water bodies with high selenium bioaccumulation potential. This conservative approach is appropriate for guidelines that may be applied province- or nation-wide. However, in recognition that provincial guidelines may be overly protective or not relevant to all water bodies, site-specific water quality objectives may be developed that account for site-specific information and the latest scientific advancements.

The site-specific selenium guideline evaluation presented by Benga was intended to build on site-specific information (*e.g.,* baseline Se bioaccumulation data, the sensitivity of relevant fish species), Se bioaccumulation data from similar receiving waters downstream of coal mines in Alberta and British Columbia, and recent research on how sulphate influences the bioavailability

of selenate. Benga will strive to manage selenium at the site to meet the BC water quality guideline, but modelling indicates that future selenium concentrations may exceed 2 µg/L. The site-specific selenium guideline developed by Benga is intended to be a preliminary benchmark for assessing whether modelled selenium concentrations may pose an unacceptable risk to fish, as represented by westslope cutthroat trout (WSCT), in Blairmore Creek. Once mining commences, monitoring data will be evaluated relative to the BC water quality guideline and used to validate the site-specific selenium guideline developed by Benga. If needed, an updated site-specific selenium objective may be developed in the future from site-specific monitoring data.

Responses to Specific Comments Under Rationale

- **Comment:** "With regard to the development of the site-specific guideline, ECCC indicated that it has concerns with the process used to derive the guideline, as well as the data used in its development. For example, ECCC indicated that the approach used for deriving the site-specific selenium guideline is based on DeForest (2017), noting that significant advances have occurred since the publication of the British Columbia (2014) and United States Environmental Protection Agency (EPA) (2016) guidelines. The DeForest *et al*. (2017) guideline relies on the fish egg selenium guideline of 20 µg/g dw of DeForest *et al*. (2012), which missed more sensitive toxicity endpoints and did not follow the Canadian protocol (CCME 2007) for deriving water quality guidelines."

Response: Development of the proposed site-specific guideline was based on the multi-step modelling approach described in Presser and Luoma (2010), which considers selenium enrichment from water to the base of the food web (*e.g.,* algae) and then trophic transfer to invertebrates and fish. This same multi-step modelling approach was used in DeForest *et al*. (2017) to derive water column selenium screening guidelines, but it is important to note that the only aspect of DeForest *et al*. (2017) used to develop the proposed site-specific guideline was the regression model for predicting selenium concentrations in macroinvertebrates from predicted selenium concentrations in periphyton. It was necessary to use an existing regression model based on data over a selenium gradient from other sites because only baseline selenium data are available for Blairmore Creek. For comparison, a second regression model from Golder (2014) was used to estimate macroinvertebrate selenium concentrations from periphyton selenium concentrations. The latter was used to develop site-specific water selenium benchmarks in support of the Elk Valley Water Quality Plan (EVWQP), which was approved by the British Columbia Ministry of Environment in 2014.

The comment also states that DeForest *et al*. (2017) relied on a fish egg selenium guideline of 20 mg/kg dw, but we note that this guideline was not used to develop the proposed site-specific guideline. Rather, modelled water selenium concentrations were entered into the multi-step model to predict egg selenium concentrations in WSCT, as

Blairmore Creek provides critical habitat for this species. The predicted WSCT egg selenium concentrations were then compared to the concentration-response relationship from this species, which relates egg selenium concentrations to embryo/larval toxicity resulting from maternal transfer. This concentration-response relationship was based on a study by Nautilus (2011). This same study and concentration-response data were used by BCMOE and the U.S. Environmental Protection Agency (USEPA) in developing their selenium water quality guideline and ambient water quality criteria, respectively (BCMOE 2014; USEPA 2016).

In summary, the only aspect of DeForest *et al*. (2017) used in developing the proposed site-specific guideline was the regression model for predicting macroinvertebrate selenium concentrations from periphyton selenium concentrations. The fish egg selenium guideline of 20 mg/kg dw was not used. Instead, concentration-response data for WSCT, the species of interest for Blairmore Creek, were used.

- **Comment:** "Furthermore, although the role of sulphate in ameliorating selenium toxicity is known, required data is lacking to enable incorporation of sulphate as a toxicity modifying factor in the US EPA and BC guidelines. In 2017, the Government of Canada published "Screening Assessment of Selenium and its Compounds" and based on available data did not recommend, sulphate-based site-specific predicted no-effects concentrations (PNECs)."

Response: The importance of sulphate in mitigating selenate uptake by algae has been known for decades (Williams *et al*. 1994), and more rigorous recent studies have tested the influence of varying sulphate and selenate concentrations on selenium bioconcentration (Lo *et al*. 2015). This study was published after BCMOE (2014) was finalized and it was not cited in USEPA (2016), although the USEPA did refer to the pre-publication data from the study. Ultimately, the USEPA concluded that "Including any type of sulfate relationship in the national criterion derivation would necessitate having sulfate measurements to accompany all observed selenium water concentrations included in the derivation database. That is, the absence of an accompanying sulfate observation would necessitate excluding the water observation. The resulting reduction in the number of sites included in the database would reduce the confidence in its ability to represent the nation's waters. For the above reasons, EPA has not included a sulfate relationship in the 2016 selenium criterion."

It should also be noted that there is often a lag time for regulations to catch up with the state of the science. For example, the influence of dissolved organic carbon (DOC) on metals bioavailability has likewise been known for decades, but, to-date, no final metals guidelines in Canada account for DOC and only two criteria in the US account for DOC (copper [USEPA 2007] and aluminum [USEPA 2018). In developing a site-specific guideline, the possibility of accounting for sulphate as a mitigating factor for selenate

enrichment in algae should be reviewed based on scientific evidence, not only on existing regulations.

- **Comment:** "The Canadian PNECs (or Federal Water Quality Guidelines) for fish egg/ovary and fish tissue are 14.7 and 6.7 µg/g dry weight, respectively. Benga has not made reference to the Canadian screening assessment in the updated EIA or addenda."

  Response: Selenium concentration-response data for WSCT were used in the evaluation of the proposed site-specific selenium guideline, as this was the species of interest for Blairmore Creek. The Canadian PNECs are driven by the sensitivity of other fish species, namely white sturgeon.

- **Comment:** "ECCC indicated that, globally, there is no jurisdiction that uses sulphate-adjusted selenium guidelines or criteria. Furthermore, ECCC is of the view that Benga's site-specific approach is mainly based on modelling with little or no validation from empirical data. Experimental testing of the relationship between selenium toxicity and sulphate concentrations in water has not been consistently quantified. ECCC highlighted that these empirical relationships for toxicity modifying factors (*e.g.,* hardness, pH, dissolved organic carbon) are the cornerstone of site-specific metal guidelines (*e.g.,* Cd, Co, Mn and Zn)."

  Response: The Nautilus (2016) study was used to model selenate concentrations in algae and duckweed as a function of sulphate. This study tested (1) a site-water under baseline conditions; (2) a site-water under baseline conditions that was amended to achieve targeted sulphate concentrations of 62.5, 125, 250, and 500 mg/L; and (3) a laboratory water to benchmark results relative prior selenate uptake studies in the Nautilus laboratory. Thus, the influence of sulphate in mitigating uptake of selenate by algae and duckweed was demonstrated from empirical testing, with a model being developed to describe the empirical data. The patterns observed were similar to those previously observed by Lo *et al*. (2015). DeForest *et al*. (2017) developed a similar sulphate model, based on Lo *et al*. (2015), which was used to develop sulphate-dependent water selenium screening guidelines—these screening guidelines were validated relative to field data to confirm that they were protective, so there is evidence from other studies that the approach has merit.

  The site-specific selenium guideline was developed as a risk-based benchmark for interpreting modelled selenium concentrations in Blairmore Creek that are predicted to exceed the BC guideline of 2 µg/L. Future monitoring data, after mining commences, will be used to validate the model used to develop the site-specific selenium guideline. An updated site-specific selenium objective may be developed in the future, if warranted.

- **Comment:** ECCC noted however that following passage through the saturated backfill zone, selenate may be reduced to selenite and released as selenite. The bioavailability predicted by Presser and Luoma's set of calculations would differ if selenium is present in a significant proportion as selenite. ECCC stated that this is likely to be the case, since the effluent from the backfill zones will contain a significant proportion of selenite. ECCC stated that lotic conditions may eventually transform selenite back into selenate, but this is a slow kinetic process. Consequently, over time, the enrichment factor calculated in Blairmore Creek will not remain the same as the one calculated pre-operations.

Response: The function of the saturated backfill zone (SBZ) will be to convert the selenate in the impacted water to selenite and elemental selenium. If working properly, the elemental selenium will precipitate in the SBZ and the selenite will be removed by adhesion, leading to low concentrations of residual selenium leaving the SBZ. Regardless of selenium species present, the presence of concentrations of residual selenium leaving the SBZ above the proposed threshold would be a signal of improper function of the SBZ, which would require remedial engineering action.

As pointed out in the comment, residual selenium leaving the SBZ is likely to be substantially comprised of selenite, given the reducing treatment environment of the SBZ. Therefore, oxidation of selenite to selenate in this discharge is desirable, to reduce uptake of selenium into aquatic algae. Benga proposes to construct a cascade from the discharge point of the SBZ that will ensure oxygen levels of the effluent are compatible with the natural environment in Blairmore Creek. The water would then pass through a coarse gravel ditch line, before entering into the SBZ holding pond where water would be allowed to further equilibrate and be monitored for specific water quality parameters (please refer to response in JRP IR-5.2 for location of the SBZ holding pond and the suite of water quality parameters to be monitored). This oxidation step would have the added advantage of converting residual nitrogen from ammonia to nitrate.

Following this oxidation/polishing step, effluent would be monitored, as part of a final water quality monitoring program, to assess the speciation of residual selenium. If treated effluent after the polishing process exhibits a high proportion of selenite, Benga will take appropriate actions to correct the improper or inefficient functioning of the SBZ. Benga will have several options for taking corrective action including:

- Recycling the off-spec effluent to the Raw Water Pond or back through the SBZ; or
- Adjusting the SBZ treatment process by changing operation parameters such as point of injection, point of extraction, type of carbon input, and amount of carbon input/oxygen content.

- **Comment:** "Benga's approach to the risk assessment presented in Appendix C-3 in Addendum 8 (CEAR #89) is based on three different models and sets of calculations. First, Benga used a food-web model (Presser *et al*. 2010) for accumulation of selenium with the objective of predicting selenium concentrations in upper trophic level organisms from a series of calculations of site-specific trophic transfer factors. Second, a mitigation factor is calculated to relate sulphate concentration to the bioavailability of selenate in the specific waterbody (DeForest *et al*. 2017). Finally, a species-specific estimate of fish egg selenium concentration is calculated from concentration of selenium in the fish whole body using United States Environmental Protection Agency data (US EPA, 2017).

Response: There are three items to clarify in this comment:

(1) Site-specific trophic transfer factors (TTFs) were not used in the model because no paired baseline selenium data were available for periphyton macroinvertebrates. This precluded calculation of periphyton-to-macroinvertebrate TTFs and macroinvertebrate-to-WSCT TTFs. Further, it was also desirable to incorporate information over a gradient of selenium concentrations, which is not possible when only baseline conditions presently exist. It should also be noted that TTFs were not used in the model; rather regression-based relationships in selenium concentrations between trophic levels were used.

(2) In the model, egg selenium concentrations in fish were not estimated from whole-body selenium concentrations. Instead, the relationship between WSCT egg selenium concentrations and co-located macroinvertebrate selenium concentrations was used, which was based on data compiled in USEPA (2016) and Golder (2014).

(3) The portion of the comment related to whole-body selenium concentrations may be referring to the estimation of brook trout and rainbow trout egg selenium concentrations from baseline whole-body selenium data for these two species. This was done as a point of comparison to the predicted egg selenium concentrations for WSCT under baseline conditions.

- **Comment:** "Finally, ECCC stated that although the numerous calculations underlying the principles explored in Presser and Luoma's paper are correct, the cumulative uncertainty as a result of the many calculations performed is substantial, resulting in the site-specific risk assessment being highly uncertain. ECCC has recommended that an existing water quality guideline for selenium be used. This precludes the use of US EPA guidelines which are based on a food web-based approach developed primarily in warmer waters and the DeForest *et al*. (2017) paper,

which utilizes a fish egg selenium guideline of 20 µg/g dry weight and excluded the more sensitive white sturgeon data (15.6 µg/g)."

Response: The site will be adaptively managed with the goal of achieving the provincial selenium guidelines. However, modelling of selenium concentrations in receiving waters indicate that the selenium guideline of 2 µg/L may be exceeded in the future. The site-specific selenium objective derived by Benga provides an initial assessment of whether the modelled waterborne selenium concentrations may pose a risk to fish, as represented by WSCT. If it becomes necessary to develop a site-specific selenium objective in the future, monitoring data available at that time may be used to update the site-specific objective currently developed, and those data may also be used to validate the present model. The approach involved site-specific studies and the best available science were used to reduce uncertainty, while ongoing monitoring and adaptive management will be used to validate the model, or update it as necessary, to help mitigate against unacceptable selenium risk.

It should also be noted that the USEPA guidelines are not necessarily developed primarily in warmer waters, as the bioaccumulation data used encompassed a wide range of conditions and the toxicity thresholds were driven by coldwater species, including white sturgeon and several trout species. Further, as noted previously, the fish egg selenium guideline of 20 mg/kg dw applied in DeForest *et al*. [2017] was not used in the present analysis, as WSCT-specific data were used.

- **Comment:** Overall, several statements in the rationale for this IR indicate that the method for developing the site-specific selenium guideline was not supported by current regulations.

Response: In some cases, there were misunderstandings about the approach, which we have attempted to clarify above. It is important to understand that selenium is unique compared to most substances with water quality guidelines, as existing guidelines are all based on consideration of selenium bioaccumulation potential. As such, most guidance does not explicitly account for the unique issues associated with development of a site-specific selenium guideline. The following, however, summarizes applicable guidance and precedents for the approach used:

- **CCME (2007):** This protocol document notes that "as sites and ecosystems vary in aquatic species composition and environmental characteristics (such as pH, water hardness, temperature regimes, chemical composition, *etc.*), the actual site-specific toxicity and environmental impact exhibited by the parameter of concern of a CWQG-PAL [Canadian Water Quality Guidelines for the Protection of Aquatic Life] varies as well. This can result in a situation where the national CWQG-PAL is potentially over- or even under-protective at a particular site." Further, CCME (2007) states that "New models and science that describe the

relationships between concentration and toxicity by considering these modifiers should be taken into account when deriving a guideline." The site-specific selenium guideline approach used by Benga is consistent with these statements in CCME (2007): site-specific species composition was considered by developing a WSCT-specific model and environmental characteristics were taken into account by developing a sulphate-dependent model.

- **USEPA (2016)**: Because the rational for the IR also refers to regulatory jurisdictions beyond Canada, we also note that the site-specific selenium guideline approach is consistent with approaches outlines in the USEPA's ambient water quality criteria document for selenium. USEPA (2016), for example, notes that the multi-step selenium bioaccumulation model described in Presser and Luoma (2010) may be used to derive site-specific selenium criteria. The first two steps of the site-specific selenium criteria approach outlined in USEPA (2016) are: (1) identify target fish species; and (2) model the food web of target fish species. In the site-specific approach applied by Benga, the site-specific target species was WSCT, and a combination of site-specific and species-specific data were used to model selenium concentrations in the eggs.
- **Elk Valley Water Quality Plan**: As noted above, the site-specific selenium guideline approach used for Blairmore Creek is similar to the approach used to develop benchmarks in Elk Valley, which were approved by BCMOE. A key difference, of course, is that the Elk Valley models were developed based on empirical data collected during active coal mining operations in Elk Valley, while the Blairmore Creek modeling is predictive. In addition, the Elk Valley model did not need to explicitly consider the influence of sulphate as the influence of sulphate in that system was an implicit component of the model.

a) Conduct an alternative risk assessment using the existing Alberta selenium water quality guideline of 2 µg/L and the British Columbia guideline for fish tissue of 11 mg/kg in egg/ovary and 4 mg/kg in muscle tissue. The risk assessment must not include sulphate as a mitigating factor in selenium toxicity.

Response:

Conducting a risk assessment based on BC guidelines would not be a true risk assessment, as this would just be a comparison of predicted Se concentrations in Blairmore Creek and WSCT eggs to generic guidelines. The water Se guideline of 2 µg/L is not based on water bodies with characteristics similar to Blairmore Creek and the fish tissue guidelines are not relevant to the known sensitivity of WSCT to selenium. As such, the guidelines may be considered screening values that provide a strong indication of negligible risk if not exceeded, but no information on risk if exceeded. For the latter, site-specific information is needed, which is why the site-specific selenium guideline approach was originally used.

As a point of comparison to the model used by Benga to develop a site-specific selenium guideline, the selenium model developed by Golder (2014) for Elk Valley was evaluated. The Golder model was developed based on empirical data and sulphate was not included as a modifying factor (any modifying influence of sulphate would have been implicitly accounted for in the periphyton data). The model predicts selenium transfer from water→periphyton→invertebrates→WSCT eggs. This model, and the resulting selenium benchmarks, were approved by BCMOE as part of the Elk Valley Water Quality Plan. The BC water selenium guideline of 2 µg/L and the predicted water selenium concentration of 6.8 µg/L for BC-07 in Blairmore Creek were both entered into the Golder (2014) model. Given that the regression relationships between water and periphyton, and invertebrates and WSCT eggs, are both shallow over these concentration ranges, both water selenium concentrations result in predicted WSCT egg selenium concentrations of 11 mg/kg dw (Table 5.1-1).

The predicted WSCT egg selenium concentration of 11 mg/kg dw using the Golder (2014) model is equivalent to the lower end of the range of predicted WSCT egg selenium concentrations in the modelling conducted by Benga. This is mostly driven by periphyton selenium concentrations in Elk Valley at water selenium concentrations <10 µg/L that are, on average, about 50% less than the baseline selenium concentration of 5.3 mg/kg dw in Blairmore Creek. If the Golder (2014) water-to-periphyton model is "shifted up" so that a periphyton selenium concentration of 5.3 mg/kg dw is associated with a water selenium concentration of 0.8 µg/L to represent baseline conditions, the predicted WSCT egg selenium concentrations are 16.4 mg/kg dw at the baseline water selenium concentration of 0.8 µg/L and 18.8 mg/kg dw at a predicted Blairmore Creek concentration of 6.8 µg/L.

Under baseline conditions, all models appear to be conservative in their prediction of benthic macroinvertebrate selenium concentrations. In September 2018, baseline selenium concentrations in three macroinvertebrate samples ranged from 2.6 to 2.7 mg/kg dw, with a mean of 2.7 mg/kg dw. For comparison, the selenium bioaccumulation models evaluated in the present assessment predicted macroinvertebrate selenium concentrations were 2- to four-fold greater: 5.7 to 11 mg/kg dw.

Application of the Golder (2014) model for Elk Valley, including a version "calibrated" to the baseline relationship between periphyton and water selenium in Blairmore Creek, result in predicted WSCT egg selenium concentrations that fall within the range of concentrations predicted by Benga in evaluating a site-specific selenium guideline. The Golder (2014) model did not include a sulphate as a modifying factor, but any influence of sulphate would have been implicitly captured in the empirical periphyton data. We believe this separate comparison provides further evidence that predicted water selenium concentrations in Blairmore Creek will not pose an unacceptable risk to WSCT, as predicted egg selenium concentrations fall between an effects level of 0 and 2% effects for this species. Again, however, it is noted that ongoing

monitoring, and adaptive management if necessary, will be used to validate the model and mitigate against potential risks.

Table 5.1-1 Predicted selenium concentrations in westslope cutthroat trout eggs using Golder (2014) model.

Water Se Basis	Water Se (µg/L)	Periphyton Se (mg/kg dw)[1]	Invertebrate Se (mg/kg dw)[2]	Westslope Cutthroat Trout Egg Se (mg/kg dw)[3]
Golder (2014) Without Modification				
BC Guideline	2	1.8	6.0	11.0
Prediction for BL-03 (Baseline)	0.78	1.6	5.7	11.0
Prediction for BC-07	6.8	2.1	6.4	11.0
Golder (2014) With Modification ("Calibrated" for Baseline Conditions in Blairmore Creek)				
BC Guideline	2	6.0	10.3	17.4
Prediction for BL-03 (Baseline)	0.78	5.3	9.8	16.4
Prediction for BC-07	6.8	7.0	11.0	18.8

[1] log periphyton Se = 0.220 + 0.125 × log water Se for water Se < 10.5 µg/L

[2] log invertebrate Se = 0.658 + 0.456 × log periphyton Se

[3] log WSCT egg Se = 1.02 + 0.026 × log invertebrate Se for invertebrate Se < 6.8 mg/kg dw

b) Provide a revised assessment of the potential effects of selenium on surface water quality and aquatic resources using the existing selenium guidelines outlined in part a) of this information request. This assessment should include:

i. description of the potential effects of selenium on the surface water quality and aquatic resources valued components;

Response:

Please see response to JRP IR-5.1 a).

ii. description of any technically and economically feasible mitigation measures required to meet the existing selenium guidelines presented in part a), with process details. This must include supporting evidence on the efficacy of proposed mitigation measures; characterization of any residual effects that remain after the implementation of mitigation (e.g. magnitude, extent, duration,

frequency, etc.) and conclusions regarding the significance of any residual effect.

Response:

In addition to the use of actively managed (not passive) saturated backfill zones (SBZs), Benga have committed to the following technically and economically feasible mitigation measures as part of the Project's overall Selenium Management Plan:

- Mitigation through design – an effective approach to mitigating a potential water quality constituent of concern is management of the source. Through mine planning, waste rock dumps were not located within valleys or directly within major watercourses. In pit dumping of waste rock was maximized, with external pit waste rock dumps being positioned to the north and south of the pit, not within the mainstems of Blairmore Creek or Gold Creek;
- Mitigation through design – grading of the waste rock foundations to facilitate effective drainage of infiltration and prevention of pooling under the waste rock dumps. Foundation preparation within the external waste rock dump areas would include surface re-contouring, and effective placement of a sub-base granular layer through use of end-dumping techniques. The objective would be to facilitate flow of contact water along the base of the waste rock dump and minimize infiltration into the foundation. Seepage that flows along the foundation can be collected in channels and in the surge ponds constructed downstream of the ex-pit dumps;
- Progressive Reclamation - Progressive reclamation of the external waste rock dumps will be conducted as soon as final contours are established which may be as early as Year 2 of operations in the case of the South Rock Dump. Establishment of surface contours that promote controlled run-off, placement of a topsoil cover, and re-vegetation will encourage runoff, discourage ponding, and increase evapotranspiration. Thus, the amount and concentration of selenium enriched water that requires treatment will be minimized;
- Secondary treatment - In the event monitoring of selenium concentrations in water pumped from the active treatment in the saturated backfill zones does not meet regulatory compliance limits, Benga will recirculate the water through the Raw Water Pond and back to the SBZ while adjustments are made to treatment parameters to improve Selenium removal rates. Parameters that can be modified include injection rates of carbon donor to change oxygen conditions in the SBZ, changes to water removal rates and retention times and changes to water removal location; and,
- Additional Active Treatment - in the event that water quality monitoring results indicate selenium compliance limits cannot be met through the aforementioned mitigation techniques and including the active treatment though an SBZ, Benga will construct an additional active selenium treatment process. The infrastructure required for the selenium treatment process would either be incorporated into a facility that

would also treat for metal parameters, or to a facility immediately adjacent to the metals treatment plant. Time to construct this secondary treatment facility will be approximately 18 months. Further information on the process of an additional facility for selenium treatment is provide in the response to JRP IR-5.6.

Water quality issues due to Project activities would be addressed by applying appropriate mitigation measures. After mitigation, potential effects on water quality and the receiving environment would be assessed as not significant in both LSA and RSA. As per any Environmental Impact Assessment (EIAs) water quality output predictions should be considered as defensible information for decision-making rather than representing absolute predictions of receiving water quality; as such, construction, operations, and closure monitoring is recommended to track and identify any trends in water quality.

5.2 Information Request 5.2

Eighth Addendum to the Environmental Impact Assessment. Figure AER-R2-17-1. (CEAR #89).

Figure AER-R2-17-1 in Addendum 8 (CEAR #89) indicated that discharge from the saturated backfill zones will be routed through the proposed metals treatment plant and subsequently discharged via three pipes into Blairmore Creek. However, there does not appear to be any capacity for holding water (i.e. post-treatment holding pond) to allow testing of water quality and receipt of results from an accredited laboratory to ensure the water meets regulatory limits prior to discharging to the environment. Further information is required on Benga's plans to prevent the discharge of water which does not meet criteria for discharge to receiving water bodies.

a) Confirm if a post-treatment holding pond downstream from the proposed metals treatment plant is planned. If it is, provide additional details (e.g. capacity, location) of the proposed pond.

Response:

Post-treatment holding (polishing) ponds will be located downstream of the saturated backfill zone (SBZ), as well as downstream of the proposed metals treatment plant (Figure 5.2-1). The intended process involves water pumped from the raw water pond (RWP) to a SBZ (pink dashed line, Figure 5.2-1). Water from the SBZ will be extracted *via* well, would discharge over a cascading structure to promote aeration, prior to discharging into a post-SBZ holding/polishing pond (green dashed line, Figure 5.2-1). The capacity of the pond would be 30,000 m^3. Water would be tested and compared to regulatory compliance limits within this pond. It is assumed (as Option 1) that all water quality parameters would be met and could then be transferred to a secondary holding/polishing pond (with a capacity of 15,000 to 30,000 m^3; to be determined through final engineering design) prior to release to the downstream environment (blue line, Figure 5.2-1). In the event some of the water quality parameters are not met, (as Option 2) the water would be transferred to the metals treatment plant (pink dashed line, Figure 5.2-1), where it would then be pumped to the post-treatment holding pond.

b) Provide a list of parameters to be analysed in the holding pond water prior to discharge.

Response:

The water quality parameters that would be analysed in the holding ponds(s) prior to discharge to the downstream receiving environments is provided in Table 5.2-1.

Table 5.2-1 List of Water Quality Analytes to be Analyzed

Physical Parameters • Alkalinity • Electrical conductivity • Hardness • pH • Temperature • Total Dissolved Solids • Total Suspended Solids **Nutrients** • Ammonia • Nitrite • Phosphorus • Sulphate • Total nitrate **Organics** • Total organic carbon • Dissolved organic carbon	**Total and Dissolved Metals** • Aluminum • Arsenic • Calcium • Cadmium • Chromium • Cobalt • Copper • Lead • Iron • Mercury • Manganese • Nickel • Uranium • Zinc • Total selenium

c) If a post-treatment holding pond is not planned, provide details on how water discharged from the metals treatment plant will be tested to ensure it meets regulatory limits. If treated water is non- compliant, and a post-treatment holding pond is not envisioned, indicate how Benga will avoid discharging non-compliant water.

Response:

Not applicable, please see responses to JRP IR-5.2 a) and b).

5.3 Information Request 5.3

Eighth Addendum to the Environmental Impact Assessment. AER-R2-23. (CEAR #89).

In response to AER-R2-23 in Addendum 8 (CEAR #89), Benga described an aeration process for saturated backfill treated water followed by application of hydrated lime (to

precipitate solids before discharging to Blairmore Creek) or acid (to scavenge hydroxides and prevent formation of calcium carbonate solids).

However, the addition of lime or acid will shift the pH of the water which will then need to be corrected prior to discharging to Blairmore Creek. In this climate, the process for precipitation of calcium carbonate is kinetically slow. Further details are required to determine how Benga will ensure sufficient mitigation of potential calcite precipitation has occurred prior to discharging to Blairmore Creek.

Response Overview

Based on available water quality data, under baseline conditions calcite precipitation is not an issue for Blairmore Creek and Gold Creek. The proposed Project mitigation to capture and treat waste rock contact water will further reduce the likelihood that calcite deposition will occur within either watercourse. Water from waste rock piles will be entrained and diverted from the overlying rock drains into surge ponds, where it will either be pumped to the raw water pond for processing or will be directed to a saturated backfill zone (SBZ). Water from the SBZ is proposed to discharge down a constructed cascade to aerate the effluent and may be diverted one of two ways: 1) to the raw water pond for process water; or 2) discharged to the SBZ holding/test pond (discussed in greater detail in response to JRP IR-5.2). From the holding/test pond, pending the results of water quality monitoring and testing, the water will either move to a second holding (clean water pond) for release to Blairmore Creek, or to a secondary treatment facility (*e.g.,* metals treatment plant).

To monitor the effectiveness of calcite mitigation and management, the Project's Aquatic Monitoring Plan (AMP) (JRP IR-5.4) will include triplicate stream-reach sampling in line with the Teck (2013) Elk Valley Water Quality Plan: Approach and Methodology to Monitor and Assess Calcite Impact. This approach includes the documentation of:

- the extent and degree of calcite deposition in time;
- calcite-specific aquatic ecological concerns (*i.e.,* critical westslope cutthroat trout habitat); and
- when and where additional calcite mitigation is required.

a) Given that precipitation of calcite solids is a kinetically slow reaction, provide details on how mitigation by hydrated lime would occur to ensure sufficient precipitation of solids prior to discharging to Blairmore Creek (e.g. use of aerated ponds, holding tanks, etc.).

Response:

Benga propose to construct a cascade from the discharge point of the SBZ that will promote CO_2 off-gassing and atmospheric equilibration and reduce the volume of calcite precipitates. The water would then pass through a coarse gravel ditch line, before entering into the SBZ holding

pond where water would be allowed to further equilibrate and monitored for specific water quality parameters (please refer to previous response in JRP IR-5.2 for location of the SBZ holding pond and the suite of water quality parameters to be monitored). This slower process of off-gassing and precipitation reduces the quantity of precipitates by at least a factor of 2 and potentially eliminates the need to use hydrated lime.

As indicated in JRP IR-5.2, in the event water quality parameters exiting the SBZ, including calcite, are found to not meet water quality compliance limits, Benga would construct a water (metals) treatment plant (JRP IR-5.6). If required, this water treatment plant will be designed to appropriately treat water prior to discharge to a post treatment plant holding pond, and subsequently to Blairmore Creek. Refer to Figure 5.2-1 for a plan and flow schematic of this treatment sequence.

If mitigation by hydrated lime is necessary, it would be performed in the water treatment plant. One of the most effective treatment approaches for calcite super-saturation with lime is the implementation of a high-density sludge (HDS) lime treatment process. HDS lime treatment is also the proposed mitigation measure for removal of dissolved metals in effluent from the saturated treatment zones, if required. The hydraulic residence time for process water in an HDS water treatment plant typically ranges between 40 and 60 minutes, which provides more than enough time to eliminate calcite supersaturation.

b) Describe how Benga proposes to address shifts in pH as a result of adding lime or acid to treat water prior to discharging to Blairmore Creek.

Response:

The post-treatment adjustment of pH would follow established treatment practices, where effluent from the lime treatment step would be discharged to an effluent holding pond where it would be allowed to reach equilibrium with atmospheric CO_2 concentrations. This typically reduces the pH to about 8.2 and can be expedited using aeration systems. If implementation of an effluent holding pond is not feasible, CO_2 can be used to adjust the effluent pH directly in the effluent pipe. In either case, the reaction for lowering pH is:

$$CO_2 + H_2O \rightarrow H^+ + HCO_3^1$$

c) Describe:

i. the water quality monitoring to be conducted on post-treated water to ensure adequate mitigation of calcite has occurred;

Response:

An on-site laboratory facility would have instruments for measuring temperature, conductivity, and pH. In addition, dissolved alkalinity would be analyzed using a HACH digital titrator. Based on these inputs, the degree of calcite saturation can be estimated. Initially, sample

aliquots would be submitted for analysis by an external laboratory to verify the validity of the field measurements.

ii. proposed post-calcite treatment targets for calcium carbonate concentrations; and

Response:

The solubility of calcium carbonate is very low; therefore, if the solid-liquid separation step of the calcite removal process works as intended, the post-treatment concentration of calcium carbonate should be very low. Since calcium carbonate is a solid, the effluent limit would be governed by the proposed limit of total suspended solids (TSS), which is 15 mg/L. It should be noted that calcite solids in the effluent would not cause cementation of streams downstream but would be carried downstream in the same manner as any other silt or clay-sized particle entrained in the water column.

iii. how water not meeting proposed targets would be handled.

Response:

Water not meeting the proposed effluent limit would be pumped to the raw water pond (RWP) for reuse in the CHPP or to an SBZ and re-treated. Pump-back to the RWP or an SBZ is the general contingency plan for effluent that exceed any effluent quality limit. The SBZ will not treat for calcite but is the first step in the closed treatment loop.

d) Describe the types of facilities envisioned by Benga for the addition of hydrated lime or acid should these facilities be required. Include details on storage of commodities (i.e. lime and acid), the surface area and volume of ponds or tanks required for hydrated lime or acid treatment and where these would be located, how the storage facilities would be managed, how secondary containment would be addressed, how any vapour emissions would be managed, and how the commodities would be added to the water.

Response:

As discussed in part a) of this IR, the most likely method for implementing calcite treatment would be HDS water treatment; if post-treatment of water is required for either calcite or metals, both can be treated in an HDS treatment plant. The footprint for the proposed post-treatment process is illustrated in JRP IR-5.2. A hopper with a screw feeder and delivery pump would be required to dose and add the HDS to the mine water. Lime used in the process would be stored in lime silos, which would be 15 to 20 ft in diameter and 30 to 45 ft tall. Design of secondary containment would follow standard design practices (capacity of secondary containment usually amounts to the volume of all tanks plus 25%). No vapor emissions are anticipated besides some minor evaporative losses.

e) Describe how the proposed treatment will be responsive to fluctuations in flows and in chemical composition of mine water saturated with calcium carbonate.

Response:

The influent for the post-treatment plant would be pumped from the SBZ holding pond to a water (metals) treatment plant. As the SBZ has a large capacity, neither the holding pond nor the secondary water treatment facility would be required to respond to sudden fluctuations in flows. The influent water quality is expected to be relative consistent from day to day although gradual weekly or monthly changes can be expected. Similarly, chemical composition of SBZ effluent is not expected to change rapidly and changes over time will be managed through adjustments in the water treatment plant to maintain a satisfactory outlet water quality. As described previously, any water treatment upset for whatever reason will be managed by recycling to the raw water pond.

5.4 Information Request 5.4

Eighth Addendum to the Environmental Impact Assessment. AER-R2-24, DFO-R2-4, DFO-R2-5, DFO-R2-6, and DFO-R2-7. (CEAR #89).

Comments from the Government of Canada - Environment and Climate Change Canada and Fisheries and Oceans Canada submissions. (CEAR # 167).

Comments from Canadian Parks and Wilderness Society Southern Alberta. (CEAR #176).

From Osler, Hoskin & Harcourt LLP on behalf of Benga Mining Limited - Response to Sufficiency Comments from Non-Indigenous Parties. (CEAR #191).

In response to a request for submission of a draft aquatic monitoring, mitigation and adaptive management plan in AER-R2-24 in Addendum 8 (CEAR #89), Benga outlined what the contents of such a plan would contain and referenced the draft Fisheries Offset Plan, but did not provide the requested draft aquatic monitoring plan. In CEAR #191, Benga indicated that details such as final locations and endpoints were not provided in Addendum 8 since they are typically finalized with appropriate regulatory bodies as part of Project conditions. While the Panel does not expect that the aquatic monitoring plan would be finalized at this stage, the draft should demonstrate:

- a thorough comprehension of potential project effects including potential locations or gradients of effects on water quality and/or aquatic biota, particularly in relation to seasonal patterns of water flow;
- the most appropriate and rigorous approach for timely detection and response to potential adverse changes in the aquatic environment, including but not limited to the selection of early warning indicators and the anticipated method(s) for derivation of data quality objectives; and
- planning for and availability of alternative mitigation measures to adaptively manage potential adverse effects.

Furthermore, in its submission to the Panel (CEAR #167), ECCC reiterated, having a draft aquatic monitoring plan would allow the Panel to evaluate Benga's ability to: detect potential changes in water quality, validate assessment predictions, and evaluate adaptive management measures to mitigate potential effects. Canadian Parks and Wilderness Society Southern Alberta (CEAR #176) also indicated that the draft aquatic monitoring plan should be available to evaluate potential effects. Finally, Fisheries and Oceans Canada requested (CEAR #167), in consideration of the responses to information request DFO-R2-4 through DFO-R2-7 in Addendum 8 (CEAR #89) and Benga's commitment to produce monitoring plans in each of these responses, a draft monitoring plan that considers potential effects of changes to fluvial geomorphology on fish and fish habitat be prepared.

a) Provide a draft aquatic monitoring, mitigation and adaptive management plan specifically addressing the following points:

   i. potential effects of the project that require mitigation;

   ii. uncertainties that necessitate the use of adaptive management including, supporting evidence on the efficacy of proposed adaptive management measures;

   iii. proposed mitigation measures, mitigation objectives and associated pre-discharge mitigation performance indicators to be used in order to confirm the effectiveness of mitigation;

   iv. details on receiving environment monitoring stressor indicators and effects indicators, including sampling location, frequency, and supporting information;

   v. supporting evidence, including reference to relevant examples, on the efficacy of the proposed mitigation measures described in (iii), along with contingency measures that are technically and economically feasible should the mitigations implemented in (iii) prove to be ineffective; and

   vi. methods to be used to develop thresholds that would trigger implementation of mitigation measures or adaptive management measures (e.g., a series of risk-based thresholds ranging from triggering confirmation of exceedance of guidelines, to confirming cause/effect, to triggering deployment of alternate or additional mitigation).

b) As part of this plan, indicate how monitoring of fish eggs and fish ovaries will be conducted in a manner that is consistent with the objectives of the Recovery Strategy for the Westslope Cutthroat Trout and that considers any potential sampling limitations to a species at risk.

c) Identify how existing baseline data and/or reference sites will be used as a basis for determining whether changes in surface water quality or aquatic biota have occurred.

d) Describe how long-term trends will be identified and mitigated, as compared to year-to-year variability.

Response:

In response to parts a) through d), please refer to Appendix 5.4-1 – draft Fisheries and Aquatic Monitoring Plan.

5.5 Information Request 5.5

Grassy Mountain Coal Project - Updated Environmental Impact Assessment. Section 3.3.2 in Appendix 10C, Section C.8. (CEAR #42).

Eighth Addendum to the Environmental Impact Assessment. AER-R2-13. Appendix C-2. (CEAR #89).

Comments from Timberwolf Wilderness Association. (CEAR #156).

Comments from the Coalition of Alberta Wilderness Association and Grassy Mountain Group, and Shirley Kirby. (CEAR #164).

Comments from the Government of Canada - Environment and Climate Change Canada. IR#6. (CEAR #167).

Comments from Ktunaxa Nation Council. (CEAR #178).

From Osler, Hoskin & Harcourt LLP on behalf of Benga Mining Limited - Response to Sufficiency Comments from Non-Indigenous Parties. (CEAR #191).

Appendix C-2 in Addendum 8 (CEAR #89) contains the results of a pilot-scale trial to simulate selenium and nitrate attenuation in saturated backfill zones. Benga indicated that the pilot-scale trial would allow for a preliminary evaluation of the process kinetics (time required for the selenium and nitrate attenuation reactions to occur) and reaction stoichiometry (how much carbon is required for the attenuation reaction) associated with the development of reducing conditions and selenium attenuation. In Section 1.2 in Appendix C-2 in Addendum 8, Benga acknowledged that the trial was limited in scale and was not intended to evaluate the hydraulics of full-scale backfill zones. In the response to AER-R2-13 in Addendum 8 (CEAR #89), Benga indicated that they plan to conduct an on-site, field-scale test in parallel with construction of the mine facilities, however, Benga indicated it is not feasible to conduct large-scale field trials in time to make the results available for the Panel's consideration (CEAR #191).

Several limitations and uncertainties of the barrel test were identified including, but not limited to:

- Waste rock source: the barrel study used weathered rocks, which could result in different processes for selenium removal compared fresh waste rock. Consequently, the study conclusions may not be applicable to the proposed saturated backfill zone system.
- Poor selenium removal: the poor selenium and nitrate removal between Week 3 and 4 of the study could have been due to inherent limitations of selenium

removal in this system. The explanation given in the conclusion in Appendix C-2 for their poor removal is inconsistent with data presented in Figure 9 in Appendix C-2 (CEAR #89).

In its submission to the Panel (CEAR #167), Environment and Climate Change Canada identified other limitations related to exposure of waste rock to air, location of effluent pipe, feed concentration, retention time, and proliferation of micro-organisms in the tubing.

In Section 3.3.2 in Appendix 10C of the updated EIA (CEAR #42), Benga provided a list of case studies to inform the proposed selenium mitigation method and that examined the attenuation process as an engineered system. However, there is very little detail provided in the updated EIA and Benga did not demonstrate that these case studies are directly relevant to the Project with respect to geochemical, climactic or other pertinent conditions.

In Section C.8.3.1 of the revised EIA (CEAR #42), Benga indicated that the Project will use comparable mining and processing methods as those employed by Teck Resources in the Elk Valley, British Columbia. Benga further indicated that Teck Resources is currently managing selenium leaching at its operations in Elk Valley as a result of increasing selenium concentrations in the Elk River, and provided a list of both passive and active measures being undertaken by Teck Resources as described in the "2014 Elk Valley Water Quality Plan". However, Benga does not demonstrate that the conditions in the Elk Valley correspond directly to those at the Project, or that the results in the Elk Valley are broadly applicable.

In CEAR #191, Benga provided a news release from Teck Resources, but the content of this document does not reduce the uncertainty associated with the use of saturated backfill zones as mitigation.

Numerous participants in the environmental assessment (CEAR #156, #164, #176 and #178) also requested further information regarding the use of saturated backfill zones given the experience of Teck Resources in the Elk Valley.

Environment and Climate Change Canada also indicated that they had concerns with the efficiency of the proposed treatment to attenuate selenium and has noted some inconsistencies in the materials filed by Benga (CEAR #167). According to Figure 6 in Appendix C-2 (CEAR #89), the rate of attenuation of selenium in optimal conditions tested is around 90%. In contrast, the project description predicts selenium attenuation above 99%, which would result in selenium concentrations in effluent of 15 µg/L. Under conditions of 90% attenuation of selenium, the resulting concentration of selenium in the effluent would be 150 µg/L. This effluent concentration would result in approximately 70 µg/L of selenium after dilution in Blairmore Creek, which is 34 times higher than the Alberta and British Columbia guideline of 2 µg/L in surface water.

Furthermore, selenium speciation was not completed as part of the trial. Environment and Climate Change Canada (CEAR #167) and Ktunaxa Nation Council (CEAR # 178) indicated that speciation of selenium is essential to determine the form of selenium in the effluent, which is the form of selenium that will be released to the environment. To

propose an appropriate water quality criterion for selenium, it is necessary to know if the soluble form of selenium released is selenate or selenite. In addition, identifying the speciation of selenium would provide information on reducing conditions efficiency (i.e. to reduce selenium to its elemental form), and allow quantification of the proportion of selenium partially reduced to selenite and to methyl selenium.

The Panel requires further information in order to reduce uncertainty associated with the proposed selenium treatment method for the Project, and to ensure Benga has a thorough understanding of all scientific and engineering aspects of this technology, as applied to this site, including how examples from other sites are relevant to the Grassy Mountain project.

a) Describe additional tests and modelling studies planned to demonstrate the effectiveness of the saturated backfill zone concept at field scales. Provide details and approximate timelines for development, implementation, evaluation and reporting as well as modelling of mitigation alternatives. Include details that address the following key areas:

   i. how the information necessary for engineering a full-scale system will be obtained;

   ii. how the limitations identified by Environment and Climate Change Canada in IR6 (CEAR #167) would be addressed;

   iii. how full-scale operating parameters will be determined, including feed rates, carbon dosing and any other relevant operating parameter;

   iv. how treatment performance will be monitored so that system operation can be adjusted to maintain acceptable selenium removal rates and compliant discharges;

   v. what selenium removal rates can be consistently attained at full-scale despite seasonal changes in temperature, flows and selenium loadings, as well as long-term changes in climate;

   vi. how these studies ensure that treatment performance will mitigate exceedances and ensure discharge criteria are achieved over the long term;

   vii. the fate of selenium retained in the saturated backfill and risks of future remobilization;

   viii. how the supply of organic carbon will respond to fluctuations in flows or chemical loadings and how this will be controlled so that it is neither excessive nor insufficient;

   ix. how the system will be maintained to prevent impairment of treatment performance, potentially due to biological fouling, siltation or development of preferential flow paths;

   x. what the long-term maintenance requirements will be for a full-scale system; and

xi. how speciation of the predicted selenium releases from the Project will be conducted in order to provide information on efficacy of treatment conditions and inform appropriate water quality objectives for selenium.

Response:

Benga considers that the scientific principles and established technology for removal of selenium in a gravel bed reactor (GBR) are well proven and in broad use in the industry. Further Benga considers that the extension of the technology to a larger scale in a coal mine through the implementation of a Saturated Backfill Zone (SBZ) to be a reasonable engineering approach for achieving a high level of selenium extraction in an environmentally elegant manner. Further, this approach has been implemented and is providing excellent results at the Teck Elk Valley facility where an SBZ has been in operation since 2017.

Notwithstanding Benga's confidence in the selenium removal concept using an SBZ, Benga also recognizes that the concept needs to be implemented well, in consideration of the specific parameters of the Project in order to achieve the excellent results that are possible. That being the case, Benga has and will continue to implement testing and other R & D initiatives to progressively develop the detailed engineering parameters for the first phase of the SBZ which will need to be implemented by 'Mine Year 4' after Project construction begins (which in calendar years includes two years of construction and five years of operations). Based on modelling of the development of the first ex-pit rock disposal zones and the time required for water percolation and selenium uptake, elevated levels of selenium in the contact water would not be encountered until that time.

Table 5.5-1 provides a high-level overview of the applicable timelines associated with the regulatory process, Construction phase, the first five years of the Operations phase, and the various selenium mitigation approaches that Benga will continue to research and develop over the next eight to nine years (prior to the first SBZ coming on line). R&D around SBZs would continue once the first SBZ comes online and carry forward through Operations and into Closure.

An overview of the types of selenium mitigation and R&D Benga have conducted, have initiated, and are committed to develop is provided in subsequent sections.

Table 5.5-1 Schedule Overview of Saturated Backfill Zone Research and Development for the Grassy Mountain Coal Mine

Project Phase	Regulatory			Construction			Operations				
Mine Year	---	---	---	---	---	---	1	2	3	4	5
R&D Year	1	2	3	4	5	6	7	8	9	10	11
Mitigation											
Water Management Plan											
Final Engineering Design											
Construction											
Operation											
Seepage Management											
Pump Testing & Design											
Installation											
Monitoring											
Source Control											
Waste Dump Final Engineering											
Gravel Bed Base Construction											
Strategic Dumping											
Progressive Reclamation											
C&R Development											
Waste Rock Dump Planning											
Waste Rock Reclamation											
Research & Development											
Impact Assessment Study's											
Field Pilot Program											
SBZ Implementation											
SBZ Operational Monitoring											

Barrel Testing (2017)

Barrel testing was conducted as a preliminary demonstration of proof of concept and successfully demonstrated that selenium removal in a hypoxic environment can be very effective and can achieve very high rates of removal. In 2017, SRK Consulting (SRK) conducted initial selenium and nitrate attenuation pilot-scale field trial for the Project. The purpose of the trial was to allow for a preliminary evaluation of the process kinetics (*i.e.,* time required for the selenium and nitrate attenuation reactions to occur) and reaction stoichiometry (*i.e.,* how much carbon is required for selenium reaction).

The objectives of the trials were to:

- Demonstrate operational control of reducing conditions and selenium attenuation within saturated back-fill zones;
- Evaluate the effect of hydraulic retention time on selenium and nitrate attenuation; and
- Examine the effects of the dose and type of carbon on the development of reducing conditions.

The following was concluded from the trial:

- The results indicated that configuration of waste rock media in each barrel did not significantly affect the internal flow hydraulics;
- Kinetics - selenium and nitrate removal was near-complete for the first two weeks of the trial in all barrels that were dosed with organic carbon (methanol or molasses/methanol); and
- Stoichiometry - The type or dose of organic carbon did not appear to affect the rate of selenium and nitrate attenuation.

Column Testing (Ongoing)

A long-term column test is currently on-going to evaluate treatment of Se and NO_3 in mine water, under varying operational conditions. Waste rock from the site was used to pack the column using rock fragments ranging from 2 to 4 cm in size, as commonly used in gravel bed reactors (GBR). Given that Se-impacted water is not yet being generated at the site, synthetic water, which represents the anticipated mine water chemistry was used in the column test. The synthetic water is also amended to represent the background geochemistry of the site's surface water in terms of anions, cations, *etc.*

The key design parameters for saturated backfills and GBRs are flow rate, influent concentration, target effluent concentration, degradation rate and temperature (which affects degradation rate). Knowing these parameters, the size of a saturated backfill or GBR can estimated. At this stage,

assumptions can be made about flow rate and influent chemistry. The column testing will generate temperature-specific degradation rate data and will test the following operating conditions:

- Treatment of Se and NO_3 at temperatures of 8ºC and 4ºC and estimation of respective treatment rates;
- Treatment of Se/NO_3 during under dosing of the carbon source;
- Treatment of Se/NO_3 during overdosing of the carbon source;
- Treatment of Se/NO_3 during periodic spikes in influent nitrate concentration (from 40 to 200 mg/L); and
- Effect of biofouling on treatment.

Preliminary results have indicated that the Se removal rate in the column experiment has ranged from 19 to 32 ug/L/day at temperatures of 4ºC and 8ºC, respectively. Field results from other field applications have shown a Se removal rate of approximately 20 ug/L/day at a similar temperature range. As such, a Se removal rate of 20 ug/L/day will be used for preliminary design for SBZ residence time.

This information, in tandem with knowledge from existing GBR and SBZ field applications, will provide key data necessary to design the proposed SBZ. Benga also notes that these column tests address a number of concerns raised by Environment and Climate Change Canada in IR6 (CEAR #167). Specifically:

- Concern related to using waste rock that has been exposed to the surface - the samples of site waste rock provided for the test included large pieces that were crushed prior to packing the columns. Therefore, the test rock fragments had fresh surface exposed to the water, rather than weathered surfaces;
- Concern related to exposure of treatment bed to air - the column used in the test is air tight; and
- Concern related to the location of effluent pipe and heterogenous distribution of redox conditions - the column used a bottom-up flow to assure full-saturation and no gas entrapment.

Future Testing and Development

After Project approval, Benga will have an opportunity to engage in additional field scale pilot testing if necessary, to fine tune engineering designs and operational parameters. As the final SBZ design will not be required until 2 or 3 years after operations begin, a field scale pilot that is established during the first year of construction could run for several years to collect additional information. Further, if located intelligently, the field scale pilot could continue to operate after

the SBZ has been established to provide longer term operating information and to test new concepts that may improve the operation.

A decision on implementation of a field scale pilot will be made based on a number of factors including:

- Results of the column testing that is currently on-going;
- Information and research that becomes publicly available from other projects that are also working on SBZ implementation; and
- Need for additional information to make engineering decisions.

Engineering Design of the SBZ

The dimensions of the SBZ will be based on the anticipated influent flow rate, concentrations of Se and NO_3, and water temperature. Dosing of the carbon source will be based on the column test results and field experience at other SBZ/GBR field applications, with the dosing adjusted as needed based on the actual field monitoring results.

The SBZ will be equipped with a network of monitoring points in the system influent, along the SBZ flow path, and the effluent. Key parameters will be monitored at sufficient frequency (*e.g.,* daily or weekly depending on location) to understand system performance and to guide adjustments of operations.

Frequent monitoring of the influent concentrations of NO_3 and Se will be performed so that carbon dosing can be adjusted as needed. SBZs and GBRs are typically designed to provide excess treatment capacity so that small fluctuations in influent NO_3 or Se can still be treated by the carbon dose. The column tests are evaluating the potential effects of under- and over-dosing and how long it takes the system to re-establish steady-state treatment conditions following under-or over-dosing.

If biofouling or mineral fouling occurs, it is expected to be localized to the influent end of the SBZ. The SBZ monitoring will include measurement of the backpressure at the influent points to detect if fouling has occurred to a degree that adversely affects the performance. Periodic rehabilitation of the treatment unit using physical or chemical measures may be required. This typically involves surging and purging injection points or application of a compressed air shock to physically dislodge and recover excess biomass, and in some cases requires addition of an acid such as glycolic acid to destabilize biofilms to improve their removal.

As a precaution for the design of the first phase of the SBZ, Benga intends to implement redundant injection, measurement and water extraction wells to provide maximum operational flexibility and redundancy. It is anticipated that information and learnings from the operation of the first phase SBZ will enable more precise and economical designs for subsequent phases.

Other engineering design details that will be developed prior to construction of the first phase of the SBZ include:

- overall layout of the infrastructure, holding pond, intake and discharge;
- design of intake pump and pipeline from RWP to SBZ;
- design of the reticulation of the feed water into the SBZ;
- design of the electron donor injection;
- design of the storage arrangements for the electron donor;
- design of holding pond for the SBZ effluent;
- design of the piping and pumping arrangements for the effluent into holding pond;
- design of the discharge from the holding pond to either the RWP (for non-compliant water) or to Blairmore Ck (for compliant water);
- design of access and monitoring systems; and
- design of retaining levee for the first phase of the SBZ.

Opportunities for Adaptive Management of the SBZ

Benga considers that the operation of the SBZ provides numerous opportunities for the application of Adaptive Management to improve the SBZ performance. As stated above, the SBZ will be implemented in 3 phases which in itself allows for lessons learned in the first phase to be applied to the phase 2 design. In addition, as mentioned, Benga has the opportunity to implement significant redundancy into the first phase SBZ to provide maximum operational flexibility and ability to adjust the operation if required.

Operational monitoring will be used to adjust the control parameters that affect the SBZ performance. As mentioned above, the infrastructure will be designed to handle a range of operation to allow for increasing or decreasing the electron donor, and injection rates or withdrawal rates.

In the event that short term results from the SBZ do not meet the required regulatory standards for selenium or nitrate removal, provision will be made for redirecting any off-spec water to the raw water pond and from there to recirculate through the SBZ. This will allow some time for Benga to make the necessary adjustments to the SBZ operation to achieve acceptable results.

b) Provide a detailed summary of case studies (including small-scale laboratory tests or other large- scale pilot projects) that have been completed and that investigate selenium attenuation in saturated backfill zones in British Columbia and elsewhere. The summary should include, at a minimum, the following information:

   i. description of the test or pilot study and objectives;

   ii. engineering details;

iii. study duration;
iv. inflow selenium concentrations, minimum and maximum selenium effluent concentrations, changes in selenium speciation, if any;
v. process kinetics;
vi. lag time anticipated between start up and consistent selenium removal rates;
vii. fluctuations in flow rates or mass loadings and their effects on treatment performance;
viii. reaction stoichiometry (if available), imputed or demonstrated removal mechanisms;
ix. required chemical inputs;
x. selenium capture rate;
xi. selenium attenuation rate;
xii. any details on seasonal variations in performance;
xiii. system treatment capacity;
xiv. description of case study outcomes;
xv. monitoring methodology;
xvi. operation and maintenance requirements; and
xvii. risk evaluation and proposed mitigation measures.

Response:

Papers detailing the case studies discussed below are included in Appendix 5.5-1.

Selenium Attenuation

Selenium Attenuation Example A

Jensen *et al*. (2018) completed a field trial in 2017 to evaluate the stoichiometry, reaction kinetics, and carbon requirement for selenium attenuation at the Grassy Mountain Coal Project in southern Alberta. A secondary goal of the field trial was to establish operating and monitoring procedures for scaling to bench-scale and eventually full-scale research and development testing.

Seven 45-gallon (170 L) plastic barrels were filled with coarse coal waste rock and coal reject from the project area to simulate small-scale reactors (Jensen *et al.*, 2018). No organic material or microbial seed was added to any of the barrels. The feed into each of barrels was adjusted to achieve a hydraulic residence time of two weeks, which was approximated as the minimum required treatment time.

The influent was dosed with 40 mg/L nitrate and 650 ug/L selenate to simulate mine water. The flow of dissolved carbon to the reactors was controlled with a drip valve. Test conditions with low and high doses of carbon, either as methanol or a mix of methanol and molasses, were applied in barrels containing 100% waste rock. In two barrels, a portion of the waste rock was replaced with coarse coal reject to evaluate if organic carbon leached from the coal would generate suboxic conditions.

The concentration of selenium in barrels dosed with varying amounts of carbon was reduced to less than 15 ug/L after two weeks (Jensen *et al.*, 2018). Attenuation rebounded after the test had been running for two weeks; this reportedly occurred due to loss of carbon in the feed solution, resulting from the formation of a biofilm in the tubing supplying carbon to the reactors (Jensen *et al.*, 2018).

The results of the pilot study indicated that a simple flow-through reactor with a starting residence time of two weeks was sufficient for attenuation of selenium (and nitrate) given the waste rock from the Grassy Mountain coal project. Future large-scale field tests are still required to evaluate process kinetics for varying residence times, as well as variable temperature field conditions (Jensen *et al.*, 2018).

Selenium Attenuation Example B

The Teck Coal Limited (Teck) Applied Research and Technology (ART) centre in Trail, BC prepared six column bioreactors using water from Bodie Creek at the Elkview Mine in the Elk Valley to evaluate selenium removal. The columns were filled with fine coal rejects from the mine with an average particle size of approximately 1 mm (Jones *et al.*, 2009).

The columns were run for a maximum of 239 days. Parameters such as temperature, fed rate, and nutrient and sulphate addition rates were varied between the columns. The inflow selenium concentrations, using water collected from the Bodie Creek rock drain, ranged from 27 - 140 ug/L (Jones *et al.*, 2009). An average removal rate of 97% was obtained for a flow rate of 1.56 $m^3/(m^2 day)$. Increases in flow rate generally resulted in decreases in removal efficiency.

Two of the columns plugged and were taken offline prematurely. A third column began to show signs of plugging after 142 days in operation and was taken offline at day 217 despite reducing the flow rate to mitigate plugging. Scanning electron microscope imagery from decommissioned columns showed that the source of plugging was largely inorganic.

Selenium Attenuation Example C

Kirk *et al.* (2017) completed batch and column studies to evaluate the ability of native microbial communities to reduce selenium in waste rock. Oxygen and growth substrate were varied to evaluate the rate and extent of selenium and nitrate reduction. Six column reactors were run in upward flow configurations to simulate aerobic, microaerobic, and suboxic conditions

(18 columns total). For each condition, three growth substrates were tested: no added carbon, glycerol, and methanol. Nitrogen gas was introduced to the columns to limit dissolved oxygen and produce microaerobic and suboxic conditions.

The influent water was adjusted to 1.0 mg/L Se-SO_4 (1.81 mg/L selenate) with nitrate varied from 1 to 10 mg/L, depending on the experiment (Kirk *et al*., 2017). The flow rate was metered to 0.85 mL/min. To simulate conditions in saturated backfilled pits, the experiments were completed in total darkness at temperatures of 10°C (± 1°C).

For columns where carbon sources were introduced to facilitate redox conditions, the acclimatization period was between 20 and 21 days. None of the columns experienced carbon limiting (Kirk *et al.*, 2017). The residence time for efficient removal was approximately 16 hours under suboxic conditions following the acclimatization period.

In both the microaerobic and suboxic column tests, the glycerol resulted in more effective selenium reduction than methanol (> 95% and 90% maximum reduction, respectively). In all oxygen conditions, the reduction of selenium followed reduction of between 40 and 95% of nitrate from the column, as expected given the redox potential of the reactions.

A significant observation of the study was the ability of the no-carbon control columns to release enough carbon into solution to drive reduction, provided adequate residence time. However, Kirk *et al*. (2017) noted that this observation may be limited to the laboratory environment and would likely change with seasonal spikes in nitrate or oxygen.

Selenium Attenuation Example D

Two 5 m^3 pilot-scale bioreactors were constructed at the Smoky River Coal Mine in BC to assess the ability to treat selenium-contaminated water in an area with restricted space, access, and power (Sobolewski, 2010; Ness *et al.*, 2014). The bioreactors were filled with gravel, wood chips, manure, lime, and bonemeal; selenium-reducing bacteria and ethylene glycol (liquid carbon source) were artificially introduced (Sobolewski, 2010). From September to November 2008, approximately 97% of the selenium was removed from the waste water (Ness *et al*., 2014). It was noted by the researchers that the addition of a liquid carbon source may allow anaerobic bioreactors to continue to operate at high efficiency under winter conditions, based on a study low temperature of 2°C.

Selenium Attenuation Example E

Envirogen Technologies completed two case studies treating selenium-rich waste water derived from coal mines using Fluidized Bed Reactor (FBR) technology. There was limited information available for each of the case studies, as the individual studies were not the focus of this whitepaper.

Case Study 1: 10 Month Coal Mining Trial – US

The first case study was completed on waste rock from a coal mine located in the US; no additional details were provided on the location of the mine. Three sealed vessels were used to created FBRs; there was no information provided regarding variation in the FBRs to differentiate the runs. The inflow parameters are provided below.

Table 5.5-2 Inflow Parameters for 10 Month FBR Trial (US)[1]

Constituent	Input Concentration
Dissolved Selenium	22 – 27 ug/L
Nitrate – Nitrogen as N	6 – 8 mg/L
Dissolved Oxygen	11 – 13 mg/L
pH	7 to 9

[1] Adapted from Envirogen, 2019

The resulting maximum effluent concentration provided for this trial was 4.7 ug/L filtered Se. There was no information available on the speciation of the selenium. As the trial specified "filtered", it can be assumed that the effluent concentration is based on elemental selenium removed from the effluent.

The design hydraulic residence time for the trial was 26.8 minutes; this was based on a flow rate of 15,261 m^3/day (2,800 gpm). The design temperature for the trial was 10°C.

Based on the input and effluent concentrations, a minimum selenium capture rate of 79% was achieved (based on an initial concentration of 22 ug/L). For a maximum effluent concentration of 4.7 ug/L, given an average input concentration of 24.5 ug/L, a rough attenuation rate of 0.8 ug/L/min was achieved based on the residence time for the trial.

Case Study 2: 4 Month Coal Mining Trial – Canada

A four-month trial was run at an undisclosed coal mine location in Canada, with higher input nitrogen concentrations and colder design temperatures. Six FBRs were reportedly used in two stages; however, it is not clear how the trial was staged due to lack of trial design data. The inflow parameters are provided below.

Table 5.5-3 Inflow Parameters for 4 Month FBR Trial (Canada)[1]	
Constituent	**Input Concentration**
Dissolved Selenium	200 – 500 ug/L
Nitrate – Nitrogen as N	15 – 40 mg/L
Dissolved Oxygen	11 – 13 mg/L
pH	7 to 8

[1] Adapted from Envirogen, 2019

The resulting effluent concentration for the Canadian trial was 10 ug/L filtered Se. As in the case study for the US, there was no attenuation or speciation data provided. It is assumed that the effluent concentration is based on elemental selenium removed from the effluent.

The design hydraulic residence time for the trial was 56.9 minutes; the difference from the US case study is likely related to the qualities of the waste rock used in the FBR, as the flow rates were the same (15,261 m^3/day or 2,800 gpm). The design temperature for the trial was 4°C.

Based on the input and effluent concentrations, a minimum selenium capture rate of 95% was achieved (based on an initial concentration of 200 ug/L). For a maximum effluent concentration of 10 ug/L, given an average input concentration of 350 ug/L, a rough attenuation rate of 6.0 ug/L/min was achieved based on the residence time for the trial.

Selenium Attenuation Example F

A biological treatment plant for selenium was in operation for two years at Goldcorp's former Wharf Resources Mine in South Dakota (Microbial Resources, 2007). The mine water, containing selenium at concentrations of 15 ug/L (as selenate; Se^{VI}), was collected through a French drain for treatment at the plant, where selenium was reportedly reduced to less than 5 ug/L. The flow rate into the plant ranged from 40 – 300 gallons per minute, operating year-round with minimal heating. The operating temperatures of the plant dropped as low as 1.5°C in the winter. To counteract decreased microbial activity in the winter, due to lower temperatures, additional nutrient was added. The full-scale plant required three to four weeks for the bacterial inoculum to grow for effective selenium removal.

There was little detail provided regarding residence time, or the impact of flow rate on treatment efficiency.

Selenium Attenuation Example G

The pit lake at the Sweetwater Uranium Mine in Wyoming was formed in 1983 following cessation of dewatering, resulting in flooding of the open pit (Martin *et al*., 2009). The initial

selenium concentration in the lake was 460 ug/L. Approximately 1.1 million lbs of organic carbon were used to dose the lake over a two-month period in 1999 (Golder, 2009). In six weeks, the selenium concentration had been reduced to 50 ug/L, meeting the applicable regulatory guideline value. Treatment of the pit lake was completed in the winter, to capitalize on a layer of ice limiting the mixing and diffusion of oxygen into the lake.

The biggest challenge to treatment of this pit lake was that the water column had not sufficiently stratified, which resulted in the need to remove dissolved oxygen as well as constituents of concern from the lake. The reduced temperature from winter conditions was not a limiting factor for the reduction reactions.

Selenium Attenuation Example H

Pahler *et al.* (2007) constructed four 208-litre (55 gallon) bioreactors as part of a bench-scale study at a gravel pit adjacent to the Colorado River in western Grand Junction, Colorado. The goal of the study was to evaluate the following:

- if a passive selenium-reducing bioreactor can accomplish high-efficiency selenium removal from local water sources;
- if zero valent iron (ZVI) is beneficial as a bioreactor component; and
- optimum detention time.

The study site was selected because of elevated concentrations of selenium in the dewatering trench for the gravel pit; concentrations varied from 31 to 93 ug/L in the year prior to the study (Pahler *et al.*, 2007). Each of the bioreactors contained a different mix of locally sourced organic compounds, including but not limited to: sawdust; hay; wood chips; agricultural limestone; and manure. ZVI was added to evaluate if chemical reduction of selenium would enhance the biological reduction of selenium (Pahler *et al.*, 2007); varying concentrations were added in each of the four bioreactors.

Table 5.5-4 Bioreactor Compositions[1]

Component	Proportion by Weight			
	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Sawdust	30%	30%	20%	2.5%
Hay	10%	10%	10%	0%
Wood chips	30%	30%	20%	2.5%
Agricultural limestone	20%	5%	5%	5%
ZVI	0%	15%	35%	85%
Cow manure	10%	10%	10%	5%

[1] Adapted from Pahler *et al.*, 2009

From July to September 2006, mine backfill trench water was introduced to each bioreactor at an average rate of 7.5 L/hour to achieve a residence time in the bioreactors of 12 hours. Selenium removal efficiencies of up to 98% were documented, with effluent concentrations typically less than 2 ug/L, and as low as < 1 ug/L (Pahler *et al.*, 2007).

Saturated Backfill

Saturated Backfill Zone – Example A - Tumbler Ridge, BC

Bianchin *et al.* (2013) conducted a hydrogeologic program on a saturated backfilled pit at an active coal mine in the Tumbler Ridge region of British Columbia. The approximate dimensions of the pit are 1,000 m long by 150 – 200 m wide. The saturated portion of the pit is approximately 22 m thick; the total waste rock depth is 50 m. Eleven monitoring wells, including seven monitoring well nests, were drilled into the saturated portion of the backfill and surrounding waste rock to characterize upgradient groundwater, as well as the water quality of water as it progressed through the saturated backfill.

From November 2011 to March 2013, hourly data was collected from selected wells using Solinst Leveloggers® and HOBO® conductivity loggers. Three sampling events were completed to capture low, high, and base flow water levels through the saturated backfill. However, only the second and third sampling events were discussed as part of the study, due to the presence of artifacts from drilling in the first round of sampling. These sampling events capture the high flow (2012) and base flow (2013) conditions. The horizontal flux through the pit was based on and estimated porosity range (25% to 40%), and a hydraulic conductivity between 10^{-4} and 10^{-5} ms^{-1}. Separate scenarios were considered for winter (low flow) and freshet (high flow). These results are summarized in the table, below.

Table 5.5-5 Flux and Residence Time Values[1]

	Winter	Freshet
Horizontal Flux (m^3day^{-1})	43 - 430	80 – 800
Hydraulic Residence Time (y)	0.5 - 3	0.3 - 2

[1] Adapted from Bianchin *et al.*, 2013

Porewater samples were collected and analysed for bulk chemistry, anions, dissolved metals, selenium speciation, and microbial analysis.

Analysis of total selenium, as well as selenite (Se^{IV}) and selenate (Se^{VI}), was completed to monitor selenium removal through the saturated backfill. The highest concentrations of total selenium were observed upgradient of the saturated backfilled pit, while the lowest concentrations were in the peripheral bedrock (Bianchin *et al.*, 2013). Upgradient of the

saturated backfilled pit, the dominant species of selenium is Se^{VI}, while in-pit and in the peripheral bedrock, it is Se^{IV}. Bianchin *et al*. (2013) noted that the total selenium concentration in the in-pit saturated water is less than 1% that observed upgradient, suggesting that up to 99% of the selenium is being attenuated. The process through which this is happening (*i.e.,* adsorption of Se^{IV}, precipitation of Se^{0}, or precipitation of selenides) is not evident from this study; however, prevalence of elevated sulphate concentrations in the saturated backfill preclude dilution as the mechanism for reduction in the selenium concentration in-pit.

Interpretation of Figure 4 indicates that there is little seasonal variability in the effectiveness of the saturated backfill at removing selenium. Upgradient locations in-pit show up to one order of magnitude of variation; however, the downgradient wells in-pit are within one order of magnitude for spring and winter conditions. Removal rates were calculated by Bianchin *et al*. (2013) for both high and low flow, with waste rock porosity variations, summarized below.

Table 5.5-6 Summary of Selenium Removal Rates[1]

	Winter	Freshet
Se Removal (mg/day/m^3)	0.03 – 0.17	0.03 – 0.33

[1] Adapted from Bianchin *et al.*, 2013

Saturated Backfill Zone – Example B - Northern Canada

Martin *et al.* (2015) evaluated the potential use of flooded open pits from historic mine sites as bioremediation cells for selenium. The objectives of the study were to:

- describe the physical and chemical limnological setting of the flooded pit;
- delineate the biogeochemical processes governing the behaviour of selenium and other mine-related parameters; and
- discuss potential applications of flooded pits for selenium bioremediation through passive and engineered methods.

The study site is a former open pit, described as being in "northern Canada", which was partially backfilled with spoil prior to the onset of passive flooding from 1998 – 2002. In 2013, *in-situ* profiling of conductivity, temperature, pH, dissolved oxygen, and fluorescence was collected at 20 cm resolution in the deepest portion of the pit (Martin *et al.*, 2015). Water quality samples were collected at depths ranging from 1 m to 60 m, and analysed for physical parameters, anions, nutrients, and dissolved or trace elements.

Pronounced stratification was observed in the water column between 3 m and 6 m. The thermocline over this interval occurred concomitantly with increases in specific conductance and water density. According to Martin *et al*. (2015), the amount of dissolved oxygen in the water

column decreased from 12 mg/L at 5 m (within the thermocline) to undetectable concentrations at depths greater than 22 m; representing a shift to anoxic conditions within the water column. Based on this information, with a lack of smear zone to indicate recent mixing, Martin *et al.* (2015) determined that the water column was likely permanently stratified. Anoxic conditions are reinforced by evidence of denitrification, increased ammonia concentrations, and elevated concentrations of dissolved manganese (Martin *et al.*, 2015).

Vertical profiles of selenium (both total and dissolved) appear to follow the redox gradient, with concentrations varying from > 15 ug/L near surface to < 3 ug/L at depths greater than 20 m. Martin *et al.* (2015) relate the decrease in selenium below the oxic-suboxic boundary to the variation in redox conditions with depth. Reduction of selenate (Se^{VI}) to selenite (Se^{IV}) and elemental selenium (Se^{0}) allows for adsorption to other particles or precipitation (Martin *et al.*, 2015). It is significant that selenium reduction is taking place to the extent observed in the presence of nitrate, which results in the waste rock both naturally and as a residual of blasting using ammonia nitrate fuel oil (ANFO).

Given the observed groundwater chemistry and the study site configuration, the approximate volume of water in which the concentration of selenium was reduced to below 3 ug/L is 1M m^3 (Martin *et al.*, 2015).

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c) Identify which of the above measures described in b) xvii are technically and economically feasible and provide details on how they could be incorporated in the design, construction and operation of the proposed systems for the Project, including details on time required to construct and implement measures, and feasibility of scaling up for any measures identified as pilots.

Response:

As stated in AER-R1-86 (CEAR #69) Benga has proposed a very conservative selenium attenuation system as part of the mine plan that consists of a saturated backfill zone(s) in the mine pit based on well understood biological and chemical processes that are considered to be technically and economically feasible. To ensure adequate residence time for the saturated backfill zones, Benga has allowed for residence times of up to one year or more than 50 times the theoretically required residence time. Implicit in the design proposed by Benga is the capture of substantially all water that is in contact with waste rock and therefore subject to selenium

enrichment. This factor alone is a major advantage in the treatment of selenium over older mines where the capture of selenium enriched water was not built into the original mine plan.

The saturated zones will be engineered and actively managed to understand and control the attenuation process and achieve the desired results. Technical and economic mitigation measures to actively manage the SBZ are being incorporated into the mine plan to allow for the provision to inject a carbon source, (*e.g.,* methanol; JRP IR-5.13), and to create and control the necessary anoxic conditions that drive attenuation. Multiple sample points will be monitored to measure oxygen content, selenium and nitrate concentrations and possibly the background biological activity. Multiple dewatering points and dewatering elevations will be possible to optimize flow through the zone.

Should the performance of the saturated zone not provide the anticipated results in terms of effluent selenium concentrations, the first action to be taken would be to use the information derived from the extensive data available to better understand the root cause of the issue. Adjustments to retention time, water recirculation, carbon additions, withdrawal points and other variables would be made to resolve the issue and achieve the necessary selenium concentrations.

In terms of other contingency plans, there are a number of options that would be considered including:

- Additional measures to minimize the quantity of water that comes in contact with waste rock through redesign and partial covering of the waste rock dumps;
- Addition of secondary gravel bed treatment systems similar to those that have been installed in other coal mines;
- Installation of secondary RO or nano-filtration systems for a portion of the effluent stream; and
- Installation of a separate water treatment plant for selenium.

As stated in AER-R1-86 (CEAR #69) if the conclusion after analysis is to install a water treatment plant to remove selenium (which is deemed to be technically and economically feasible), the original conservative timeline to design, procure, construct, and commission, would take 3 years.

d) Provide a copy of the most recent Elk Valley Water Quality Plan produced by Teck Resources.

Response:

The following resources regarding Teck Resources Elk Valley Water Quality Plan are available in Appendix 5.5-2:

- Elk Valley Water Quality Plan – 2019 Implementation Plan Adjustment - Summary
- Elk Valley Water Quality Plan – Summer 2017 Update
- Elk Valley Water Quality Plan

5.6 Information Request 5.6

Fifth Addendum to the Environmental Impact Assessment. AER-R1-86. (CEAR #69).

Eighth Addendum to the Environmental Impact Assessment. AER-R2-11. (CEAR #89).

Comments from the Livingstone Landowners Group to the Joint Review Panel. (CEAR #160).

Comments from the Government of Canada - Environment and Climate Change Canada submission. (CEAR #167).

Comments from Sierra Dakin Kuiper. (CEAR #170).

Comments from the Canadian Parks and Wilderness Society Southern Alberta. (CEAR #176).

In the response to AER-R2-11 in Addendum 8 (CEAR #89) that requested Benga confirm whether a selenium treatment plant would be incorporated within the metals treatment plant, or would require a separate plant, Benga indicated that they do not anticipate being required to treat selenium separately within the metals treatment plant. Further, Benga indicated in the response that an active water treatment plant facility is considered to be a contingency measure only. The purpose of information request AER-R2-11 regarding the selenium treatment process and location was to obtain information for consideration should there be need to implement this contingency measure. Several participants expressed concern with a lack of information and clarity regarding contingency measures to treat selenium (CEAR #160, #170, #176), including Environment and Climate Change Canada (CEAR #167).

In the response to AER-R1-86 in Addendum 5 (CEAR #69), the Alberta Energy Regulator requested information on how water with selenium concentrations that did not meet targets would be handled while further treatment facilities were being developed. In response to this request, Benga indicated that a secondary treatment system employing gravel beds could be installed if selenium levels did not meet guidelines while a full treatment plant was being constructed. However, Benga did not provide further details on the secondary gravel bed system. Given the uncertainties with the effectiveness of the full

scale saturated backfill zone for treating selenium and the potential implications for cost and complexity of the proposed Project, additional details on contingency treatment of selenium are needed.

a) In a situation where the saturated backfill zones fail to reduce selenium to levels required to meet regulatory limits, confirm whether additional selenium removal would occur within the proposed metals treatment process, or whether a separate treatment process would be constructed. In addition:

If selenium removal is to occur as part of the metals treatment process:

i. provide case studies of treatment plants that remove dissolved metals and selenium from mine water and demonstrate that their operating conditions are comparable and relevant to those expected at Grassy Mountain.

Response:

In the event that selenium concentrations in water pumped from a saturated backfill do not meet regulatory compliance limits, Benga is not proposing to remove selenium as part of a metals treatment process. The removal of selenium would occur through a separate process.

If selenium removal is to occur as a separate treatment process step:

ii. provide case studies of treatment plants and/or treatment approaches that remove selenium from mine water and demonstrate that their operating conditions are comparable and relevant to those expected at Grassy Mountain.

Response:

Several treatment technologies are available to remove selenium from mine wastewater, including physical, chemical and biological treatment options. Physical treatment technologies include reverse osmosis and ion-exchange processes. Chemical methods for selenium removal include zinc or iron reduction, or iron precipitation (Khamkhash *et al*., 2017; Sobolewski, 2005).

Biological treatment options are considered superior to physical-chemical processes based on optimal efficacy, costs and other factors (*e.g.,* effectiveness in cold climates). In brief, biological treatment systems use microorganisms to catalyze the reduction of selenium Se to selenate (Se^{VI}), followed by selenite (Se^{IV}), and finally to elemental selenium (Se^{0}) and selenide (Se^{II}). The reduced forms of selenium (elemental selenium and selenide) are virtually insoluble and can therefore be removed from the wastewater using conventional separation and disposal techniques, ultimately reducing the concentration of selenium to very low levels in wastewater (Environgen, 2011; Sobolewski, 2005).

Previous research identified *in-situ* and biological treatment plants as the most suitable technology for selenium treatment at coal mines in Alberta. Suitability was based on removing selenium to acceptable concentrations cost-effectively, given the challenging climate conditions (*i.e.,* cold winters) (Sobolewski, 2005).

Biological processes are currently being used by Teck Resources Ltd. (Teck) in the Elk River watershed to address selenium and nitrate concentrations in mine effluent. The coal-bearing formation in the Elk Valley is geologically similar to that at Grassy Mountain, making the work being completed at Teck most relevant to that proposed by Benga.

As part of the 2014 Elk Valley Water Quality Plan, Teck commissioned an Active Water Treatment Facility (AWTF) at Line Creek Operations (Teck, 2013). The AWTF uses a fluidized bed reactor (FBR), which has been shown to efficiently reduce selenium concentrations to below 20 ug/L based on a capacity of 7,500 m^3/day for influent at West Line Creek, where influent concentrations of selenium are in excess of 100 ug/L (Teck, 2013). Following two years of operation (2016 – 2018), an advanced oxidation process (AOP) system was added to address elevated concentrations of selenite in the discharge water. Addition of the AOP resulted in the oxidation of selenite and other reduced and organo-selenium species, which are the most readily bioavailable species of selenium, to selenate (Minnow Environmental, 2018). However, as mentioned previously, selenate is still readily bioavailable. Ongoing monitoring downstream of the AWTF is required. Exceedances of selenium and nitrate water quality targets (compliance and site performance objectives) are only anticipated with respect to seasonal conditions, such as high flow associated with spring freshet (Teck, 2013).

iii. confirm if separate treatment would be incorporated within existing infrastructure anticipated for the metals treatment plant, or if a separate treatment plant for selenium would need to be constructed. Provide an updated site map indicating the location of a selenium treatment plant or any expansions required to the metals treatment plant to incorporate selenium removal.

Response:

Benga has allocated space in the plant area for a metals treatment plant if required to treat water after the SBZ. Infrastructure for selenium removal is not planned to be incorporated into the metals treatment plant. If required, a selenium treatment facility will be added to the metals treatment facility as an expansion.

b) For both the metals treatment process and the selenium treatment process, provide the following details:

i. the type of treatment processes to be employed (for metals and selenium);

Response:

As indicated above, a Fluidized Bed Reactor is the likely choice for a contingency water treatment option for selenium, given the success in B.C. at the Teck Line Creek AWTF. A standard high-density sludge (HDS) lime treatment process would be used for removal of dissolved metals.

ii. the expected effectiveness of the treatment process (i.e. the treatment efficacy to reduce selenium levels and metals levels by a certain percentage). The effectiveness should be supported by case studies and/or technical data from historical or existing operations;

Response:

Please refer to previous response in JRP IR-5.5.

iii. discussion of advances of the technology for selenium removal, including information on existing operating treatment facilities, their performance and relevance or applicability to this project;

Response:

As discussed above and in JRP IR-5.5, there are numerous case studies highlighting the effectiveness of selenium removal from mining waste water using saturated backfill zones and fluidized bed reactors. While some of these case studies represent lab-scale applications, Teck has effectively implemented both a water treatment facility and *in situ* suboxic biological treatment in the Elk Valley at two different sites. Benga considers its proposed SBZ, which is directly comparable to the Teck *in situ* treatment facility, to be the best available technology for treatment of selenium for the Project.

iv. any required process aids, treatment chemicals, additives and substances that are used in the processes and how these would be managed, stored, how secondary containment issues would be addressed and how any vapours and potential odour issues would be managed;

Response:

To facilitate ongoing reduction of selenium in an SBZ, a carbon source (*i.e.,* methanol) will be added as a process to provide readily available electron acceptors to the reaction. The carbon source will be injected at points throughout the SBZ, which will be finalized during detailed design. Information regarding the storage, handling and secondary containment of the carbon source is provided in JRP IR-5.13.

If biofouling or mineral fouling occurs, addition of an acid such as glycolic acid to destabilize biofilms may be required. In addition, Teck indicated that phosphate was a required additive at the Line Creek Operation. Storage and management of any acid or phosphate required based on operating experience will be consistent with the handling practices for other hazardous materials, as outlined in JRP IR-5.13.

v. waste streams, waste products and waste residuals (i.e. sludge) and how these wastes will be handled and information on how the metal and selenium precipitates are immobilized and stabilized;

Response:

Residuals from selenium treatment at the WLC AWTF reportedly contain large volumes of water and biomass. Teck's plan for disposal of the residual is dewatering to a solids content of 20% (Teck, 2013), and subsequent storage of the residual in lined containment cells to be capped and covered for long-term storage. Various technologies are available to facilitate separation, such as ballasted sand clarifiers, membrane filters and sand filters (CH2M Hill, 2013).

Selenium removed by the SBZ becomes permanently lodged within the rockfill. As conditions within the backfilled zone remain anoxic, the selenium will remain in a stable form, much the same way selenium contained in waste rock is stable until it becomes exposed to ambient air. The backfilled zone can be kept anoxic in perpetuity simply by ensuring that the water cover is maintained.

vi. discharge temperature of effluent streams discharged to receiving waters and measures that will be implemented to mitigate environmental effects associated with the discharge of higher temperature effluent;

Response:

Biological treatment systems rely on the activity of bacteria to reduce selenium. A successful treatment system that supports optimum biological activity relies on various parameters being tightly controlled, such as temperature (Sobolewski, 2005). However, this restriction is likely limited to laboratory scale experiments. Bianchin *et al*. (2013) conducted a study of saturated backfill in the Rocky Mountains of British Columbia and observed little difference in temperature between upgradient pit water and water in the saturated backfill. A temperature increase of less than 2°C was reported between the monitoring wells in the saturated backfill, moving downgradient. Schabert (2016) reported an *in-situ* temperature of 4.7°C during testing completed at the saturated backfill zone at Henretta Creek on Teck's Fording River Operations.

Monitoring programs can be implemented to monitor for and mitigate effects related to the operation of the AWTFs. Temperature is evaluated at Teck post-AWTF as part of their local monitoring program. Results from the 2016 local monitoring program indicated that, with respect to fish, the AWTF operation has not adversely affected water temperatures in Line Creek (immediately downstream of the AWTF) (Minnow, 2018).

vii. anticipated dissolved oxygen content in the effluent streams and mitigation measures will be implemented to mitigate environmental effects in the receiving environment;

Response:

As mentioned above, monitoring programs have been used to monitor for effects related to the operation of the AWTFs and to mitigate environmental effects, including changes in dissolved oxygen content. Results from Teck's 2016 local monitoring program indicated that Line Creek has reportedly remained well oxygenated with dissolved oxygen concentrations greater than applied guidelines for the protection of fish (Minnow, 2018). As indicated in JRP IR-5.21, Benga has proposed infrastructure to aerate water being discharged from the SBZ. Furthermore, there will be no direct discharge to downstream receiving water bodies prior to testing for parameters such as dissolved oxygen.

c) Discuss what processing equipment would remain at the site after mine closure to address legacy water treatment including:

i. metals treatment plant;

ii. selenium treatment plant;

iii. forecast of how long the plant(s) would need to be in operation;

iv. forecast of capital, operating and reclamation expenditures for the treatment plants for the expected duration of their operation.

Response:

As part of the Project's Water Management Plan, the development of a metals treatment plant would be determined through operational monitoring. Related, through continued research and development, implementation, monitoring, and adaptive management, it is unknown if or when a selenium treatment plan would be required for the Project. For either case, in the event one or both facilities are required, they would likely both be in place for a period of time during Closure, and then phased out and decommissioned as water treatment requirements allow. Based on the uncertainty of what treatment plants may be needed, and for what particular parameters, it is difficult to estimate capital and operating costs; however, JRP IR-5.33 b) speaks to the specifics of reclamation as such pertinent information is summarized here as well.

Sediment ponds, surge ponds, and saturated backfill areas will have to be managed until the TSS levels are similar to background (settling ponds), or selenium levels are within guidelines (surge ponds and SBZs). Then the facilities can be removed, reclaimed and stabilized.

It is expected that it may take many decades following EOM before selenium levels are within guidelines. During this period, both the pumping system and saturated backfill system will need to be maintained. The total cost is expected to be approximately $20 million for 25 years or less than $1 million per year. Note that this cost includes care and custody of the settlement ponds

but does not include the decommissioning of a selenium treatment plant, as the commissioning of a plant is not a confirmed expenditure for the project.

If metal treatment of the effluent is required, the metal treatment plant must be maintained and operated on-site until it is no longer required. The removal of the metals treatment plant (when it is no longer required) is expected to be captured within the decommissioning portion of the budget, the total of which is $1.72M.

d) Provide information and design details that indicate how temporary gravel beds will effectively remove selenium. Provide case studies and supporting data for such systems operating under similar climactic conditions, at a scale and for a duration (up to four years) that are applicable to the Project.

Response:

Gravel bed bioreactors (GBRs) have been used for the successful removal of selenium from surface water and groundwater at multiple sites in North America. In brief, GBRs are biologically based systems that use semi-passive water treatment technology. A GBR consists of an engineered gravel bed through which mining wastewater is passed and treated. Similarly, to other biological technologies discussed above, GBRs contain microorganisms capable of catalyzing the reduction of selenium. The microbial community form a fixed, stable biofilm on the gravel bed which allows for efficient removal of excess biological solids and immobilized contaminants (Mancini *et al*., 2019). Reduced forms of selenium (*e.g.,* selenide and elemental selenium) are then sorbed onto the gravel bed, precipitated or incorporated into the biomass within the GBR. GBRs also include engineered design components, including regulation of the oxidation / reduction potential within the bioreactor by controlling the dose rates of the electron donors (*e.g.,* organic carbon) in the influent water.

Recent publications (Mancini *et al*., 2019; Heffernan, 2019) provide information relevant to the project plan for implementation of temporary gravel beds in the event that a full-scale selenium treatment plant is required. A GBR was used to effectively reduce selenium concentrations in surface water to less than 5 µg/L over an operating period of nearly eight years, to meet the requirements of the Irvine Ranch Water District's Nitrogen and Selenium Management Program. Sodium benzoate, which is naturally present in fruits and vegetables, was used as the electron donor. Treatment flows in the GBR varied between 890 to 1,500 m3/day, with temperatures as low as 12°C.

A similar GBR was also constructed to treat selenium in seeps and surface water at a coal mine in West Virginia. The GBR successfully reduced selenium concentrations to less than 5 µg/L over an operating period of about one year, with water temperatures as low as 13°C (Mancini *et al*. 2019) using citric acid as the electron donor.

In 2008, two bioreactors were trialed at the Smoky River Coal mine in Alberta to treat selenium drainage. The bioreactors (5 m3 in size) used ethylene glycol as an electron donor and were filled with a mix of crushed gravel, wood chip, manure, lime, and bone meal. The bioreactors reportedly removed reduced selenium concentrations from 80-90 µg/L to 1-5 µg/L. The bioreactors were tested during the summer and winter months, and treatment performance was not noticeably impacted by a decrease in temperature during the winter months (minimum temperature of 2°C) (Sobolewski, 2010).

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5.7 Information Request 5.7

Eighth Addendum to the Environmental Impact Assessment. Appendix C-3. (CEAR #89).

In Appendix C-3 in Addendum 8 (CEAR #89), Benga used a number of regression models based on toxicity literature and concentrations-response data to derive predicted Westslope Cutthroat Trout (WSCT) egg selenium concentrations of 11.0 to 20.1 µg/g dw, below the egg selenium EC10[2] value of 24.8 µg/g dw derived for WSCT by Golder at Elk Valley. In addition to inherent uncertainties in predictive models, Benga notes a number of uncertainties in Section 4.5 in Appendix C-3. The Golder- derived selenium benchmarks use a combination of both literature data and field data from the Elk Valley, however there are substantially fewer site-specific field data for Grassy Mountain. When site- specific data is limited, uncertainty factors (UFs) are applied to guidelines to address

2 The EC10 is the sublethal concentration causing a 10% reduction in growth.

these limitations and ensure protection of the receptor. This is the case with the Alberta selenium egg/ovary tissue guidelines (11 µg/g dw with an UF of 2 applied).

The proposed site-specific water quality guideline of 10.6 µg/L is dependent upon elevated sulphate concentrations (predicted to be 529 mg/L), as are modeled concentrations for selenium uptake in periphyton (and hence WSCT tissues). In the absence of increases in sulphate concentration or presence of selenium species for which sulphate does not provide an ameliorating effect, selenium concentrations in periphyton, benthic macroinvertebrate, and WSCT tissues would be expected to be higher.

a) Given the identified uncertainties in the models and assumptions used, provide calculated probabilities for measured WSCT egg selenium concentrations within the predicted range of concentrations (11.0 to 20.1 µg/g dw).

b) Provide justification for not applying an uncertainty factor to the Golder-derived benchmarks for selenium at Elk Valley, given that Elk Valley site conditions may not be applicable to site-specific conditions at Blairmore Creek.

Response to a) and b) combined:

This IR is seeking more information on uncertainties in the selenium bioaccumulation model and how those uncertainties may affect the range of selenium predictions for westslope cutthroat trout (WSCT) eggs. Additionally, since some Elk Valley data were incorporated into the Blairmore Creek model, the IR is wondering why an uncertainty factor of 2 was not applied to the site-specific water selenium guideline that was derived.

To predict WSCT egg selenium concentrations based on future conditions, it was necessary to combine site-specific and non-site-specific information into the three-step selenium bioaccumulation model (water→periphyton→macroinvertebrates→WSCT eggs).

- **Water→Periphyton:**

  Most of the site-to-site variability in selenium bioaccumulation occurs at the base of the food web, *i.e.,* water to algae. In selenate-dominated streams, one important source of site-to-site variability is the waterborne sulphate concentration. Accordingly, to reduce uncertainty in modelling selenium bioaccumulation by algae, a site-specific study, in which Blairmore Creek water was amended with a series of selenate and sulphate concentrations, was used to characterize how selenium concentrations in algae respond to varying combinations of selenate and sulphate. This selenate-sulphate relationship was then calibrated to the mean site-specific baseline selenium concentration in periphyton (5.3 mg/kg dw).

  The mean periphyton selenium concentration of 5.3 mg/kg dw is greater than the mean baseline periphyton selenium concentration in Elk Valley. For example, in the water-to-periphyton model used to develop site-specific selenium benchmarks, the expected periphyton selenium concentration was <2 mg/kg dw at water selenium concentrations

ranging up to 10 µg/L. Thus, the selenate-sulphate model was calibrated to a higher baseline periphyton selenium concentration then in the Elk Valley modelling. In addition, the water-to-periphyton selenium model for Elk Valley was a two-piece model where periphyton selenium concentrations did not substantially respond to waterborne selenium until a concentration of 10 µg/L was reached. This pattern is not unusual, as lower selenium concentrations may be regulated by aquatic biota. In the Blairmore Creek model, however, it was conservatively assumed that selenium concentrations in periphyton would immediately increase with increasing water selenium concentrations (*i.e.,* as soon as they begin to exceed the baseline concentration of 0.78 µg/L).

- **Periphyton→Macroinvertebrates:**

The ratio between selenium concentrations in macroinvertebrates to their food (*i.e.,* trophic transfer factors, or TTFs) typically ranges from about <1 to about 3 (Presser and Luoma 2010). For Blairmore Creek, a mean periphyton-to-macroinvertebrate TTF of 0.5 can be estimated based on baseline data. These baseline data were not co-located, but the TTF provides an indication of trophic transfer potential in the Blairmore Creek system.

In developing the model to derive the site-specific selenium guideline, it was desirable to use regression relationships for each step of the food web because TTFs are usually not constant over a range of exposure concentrations (DeForest *et al*. 2007). Consequently, regression models from other efforts were used. Because of uncertainty about which would be more applicable to Blairmore Creek, two independently derived models were used for comparison. One was the Elk Valley model described in Golder (2014) and the second was a model described in DeForest *et al*. (2017), which included data from Elk Valley but also a wide variety of other sites in Canada and the United States.

These two regression models resulted in predicted macroinvertebrate selenium concentrations that resulted in TTFs that were higher than those based on the baseline data and within the range of typical TTFs reported in Presser and Luoma (2010). For example, selenium TTFs of about 1.3 and 1.9 were calculated based on the models from DeForest *et al*. (2017) and Golder (2014), respectively. This indicates that the periphyton-to-macroinvertebrate models are providing reasonable prediction of macroinvertebrate selenium concentrations in Blairmore Creek.

- **Macroinvertebrates →WSCT Eggs:**

The third step of the model is the trophic transfer of selenium from macroinvertebrates to WSCT eggs. The ratio between selenium concentrations in whole-body fish tissue and fish diet usually averages about 1.1 (Presser and Luoma 2010). The ratio between selenium concentrations in fish eggs and whole-body tissue can vary widely, but, on

average, egg selenium concentrations are often about two-times whole-body concentrations (USEPA 2016). For WSCT, based on 88 co-located egg and invertebrate (dietborne) selenium concentrations, the median and arithmetic mean TTFs were 2.2 and 2.5, respectively—this is consistent with the patterns observed for most fish species.

- **Summary of Conservatism in Model**

  Overall, the bioaccumulation model used to develop the site-specific selenium guideline balanced the use of site-specific data and conservative assumptions where necessary. For example, the selenate-sulphate model was calibrated to the mean baseline periphyton selenium concentration in Blairmore Creek (5.3 mg/kg dw at a baseline water selenium concentration of 0.78 µg/L), which was more than two-fold greater than predicted periphyton selenium concentrations in Elk Valley at water selenium concentrations up to 10 µg/L. Further, it was assumed that periphyton selenium concentrations would immediately begin to increase with increasing water selenium concentrations above baseline, although the periphyton selenium concentrations typically respond slowly to increasing water selenium concentrations until a threshold concentration in water is reached (in Elk Valley, this threshold was about 10 µg/L [Golder 2014]). For the remaining steps of the bioaccumulation model (*i.e.,* from periphyton to macroinvertebrates and from macroinvertebrates to WSCT eggs), the TTFs were consistent with typical values reported in the literature.

- **Response to IRs**

  In response to IR (a), we cannot provide calculated probabilities of measured WSCT egg selenium concentrations between the predicted range of 11.0 to 20.1 mg/kg dw, as this range was derived based on consideration of two separate periphyton-to-macroinvertebrate selenium models. However, the 95% confidence interval was developed for the water-to-periphyton model step, which was bounded by predicted periphyton concentrations of 3.7 to 6.8 mg/kg dw for Blairmore Creek. Using the upper confidence limit of 6.8 mg/kg resulted in a mean predicted macroinvertebrate selenium concentration of 10.9 mg/kg dw using the more conservative Golder (2014) periphyton-to-macroinvertebrate model, which in turn would result in a mean WSCT egg selenium concentration of 22.5 mg/kg dw. This reasonable worst-case WSCT egg selenium concentration, which is based on the upper confidence limit of the water-to-periphyton model is associated with a 4% effect level in WSCT larvae, which is within the 10% effect concentration (EC10) typically considered for guideline derivation.

  In response to IR (b), the request is confusing as written because it refers to application of an uncertainty factor to Golder-derived benchmarks for Elk Valley. Elk Valley benchmarks were not recommended for Blairmore Creek.

Ultimately, use of an uncertainty factor is a policy decision, not a scientific decision. However, given the incorporation of site-specific data and conservatism in the selenium bioaccumulation model, an uncertainty factor is not warranted for the recommended site-specific guideline. Further, inclusion of multiple conservative assumptions in the multi-step bioaccumulation model can result in compounding conservatism that starts to become unrealistic and unnecessarily conservative for a naturally occurring element such as selenium. In developed water selenium screening guidelines, DeForest *et al*. (2017), for example, considered 75th quantile regression models for each step of a three-step bioaccumulation model, as use of a more conservative quantile at each step, such as the 90th quantile, resulted in back-calculated water selenium concentrations that would fall within background concentrations. In developing its water selenium criteria, the USEPA similarly selected a 75th percentile rather than a 95th percentile, for example, as that would have resulted in unreasonably low water selenium criteria (USEPA 2016). Application of an arbitrary uncertainty factor to a model based on conservative assumptions would only exacerbate this issue.

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5.8 Information Request 5.8

Environment and Climate Change Canada. (November 2017). Proposed Approach for Coal Mining Effluent Regulations. Consultation Document.[3]

Draft federal Coal Mining Effluent Regulations have proposed a maximum mean-monthly aqueous selenium limit of 10 µg/L or 5 µg/L depending on whether the mine is considered existing or new. For the Grassy Mountain Coal Mine, the limit applied will depend on the timing of start-up of mine operations and publication of the new federal regulations in the Canada Gazette, Part II. While the exact timing for both the mine operations and publication of new federal regulations remain unknown, given that the Project is a new site and the 10 µg/L limit is intended to recognize challenges faced by mines with pre-existing elevated selenium concentrations, which is not the case at Grassy Mountain, there is reasonable likelihood that the Project would face a 5 µg/L limit under the proposed regulation.

a) Provide the estimated selenium concentrations at discharge points (before mixing) to Blairmore Creek over the project life.

Response:

The maximum predicted concentration of selenium in water based on the water and load balance model for the Project is 1.2 mg/l in the SE Surge Pond, 0.6 mg/l in the NW Surge Pond and 0.7 mg/l in the Raw Water Pond (Figure 7-14, Appendix 10b, EIA, CEAR #42). For purposes of the environmental impact assessment , to assure a conservative approach was taken, Benga assumed a Project maximum concentration of 1.5 mg/l and a 99% attenuation rate in the SBZ to arrive at a maximum selenium concentration at discharge points, before mixing of 0.015 mg/l (15 ug/L) of selenium (Section 2.5.1, Appendix 10b, EIA, CEAR #42).

Based on this conservative assumption, concentrations of selenium at point BC03 in Blairmore Creek, which is the most downstream discharge point, are below current provincially accepted concentrations (2 ug/L) within the first 10 to 15 years of mine operations with an increase near 5 ug/L closer to year 20 of mine operations. Current model predications indicate a range of 5 ug/L to < 7 ug/L at closure.

As discussed CR#5, Appendix A1, CEAR #42; AER-R1-108, CEAR #69; AER-R2-22, Appendix C-3, CEAR #89; JRP IR-5.1) Benga has demonstrated that even this very conservative assumption of selenium concentrations is not expected to have a significant impact to aquatic life, including westslope cutthroat trout, based on the specific conditions and chemistry expected in Blairmore Creek after Project implementation.

3 The Proposed Approach for Coal Mining Effluent Regulations Consultation Document is publically available from: http://www.coal.ca/wp-content/uploads/2017/12/Proposed-Approach-for-Coal-Mining-Effluent-Regulations-November-2017.pdf

As discussed in JRP IR-5.5, based on more recent experience with SBZs and Gravel Bed Reactors, and based on preliminary results from the Column Testing being conducted by Benga, an attenuation rate of 20 ug/l /day can be expected in the SBZ. Using this attenuation rate and starting with the estimated maximum of 1200 ug/l modelled for the SE Surge Pond, near complete attenuation of selenium could be expected with a retention time of 60 days. Since the retention time predicted for the Project is in the order of one year or more, Benga expects that under ideal conditions, near complete removal of selenium may be possible. This coincides with initial results encountered by Teck with their full scale SBZ trial at their Elk Valley mine. These data need further support based on full scale field trials and operational experience to confirmed.

In summary, Benga has assumed concentration of selenium in the treated effluent up to a maximum of 15 µg/L, which was thought to be a reasonable conservative value for modelling purposes. Benga has further demonstrated that at this conservative selenium concentration, no significant adverse effect is expected to the aquatic environment of Blairmore Creek. Finally, Benga has shown that recent testing indicates a much better result may be attainable with the SBZ approach but that additional testing is required to prove the reliability of this data.

b) Indicate whether a potential limit of 5 µg/L for aqueous selenium concentrations at the point of discharge (before mixing) is achievable using the proposed treatment technology, assuming the proposed federal Coal Mining Effluent Regulations come into force in the future.

Response:

The Government of Canada (GOC) have indicated that the draft federal Coal Mining Effluent Regulations considered achievability when the proposed limits on selenium in effluent were defined; however, the GOC have not published any documentation illustrating how the proposed regulations are achievable at an industry level. The Coal Association of Canada (CAC) and other leading proponents within the Canadian coal industry have expressed concerns to the GOC regarding challenges associated with meeting the proposed Coal Mining Effluent Regulations through the associated public comment periods. Benga will strive to consistently achieve a selenium concentration that does not have a negative impact to downstream receiving aquatic environment. As discussed above, Benga considers that the limit of 5 ug/L may be achievable but that further research and operational experience are required to demonstrate this level of performance.

5.9 Information Request 5.9

Canadian Environmental Assessment Agency Interim Technical Guidance "Assessing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act, 2012*". (March 2018).

Eighth Addendum to the Environmental Impact Assessment. AER-R2-23, Appendix C-3. (CEAR #89).

Grassy Mountain Coal Project - Updated Environmental Impact Assessment. Consultant Report #5 – Water Quality. (CEAR #42).

Ministry of Environment, Province of British Columbia. April 2013. Ambient Water Quality Guidelines for Sulphate Technical Appendix Update. Prepared by C. Meays and R. Nordin, Water Protection and Sustainability Branch, Environmental Sustainability and Strategic Policy Division, BC Ministry of Environment. 55pp.

In Appendix C-3 in Addendum 8 (CEAR #89), Benga provided additional data supporting the use of a site- specific derived sulphate guideline based on increased hardness. Additional evidence provided included a species sensitivity distribution (SSD) curve for sulphate at 100 mg/L hardness based on EC20s[4], EC25s or no-observed-effect-concentrations (NOECs) which indicate a HC5[5] of 593 mg/L, and results for sulphate toxicity tests on three organisms in varying hardness water at Elk Valley indicating ameliorating effects of hardness on sulphate toxicity up to 485 mg/L hardness. This differs from the established B.C. sulphate guideline technical appendix (used by Alberta) which suggests potential osmotic stress effects at hardness >250 mg/L[5].

Furthermore, in the response to information request AER-R2-23 in Addendum 8 (CEAR #89), Benga indicated aeration and possible chemical treatment would be used on water prior to discharge to Blairmore Creek to address potential calcite deposition issues. Lowering hardness through this process could result in a potential reduction in calcium carbonate concentrations within Blairmore Creek. In turn, this may result in a reduction of the site-specific derived sulphate guideline which relies in part on the ameliorating effects of elevated calcium carbonate concentrations.

The interactions between sulphate, hardness and calcite discussed above illustrate the complexity and potential uncertainty associated with the assessment of effects of multiple stressors. Complexity is increased further because sulphate and hardness affect the toxicity of selenium and other trace elements such as cadmium, cobalt and zinc (see rationale for IR 5.10). In addition, Consultant Report #5 (CEAR #42) reported that baseline concentrations of several trace elements were above guidelines in water and/or sediment of Blairmore Creek. Thus, consideration of sulphate toxicity should not be in isolation, but should include the cumulative effects of multiple stressors such as selenium

4 The EC20 and EC25 is the sublethal concentration causing 20% or 25% reduction in growth.
5 The HC5 is the concentration at which five percent of the species in the species sensitivity distribution exhibit an effect.
[5] The Ministry of Environment Province of British Columbia Ambient Water Quality Guidelines for Sulphate – Technical Appendix is publically available from https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/wqgs-wqos/approved-wqgs/bc_moe_wqg_sulphate.pdf.

and other trace elements predicted to be present in Blairmore Creek as a result of the combination of baseline concentrations, the Project, past and current projects and other activities.

a) Provide publication references for each of the 11 species used to derive the SSD in Figure 11 in Appendix C-3 in Addendum 8.

Response:

Table 5.9-1 outlines the sulphate toxicity studies used to develop species sensitivities distribution.

Table 5.9-1 Sulphate toxicity studies used to develop species sensitivity distribution.

Species	Common Name	Duration	Effect	Mean Hardness (mg/L)	EC20/25s (as available)			Reference
					Endpoint	Sulphate Toxicity Value (mg SO_4/L)	Species Mean Toxicity Value (mg SO_4/L)	
Elliptio complanata	Mussel	28-d	survival	250	LC20	>2030	>2030	Meays and Nordin 2013
Hyalella azteca	Amphipod	28-d	growth	100	EC25	1030	1058	Meays and Nordin 2013
Hyalella azteca	Amphipod	28-d	growth	250	EC25	1198		Meays and Nordin 2013
Hyalella azteca	Amphipod	14-d	growth	245	NOEC	950		Golder 2014
Hyalella azteca	Amphipod	14-d	growth	161	NOEC	947		Golder 2014
Hyalella azteca	Amphipod	14-d	growth	485	NOEC	1150		Golder 2014
Hyalella azteca	Amphipod	14-d	growth	378	NOEC	1100		Golder 2014
Ceriodaphnia dubia	Cladoceran	7-d	reproduction	160	EC25	1212	935	Elphick *et al*. 2011
Ceriodaphnia dubia	Cladoceran	7-d	reproduction	320	EC25	542		Elphick *et al*. 2011
Ceriodaphnia dubia	Cladoceran	7-d	reproduction	245	NOEC	894		Golder 2014
Ceriodaphnia dubia	Cladoceran	7-d	reproduction	161	NOEC	951		Golder 2014
Ceriodaphnia dubia	Cladoceran	7-d	reproduction	485	NOEC	1165		Golder 2014
Ceriodaphnia dubia	Cladoceran	7-d	reproduction	378	NOEC	1030		Golder 2014
Brachionus calyciflorus	Rotifer	48-h	reproduction	160	EC25	1292	1152	Elphick *et al*. 2011
Brachionus calyciflorus	Rotifer	48-h	reproduction	320	EC25	1027		Elphick *et al*. 2011
Oncorhynchus mykiss	Rainbow trout	21-d	survival	100	EC20	618	580	Meays and Nordin 2013
Oncorhynchus mykiss	Rainbow trout	21-d	survival	250	EC20	857		Meays and Nordin 2013
Oncorhynchus mykiss	Rainbow trout	21-d	survival	100	EC20	427		Meays and Nordin 2013
Oncorhynchus mykiss	Rainbow trout	21-d	survival	250	EC20	502		Meays and Nordin 2013

Table 5.9-1 Sulphate toxicity studies used to develop species sensitivity distribution.

Species	Common Name	Duration	Effect	Mean Hardness (mg/L)	EC20/25s (as available)			Reference
					Endpoint	Sulphate Toxicity Value (mg SO_4/L)	Species Mean Toxicity Value (mg SO_4/L)	
Oncorhynchus tshawytscha	Chinook salmon	28-d	survival	250	EC10	1287	>1287	Meays and Nordin 2013
Pimephales promelas	Fathead minnow	7-d	biomass	250	EC25	2999	2590	Meays and Nordin 2013
Pimephales promelas	Fathead minnow	7-d	growth	160	EC25	3077		Elphick *et al*. 2011
Pimephales promelas	Fathead minnow	7-d	growth	320	EC25	3463		Elphick *et al*. 2011
Pimephales promelas	Fathead minnow	7-d	survival	100	EC25	1408		Meays and Nordin 2013
Pimephales promelas	Fathead minnow	7-d	survival	245	NOEC	948*		Golder 2014
Pimephales promelas	Fathead minnow	7-d	survival	161	NOEC	973*		Golder 2014
Pimephales promelas	Fathead minnow	7-d	survival	485	NOEC	1170*		Golder 2014
Pimephales promelas	Fathead minnow	7-d	survival	378	NOEC	1085*		Golder 2014
Pseudokirchneriella subcapitata	Algae	72-h	growth	320	EC25	1727	1727	Elphick *et al*. 2011

* Excluded from species mean because NOEC values are less than EC25 values.

References:

Elphick JR, Davies M, Gilron G, Canaria EC, Lo B, Bailey HC. 2011. An aquatic toxicological evaluation of sulphate: The case for considering hardness as a modifying factor in setting water quality guidelines. Environ Toxicol Chem 30:247-253.

Golder. 2014. Elk Valley Water Quality Plan. Annex F. Benchmark derivation report for nitrate and sulphate. Prepared for Teck, Calgary, AB.

Meays C, Nordin R. 2013. Ambient water quality guidelines for sulphate: Technical appendix. Water Protection & Sustainability Branch, Environmental Sustainability and Strategic Policy Division, BC Ministry of Environment.

b) Confirm if the predicted hardness concentrations in Blairmore Creek in the updated EIA considered the effects of proposed mitigation to prevent calcite precipitation described in the response to information request AER-R2-23 in Addendum 8. If not, provide updated predicted hardness concentrations for Blairmore Creek.

Response:

For the Project's water quality predictions, as it relates to treated water that would be discharged to Blairmore Creek, it was assumed that it would not be supersaturated with calcite, which means that the predicted calcium concentrations are conservatively low.

c) Given that the BC Ambient Water Quality Guidelines for Sulphate Technical Appendix observed potential osmotic stress effects on *C. dubia* at elevated hardness concentrations which were not observed in the Golder Elk Valley study, provide an overview of planned tests which would address this uncertainty for Blairmore Creek and provide more site-specific information for the Project.

Response:

A sulphate toxicity study using Blairmore Creek water and high hardness concentrations was conducted in Fall 2018 (Nautilus 2019). A Blairmore Creek water sample was collected on November 5, 2018. Sulphate was added to the water sample as $CaSO_4 \cdot 2H_2O$ and $MgSO_4 \cdot 2H_2O$, at a 5:1 Ca:Mg ratio to mimic the ratio at the site. The nominal sulphate concentration in the spiked sample was 1,500 mg/L, which was then diluted with site water to achieve a series of sulphate concentrations. The following toxicity tests were performed: (1) 72-h *Pseudokirchneriella subcapitata* (alga) growth inhibition test; (2) 6 to 8-d *Ceriodaphnia dubia* (cladoceran) survival and reproduction test; and (3) 30-d *Oncorhynchus mykiss* (rainbow trout) embryo-alevin test.

Sulphate IC20s (20% inhibition concentrations) were >1,475 mg/L for *P. subcapitata* growth, 744 mg/L for *C dubia* reproduction, and 701 mg/L for *O. mykiss* viability (Nautilus 2019). Because sulphate was spiked to the site water using Ca and Mg salts, water hardness also

increased in the initial spiked water sample and then subsequently diluted along with sulphate when developing the series of sulphate concentrations for the toxicity tests. This means that hardness concentrations decreased with decreasing sulphate concentrations in the tests. The hardness concentration in the treatment at the "greater than" EC20 for *P. subcapitata* was 1,373 mg/L. For *C. dubia*, the hardness concentrations in the treatments bracketing the EC20 were 834 and 1,146 mg/L, and for *O. mykiss* they were 879 and 1,127 mg/L. All test organisms met control acceptability criteria. Accordingly, all three test species were able to tolerate hardness concentrations of ≥834 mg/L without any indication of osmotic stress. This is similar to the observations from the Elk Valley study that is referred to in the IR.

In summary, the BC guideline for sulphate states that for waters with a hardness >250 mg/L, toxicity testing should be conducted with a site water (Meays and Nordin 2013). The study described in Nautilus (2019), using site water, fulfilled this requirement and demonstrated that the test organisms were not osmotically stressed by the high hardness concentrations tested.

d) Evaluate the potential for combined, multiple stressor effects (antagonistic, additive or synergistic) on periphyton and benthic community composition, fish reproduction and growth from combined chronic effects of the estimated elevated levels of sulphate and hardness, alone and in combination with: selenate, selenite, organo-selenium; trace elements with baseline water or sediment concentrations which exceed guidelines in at least one season (total copper, chromium, lead, mercury, silver, and zinc in water, dissolved aluminum in water); and, trace elements which are predicted to exceed guidelines due to the Project (cadmium, cobalt and zinc). The assessment should also consider the effects of nitrogen compounds (particularly ammonia), total suspended solids, dissolved organic carbon, pH, and temperature. To undertake this assessment, Benga is encouraged to consult the Technical Guidance entitled "Assessing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act, 2012*".[6]

Response:

Overview of Water Quality Model Inputs

As described in Appendix 10B: Water and Load Balance (EIA, CEAR #42), the water quality model was conducted using the GOLDSIM model. Source terms for background concentrations were developed using water quality data measured from the site (Section 3.2.3, CR #5, EIA, CEAR #42). This means that the historic measurements from the Crowsnest River from 1974-2008 were not used as inputs to the model (Section 3.2.1, CR #5, EIA, CEAR #42). These historical data sometimes had few QA/QC issues, including higher analytical detection limits than the water quality guideline values (Section 3.1.1, CR #5), and it was felt the local data from

6 Available online: Interim Technical Guidance "Assessing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act, 2012*". https://www.canada.ca/en/environmental-assessment-agency/services/policy-guidance/assessing-cumulative-environmental-effects-ceaa2012.html.

the Blairmore Creek and Gold Creek were more appropriate data to use to model/predict potential Project changes in water quality. As such, there were no exceedances of guidelines in total copper, chromium, lead, silver, zinc in the relevant baseline data in Blairmore Creek.

According to CEAA (2018) Assessing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act*, 2012: Interim Technical Guidance, "a synergistic cumulative effect occurs as a result of the interaction between two or more effects, then the resultant combination is greater or different that the simple addition of the effects." In order to assess this, predicted Project effects should be examined, and the relationship between those effects.

Predicted Project Effects

Those elements predicted to exceed water quality guidelines due to the Project warrant further consideration with regards to synergistic cumulative effects and are discussed in more detail below.

A total of 39 water quality variables were modelled including metals, major nutrients (ammonia, nitrite, nitrate, and phosphorus), and major ions (calcium, magnesium, potassium, sodium, chloride, and sulphate). Of the 39 variables modelled, 21 variables have published Alberta water quality guidelines. Predicted concentrations of all the 21 regulated water quality variables during the construction, operation, closure and post-closure periods of the Grassy Mountain Mine fell within published Alberta guidelines (or for Se, the proposed site-specific objective) in Gold Creek. In Blairmore Creek, predicted concentrations of all variables fell within these guidelines or the proposed Se objective except sulphate (Section 4.1.1.3, CR #5, EIA, CEAR #42).

The relationships between selenium, sulphate, and hardness are discussed below.

Consideration of Antagonistic Cumulative Effects

The first step of the environmental assessment framework as it applies to cumulative environmental effects assessment is identification of valued components for which residual environmental effects are predicted (CEAA 2018). For the present Project, the westslope cutthroat trout (WSCT) was defined as the key valued component while the aquatic community, including algae, aquatic plants, invertebrates, were applied as intermediate components (effect pathways) used to assess for potential residual effects on WSCT. The potential effects resulting from changes in water quality predicted from mining operations were evaluated based on a conservative screening of predicted chemical concentrations in Blairmore Creek relative to water quality guidelines.

Selenium, sulphate, and cobalt were identified as constituents of potential concern in Blairmore Creek. In addition, the high predicted hardness concentrations have raised questions about the possibility of osmotic stress. Other stressors were not identified as constituents of potential

concern based on the fact they were below guidelines (CR#5), so they are not expected to contribute to any cumulative effects and are not discussed further as part of this IR response.

When considering the potential cumulative effects of selenium, sulphate, cobalt, and hardness, most of the interactions are antagonistic. For example, sulphate competes with selenate for uptake by primary producers, such that high sulphate concentrations reduce selenium bioaccumulation potential. Similarly, hardness has a mitigating effect on both sulphate and cobalt toxicity. To reduce uncertainty in evaluating the cumulative influence of these constituents on the valued component, site-specific studies and information were used in the effects assessments for these constituents:

- **Selenium:** Blairmore Creek water was collected and spiked with varying selenate and sulphate concentrations to encompass the range of predicted future water chemistry conditions. The influence of sulphate on selenate bioaccumulation by algae and an aquatic plant was then studied (Nautilus 2016), with the results used to support development of a selenium bioaccumulation model for evaluating selenium risks to the valued component, westslope cutthroat trout (WSCT). This selenate-sulphate model was used to predict future periphyton selenium concentrations in Blairmore Creek, after calibration to the mean baseline periphyton selenium concentration in the creek. Selenium concentrations in macroinvertebrates were then predicted using two different trophic transfer models from other studies (Golder 2014; DeForest *et al*. 2017), which have been demonstrated to at least be conservative for baseline conditions (please see response to JRP IR-5.7). Trophic transfer of selenium from macroinvertebrates to WSCT eggs was then predicted using a robust dataset (n = 88) of co-located macroinvertebrate and WSCT eggs concentrations from other locations, which were then compared to a WSCT-specific concentration-response model (a dataset previously used by BCMOE and USEPA in deriving their respective guidelines/criteria). Thus, cumulative influence of predicted selenate and sulphate concentrations were incorporated into the selenium effects assessment based on a site-specific study.
- **Sulphate and Hardness:** A second site-specific study evaluated the cumulative effects of high sulphate and hardness concentrations on an alga (*P. subcapitata*), a cladoceran (*C. dubia*), and rainbow trout (*O. mykiss*) (Nautilus 2019). This study was conducted in response to the Alberta sulphate guideline, which was adopted based on the British Columbia guideline. The guidance states that a site-specific study should be conducted to develop a sulphate guideline when the water hardness is greater than 250 mg/L. Per the response to (b) above, this study confirmed that the test organisms were not osmotically stressed at high hardness and that high hardness ameliorated the toxicity of sulphate.
- **Cobalt:** A site-specific cobalt toxicity study was not conducted, but the cobalt guideline is hardness-dependent and thus the predicted hardness of Blairmore Creek

was factored into the effects assessment. The maximum predicted cobalt concentration in Blairmore Creek is less than the predicted hardness-adjusted EC10 for the most sensitive species to cobalt (*Hyalella azteca*), which is plotted at the 3rd percentile of the species sensitivity distribution (SSD). The maximum predicted cobalt concentration exceeds the hardness-dependent guideline, but, as discussed in the response to JRP IR-5.11, the cobalt guideline is biased low due to the poor fit of the SSD model to the lower tail of the SSD.

Uncertainty in Project predictions can be managed according to the Technical Guidance on *Determining Whether a Designated Project is Likely to Cause Significant Adverse Environmental Effects Under the CEAA, 2012.* Adaptive management may be used to address uncertainty. Adaptive management provides flexibility to identify and implement new mitigation measures or to modify existing ones during the life of a project. Water quality will be monitored to verify the accuracy of predictions and adaptive management strategies will be implemented in the event predictions are not achieved.

In summary, the analysis of cumulative effects considered the mitigating influence of sulphate on selenate bioaccumulation and the ameliorating effects of hardness on both sulphate and cobalt toxicity. When considering these ameliorating effects, predicted concentrations of all of these constituents result in negligible risks to WSCT (VC) and the aquatic community of Blairmore Creek. Another aspect of cumulative effects assessment is spatial considerations. An additional response relative to the potential effects of selenium downstream in Oldman Reservoir is provided in the response to JRP IR-5.29.

References

CEAA. 2018. Assessing cumulative environmental effects under the Canadian Environmental Assessment Act, 2012. Interim Technical Guidance, Version 2. Ottawa, Ontario.

DeForest DK, Brix KV, Gilron G, Hughes SA, Tear LM, Elphick JR, Rickwood CJ, DeBruyn AMH, Adams WJ. 2017. Lentic, lotic, and sulfate-dependent waterborne selenium screening guidelines for freshwater systems. Environ Toxicol Chem 36:2503-2513.

Golder. 2014. Elk Valley Water Quality Plan. Annex E. Benchmark derivation report for selenium. Prepared for Teck, Calgary, AB.

Hatfield. 2016. Riversdale Resources Grassy Mountain Coal Project: Surface Water Quality Assessment Consultant Report #5. Hatfield Consultants, North Vancouver, BC, Canada.

Hatfield. 2017. Grassy Mountain Coal Project: Aquatic Ecology Effects Assessment Addendum Consultant Report #6. Hatfield Consultants, North Vancouver, BC, Canada.

Meays C, Nordin R. 2013. Ambient water quality guidelines for sulphate: Technical appendix. Water Protection & Sustainability Branch, Environmental Sustainability and Strategic Policy Division, BC Ministry of Environment.

Nautilus. 2016. Evaluation of selenium uptake in waters by primary producers associated with the Grassy Mountain coal mine project. Draft report. Submitted to Hatfield Consultants, North Vancouver, BC. Nautilus Environmental, Calgary, AB.

Nautilus. 2019. Evaluation of toxicity of sulphate for the Grassy Mountain Coal Project. Final report. Submitted to Hatfield Consultants, North Vancouver, BC. Nautilus Environmental, Calgary, AB.

5.10 Information Request 5.10

Grassy Mountain Coal Project - Updated Environmental Impact Assessment. Consultant Report #5 – Surface Water Quality. (CEAR #42).

Comments from the Government of Canada - Environment and Climate Change Canada submission. IR#10. (CEAR #167).

Comments from Ktunaxa Nation Council. (CEAR #178).

In its submission to the Panel (CEAR #167), Environment and Climate Change Canada highlighted that sulphate concentrations in Blairmore Creek are predicted to increase from pre-mining levels of about 20 mg/L to levels of 650 mg/L during late operations, remaining above 500 mg/L in closure and post-closure (Figure 6 of Consultant Report #5, CEAR #42). The predicted values are above the BC sulphate guideline of 429 mg/L at 250 mg/L hardness (noting that sulphate toxicity is attenuated by hardness). Project-area streams have very high hardness; for example, hardness in Gold Creek exceeds 300 mg/L seasonally, and hardness is predicted to increase to approximately 350 mg/L. The effect of this high hardness level on the toxicity of sulphate has not been documented through toxicity testing.

A conservative approach would be for Benga to rely on BC's sulphate guidelines (adopted by Alberta) of 309 and 429 mg/L for the moderately hard to hard or very hard water hardness, respectively.

Benga continues to support the use of a higher sulphate guideline while recognizing that sulphate concentrations are expected to exceed the guideline of 429 mg/L by the mid-2030s.

The upper limit of BC's sulphate guideline is set at 429 mg/L for very hard waters (181-250 mg/L hardness) because the toxicity tests on the early stage rainbow trout were only conducted up to the water hardness of 250 mg/L. BC also recommends additional toxicity tests on several species for waters of hardness of greater than 250 mg/L. Setting the lower and upper bounds for toxicity modifying factors (hardness in this case) corresponding to the range of concentrations at which toxicity tests are conducted is a standard practice in developing guidelines.

In Section 4.1.1.3 of Consultant Report #5 (CEAR #42), Benga acknowledged the need for additional work on a sulphate guideline: "[…] development of a site-specific sulphate objective reflective of predicted hardness (i.e., ~350 mg/L) and ionic composition of Blairmore Creek at a future time is recommended for Blairmore Creek, using site waters for test dilution to reflect the specific ionic composition of Blairmore Creek waters."

Benga proposes to defer development of a site-specific sulphate guideline to a future time; however, both Environment and Climate Change Canada (CEAR #167) and Ktunaxa Nation Council (CEAR #178) noted that this will not allow for the evaluation of the effects of the high sulphate/high hardness conditions associated with the Project. Further testing should be carried out in support of an appropriate sulphate guideline, with additional testing which expands the hardness range for the toxicity tests considered in the BC guideline.

a) Using provincial and/or federal guidance on deriving site-specific guidelines, provide additional site- specific information (including chemistry and ecosystem receptors) supporting the development of a site-specific sulphate guideline for waters with hardness exceeding the hardness range for toxicity data considered in developing the BC sulphate guideline.

Response:

A sulphate toxicity study using Blairmore Creek water and high hardness concentrations was conducted in Fall 2018 (Nautilus 2019). The results of the study are provided in Appendix 5.10-1. The following response, which was developed from a similar request in JRP IR-5.9, summarizes this study further.

A Blairmore Creek water sample was collected on November 5, 2018. Sulphate was added to the water sample as $CaSO_4 \cdot 2H_2O$ and $MgSO_4 \cdot 2H_2O$, at a 5:1 Ca:Mg ratio to mimic the ratio at the site. The nominal sulphate concentration in the spiked sample was 1,500 mg/L, which was then diluted with site water to achieve series of sulphate concentrations. The following toxicity tests were performed: (1) 72-h *Pseudokirchneriella subcapitata* (alga) growth inhibition test; (2) 6 to 8-d *Ceriodaphnia dubia* (cladoceran) survival and reproduction test; and (3) 30-d *Oncorhynchus mykiss* (rainbow trout) embryo-alevin test.

Sulphate IC20s (20% inhibition concentrations) were >1,475 mg/L for *P. subcapitata* growth, 744 mg/L for *C. dubia* reproduction, and 701 mg/L for *O. mykiss* viability (Nautilus 2019). Because sulphate was spiked to the site water using Ca and Mg salts, water hardness also increased in the initial spiked water sample and then subsequently diluted along with sulphate when developing the series of sulphate concentrations for the toxicity tests. This means that hardness concentrations decreased with decreasing sulphate concentrations in the tests. The hardness concentration in the treatment at the "greater than" EC20 for *P. subcapitata* was 1,373 mg/L. For *C. dubia*, the hardness concentrations in the treatments bracketing the EC20 were 834 and 1,146 mg/L, and for *O. mykiss* they were 879 and 1,127 mg/L. All test organisms met control acceptability criteria. Accordingly, all three test species were able to tolerate

hardness concentrations of ≥834 mg/L without any indication of osmotic stress. This is similar to the observations from an Elk Valley study in which sulphate no-observed-effect concentrations (NOECs) up to 1,165 mg/L were observed for *C. dubia*, rainbow trout, and the amphipod *Hyalella azteca* in waters up to a hardness of 485 mg/L (the highest hardness tested; Golder 2014).

The *P. subcapitata*, *C. dubia*, and rainbow trout IC20s of >1,475, 744, and 701 mg/L are all greater than the sulphate HC5 of 593 mg/L previously recommended by Benga for Blairmore Creek, which supports that 593 mg/L is a protective concentration for sulphate.

In summary, the BC guideline for sulphate states that for waters with a hardness >250 mg/L, toxicity testing should be conducted with a site water (Meays and Nordin 2013). The study described in Nautilus (2019), using site water, fulfilled this requirement and demonstrated that the test organisms were not osmotically stressed by the high hardness concentrations tested.

References

Golder. 2014. Elk River Water Quality Plan. Annex F. Benchmark derivation report for nitrate and sulphate. Submitted to Teck Coal Limited, Calgary, AB.

Meays C, Nordin R. 2013. Ambient water quality guidelines for sulphate: Technical appendix. Water Protection & Sustainability Branch, Environmental Sustainability and Strategic Policy Division, BC Ministry of Environment.

Nautilus. 2019. Evaluation of toxicity of sulphate for the Grassy Mountain Coal Project. Final report. Submitted to Hatfield Consultants, North Vancouver, BC. Nautilus Environmental, Calgary, AB.

b) If no additional supporting information is available, describe the plan to undertake further studies in support of developing a site-specific guideline, including the timeline and desired outcomes of the studies.

Response:

Please refer to previous response in JRP IR-5.10 a).

5.11 Information Request 5.11

Eighth Addendum to the Environmental Impact Assessment. Appendix C-3. (CEAR #89).

Federal Environmental Quality Guidelines – Cobalt. Environment Canada. May 2017.[7]

In Appendix C-2 in Addendum 8 (CEAR #89), Benga used a cobalt biotic ligand model (BLM) to derive a site specific HC5[8] of 2.7 µg/L. It is unclear if the model accounted for other competing metals for the same ligands, but Benga stated that the derived HC5 includes the use of predicted, elevated concentrations of hardness and sulphate. While there may be other factors that influence cobalt toxicity in addition to hardness, the BLM for cobalt has not been accepted for use in Alberta or other Canadian jurisdictions. Until such time that the BLM for cobalt is accepted for broader use this method cannot be used to derive site specific objectives for projects trying to predict future risk.

a) Using the 2017 Environment Canada derived cobalt guideline based on the current baseline hardness value measured in Blairmore Creek (not the predicted concentration of 372 mg/L), provide an alternative risk assessment for cobalt on the most sensitive aquatic receptors (plant, invertebrate and vertebrate species) in Blairmore Creek. The guideline should be calculated based on the baseline water hardness value in a Blairmore Creek as per the relationship described in the Environment Canada (2017) Federal Environmental Quality Guidelines for cobalt.

Response:

The IR requests an alternative risk assessment be provided for the most sensitive aquatic receptors (plant, invertebrates, and fish species) in Blairmore Creek. The Blairmore Creek macroinvertebrate survey identified oligochaetes (worms), arachnids (*e.g.,* water mites), and insects (*e.g.,* chironomids, mayflies), while fish species in the creek include westslope cutthroat trout, non-native brook trout and rainbow trout, and westslope-rainbow trout hybrids. The most sensitive surrogate species in the cobalt EC10 are L. minor for aquatic vegetation, Aeolosoma sp. (a surrogate for other oligochaetes) and Chironomus tentans (a surrogate for other chironomids and aquatic insects), and rainbow trout (also a surrogate for other trout species) (Figure 5.11-1). The hardness-normalized EC10s for these species are 10.9 and 7.8 µg/L for L. minor at a predicted hardness of 372 and baseline hardness of 170 mg/L, respectively; 345 and 250 µg/L for Aeolosoma at a hardness of 372 and 170 mg/L, respectively; 348 and 252 µg/L for C. tentans at a hardness of 372 and 170 mg/L, respectively; and 3,530 and 2,552 µg/L for rainbow trout at a hardness of 372 and 170 mg/L, respectively. The maximum predicted cobalt concentration in Blairmore Creek of 2.4 ug/l is well-below the cobalt EC10s, based on both the baseline hardness of 170 mg/L and predicted hardness of 372 mg/L, for these most sensitive surrogate aquatic

7 The Federal Environmental Quality Guidelines for Cobalt are publically available from: https://www.ec.gc.ca/ese-ees/default.asp?lang=En&n=92F47C5D-1

8 The HC5 is the concentration at which five percent of the species in the species sensitivity distribution exhibit an effect.

plant, invertebrate, and fish species (Table 5.11-1). Therefore, using this alternate risk assessment, no significant adverse effect is predicted.

Table 5.11-1 Comparison of maximum predicted cobalt concentrations in Blairmore Creek to species that occur or are surrogates for species in Blairmore Creek: (1) *L. minor* (aquatic plant surrogate); (2) *Aeolosoma* sp. and *C. tentans* (aquatic invertebrate surrogates); and (3) rainbow trout (also surrogate for other trout species).

Maximum Predicted Co Concentration (µg/L)					Cobalt EC10s (µg/L) Normalized to Hardness of 372 mg/L			Cobalt EC10s (µg/L) Normalized to Hardness of 170 mg/L		
BL03	**BC07**	**BL02**	**BC03**	**BC01**	**Aquatic Plant (*L. minor*)**	**Aquatic Invertebrates (*Aeolosoma* sp., *C. tentans*)**	**Fish (Rainbow Trout)**	**Aquatic Plant (*L. minor*)**	**Aquatic Invertebrates (*Aeolosoma* sp., *C. tentans*)**	**Fish (Rainbow Trout)**
0.27	1.7	1.9	2.4	1.9	10.9	345 (*Aeolosoma*) 348 (*C. tentans*)	3,530	7.8	249 (*Aeolosoma*) 252 (*C. tentans*)	2,552

Benga respectfully disagrees with the request to calculate the ECCC cobalt guideline based on the baseline hardness for Blairmore Creek, as this does not correspond with the future water chemistry conditions, including the maximum predicted cobalt concentration of 2.4 µg/L in the creek (at BL03). Use of the baseline hardness concentration would underestimate calcium competition with cobalt for uptake by aquatic biota under future conditions. However, we did normalize the chronic cobalt toxicity values in ECCC (2017) to the predicted Blairmore Creek hardness of 372 mg/L using the hardness slope of 0.414, also from ECCC (2017) (Figure 5.11-1). There are two primary observations from this figure:

- Species sensitivity distribution (SSD) models were fit to cobalt toxicity values using SSD Master (Version 3.0), the same program used by ECCC in developing its cobalt guideline. Four different models provided very different fits to the toxicity values, with HC5s (*i.e.,* 5th percentiles of the SSDs) ranging from 0.49 to 3.5 µg/L (Figure 5.11-1). ECCC (2017) had selected the normal model for guideline development (HC5 of 1.8 µg/L), because it had the best Anderson-Darling goodness-of-fit statistic. However, all SSD models with the exception of the Gumbel model provided a relatively poor fit to the lower tail of the distribution (Figure 1). The Gumbel model estimates an HC5 of 3.5 µg/L, which is slightly less than the hardness-normalized EC10 of 3.8 µg/L for *Hyalella azteca*, the most sensitive species. Accordingly, the Gumbel model estimates an HC5 that is more consistent with the empirical data.

The conservatism in some of the SSD models can also be observed based on the baseline cobalt concentration of 0.27 µg/L and hardness of 170 mg/L (Figure 5.11-2).

In this example, the baseline cobalt concentration overlaps with the lower tail of three models (normal, logistic, and extreme value), but not the Gumbel model, which again provides a better fit to the lower tail of the SSD.

- *H. azteca* is the most sensitive species in the cobalt toxicity dataset, with an EC10 that is about 65% lower than the second most sensitive species (*Lemna minor* [duckweed]) (Figure 5.11-1). There has been a lot of recent research on chronic toxicity test methods for *H. azteca*, which has been led by the US Environmental Protection Agency (USEPA), the US Geological Survey, the Illinois Natural History Survey, and Environment Canada, which was designed to improve test performance as inappropriate diets and water conditions were found to stress the organisms.

  Recently, Besser *et al*. (2016) demonstrated that one of the newly recommended test diets, comprised of a combination of live diatoms and TertraMin, with dietary rations increased weekly as the organisms grew, had an important influence on the apparent toxicity of lead. In a previous study, Besser *et al*. (2005) reported a low lead toxicity threshold that made *H. azteca* the most sensitive species tested. However, the study by Besser *et al*. (2016) with the improved diet resulted in a toxicity threshold that about four-fold greater than that from Besser *et al*. (2005). Besser *et al*. (2016) attributed the higher sensitivity of *H. azteca* in Besser *et al*. (2005) study to an inadequate diet.

  For cobalt, chronic *H. azteca* toxicity data are from Norwood *et al*. (2007) and Heijerick *et al*. (2007). Norwood *et al*. (2007) fed *H. azteca* a TetraMin diet and Heijerick *et al*. (2007) fed *H. azteca* a diet comprised of YCT (yeast-cereal leaves-trout pellets) and algae. Norwood *et al*. (2007) increased the feeding rations during the study, while Heijerick *et al*. (2007) did not. Neither of these study designs are consistent with the recently recommended feeding regimes for chronic tests with *H. azteca*, which may indicate that the cobalt toxicity threshold in the SSD may be biased low. However, this can only be identified as an uncertainty unless and until additional cobalt testing is conducted.

The maximum predicted cobalt concentrations at BL02 (1.9 µg/L), BC03 (2.4 µg/L), and BC01 (1.9 µg/L) exceed the ECCC cobalt guideline of 1.8 µg/L based on the predicted hardness of 372 mg/L (Table 5.11-2). As noted above, this guideline is driven by an SSD model (normal distribution) that provides a poor fit to the lower tail of the SSD (*i.e.,* the portion of interest for estimating the 5th percentile). An alternative model, the Gumbel distribution, provides a better fit to the lower tail, which would result in an alternative guideline of 3.5 µg/L. This alternative guideline is not exceeded by the maximum predicted cobalt concentration at any node of Blairmore Creek (Table 5.11-1). Further, recent studies on the optimization of the toxicity test method for *H. azteca*, the most sensitive species in the SSD, suggest that the *H. azteca* EC10 may be biased low. Regardless, even the EC10 for this species is not exceeded by the maximum predicted cobalt concentration (Table 5.11-2).

Overall, the above lines of evidence further support that the predicted cobalt concentrations would not pose an unacceptable risk to aquatic life in Blairmore Creek.

Table 5.11-2 Comparison of maximum predicted cobalt concentrations in Blairmore Creek to: (1) the ECCC hardness-based guideline; (2) a hardness-based guideline based on an alternative model; and (3) the hardness-normalized sensitivity of *Hyalella azteca*. Values were normalized to the predicted hardness of 372 mg/L.

Maximum Predicted Co Concentration (µg/L)							
BL03	**BC07**	**BL02**	**BC03**	**BC01**	**ECCC Hardness-based Co Guideline (µg/L)**	**Alternative Hardness-based Co Guideline (µg/L)**	**Hardness-normalized H. azteca Co EC10 (µg/L)**
0.27	1.7	1.9	2.4	1.9	1.8	3.3	3.8

References

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Besser JM, Ivey CD, Brumbaugh WG, Ingersoll CG. 2016. Effect of diet quality on chronic toxicity of aqueous lead to the amphipod *Hyalella azteca*. Environ Toxicol Chem 35:1825-1834.

ECCC. 2017. Federal Environmental Quality Guidelines: Cobalt. May 2017.

Hatfield. 2017. Grassy Mountain Coal Project: aquatic ecology effects assessment addendum consultant report #6. Hatfield Consultants, North Vancouver, BC, Canada.

Heijerick D, Ghekiere A, Van Sprang P, De Schamphelaere K, Deleebeeck N, Janssen C. 2007. Effect of cobalt ($CoCl_2.6H_2O$) on freshwater organisms. EURAS and Ghent University, Belgium.

Norwood WP, Borgmann U, Dixon DG. 2007. Chronic toxicity of arsenic, cobalt, chromium and manganese to *Hyalella azteca* in relation to exposure and bioaccumulation. Environ Pollut 147:262-272.

5.12 Information Request 5.12

Eighth Addendum to the Environmental Impact Assessment. Appendix B-1, Appendix C-4. (CEAR #89).

Comments from Jim Rennie to the Joint Review Panel. (CEAR #133).

Comments from Allan Garbutt to the Joint Review Panel. (CEAR #158).

Comments from David McIntyre to the Joint Review Panel. (CEAR #159).

Comments from Ron and Monelle Fraser to the Joint Review Panel. (CEAR #166).

Comments from Kevin Turner to the Joint Review Panel. (CEAR #177).

Several participants (CEAR #133, #158, #159, #166, and #177) expressed concerns regarding the 2015 release of contaminants into Gold Creek from existing legacy coal piles during a heavy rainfall event. In response to Káínai Nation (Blood Tribe's) January 4, 2016 statement of concern in Appendix C-4 in Addendum 8 (CEAR #89), Benga indicated that as part of the Project mine plan, it was their intention to clean up and reclaim the environment affected by legacy mining activities.

In Appendix B-1 in Addendum 8 (CEAR #89), Benga identified the existence of legacy coal piles in proximity to Gold Creek near the historic town of Lille. Benga indicated that the area adjacent to the legacy coal piles is a candidate site for habitat enhancement on Gold Creek, and that this area would be part of offsetting measures focusing on the re-establishment of critical habitat connectivity for Westslope Cutthroat Trout. However, it is unclear whether there are additional legacy coal piles adjacent to Gold and Blairmore Creeks, and whether any Project activities could interact with these legacy coal piles and result in potential adverse environmental effects.

a) Provide a map that indicates the locations of the existing legacy coal piles within the mine permit boundary. Indicate which piles are within a 100 m buffer of Gold and Blairmore creeks.

Response:

Please refer to Figure 5.12-1 which indicates three identified areas of legacy coal within a 100 m buffer of Gold Creek. There are no known or identified occurrences of legacy coal within a 100 m buffer of Blairmore Creek. Figure 5.12-1 illustrates landscape degradation along Gold Creek primarily due to legacy coal mining activities near the historic Town of Lille (photos 1, 2, and 3).

b) Provide a description of Project activities that could potentially interact with the existing legacy coal piles, and describe any resultant potential effects to valued

components. Include any interactions resulting from potential accidents and malfunctions associated with the Project.

Response:

As indicated on Figure 5.12-1 there are no Project activities that could potentially interact with the existing legacy coal piles observed along Gold Creek.

5.13 Information Request 5.13

Eighth Addendum to the Environmental Impact Assessment. Appendix C-2. (CEAR #89).

In the EIA and its addenda, Benga makes reference to the use of a carbon source to create reducing conditions so that selenium attenuation can take place in the saturated backfill zones. In Appendix C-2 in Addendum 8 (CEAR #89), Benga indicated that methanol and molasses were selected in the barrel selenium attenuation trial because they are known to be suitable carbon sources and they can be readily sourced in large quantities at low cost. Benga also highlighted that coal reject is another potential source of carbon. However, there are no details regarding the storage of the carbon source that would be used in the saturated backfill zones for the Project, and whether there are any potential environmental effects that could result from storage of the carbon source on the Project site.

a) Indicate the anticipated volume of methanol, or any other carbon source under consideration, that would be required annually for use in the saturated backfill zones.

Response:

Based on an estimated volume of 4,500,000 m^3/year of water to be treated, at a methanol concentration of 121 mg/L, approximately 680 m^3 of methanol per year would be required.

b) Provide a map depicting where methanol, or any other carbon source would be stored on the Project site, and provide a description of how it would be supplied to and stored on the Project site, in a manner that prevents attraction by wildlife.

Response:

A central carbon source storage facility would be located at the coal handling process plant (CHPP) Figure 5.13-1. The methanol storage would include double-walled tanks on a concrete pad surrounded by a concrete berm, which would serve as secondary containment. Given that the methanol is in a tank and in an active area of the CHPP, no interaction with wildlife is anticipated. However, if a wildlife issue is experienced, Benga would consider fencing or other deterrents to prevent attraction of wildlife.

c) Provide details on the storage facilities for methanol, or any other carbon source, including the size of structures and/or facilities, any leak detection and monitoring

equipment provided, considerations for secondary containment, and management of any vapour emissions.

Response:

Methanol will be stored per the guidelines set under the Alberta Energy Regulator (AER) Directive 055: Storage Requirements for the Upstream Petroleum Industry or equivalent for the mining industry (AER 2001). The size of the tank expected to store methanol would have an internal capacity of 50 m^3, which will provide approximately 1 month's supply for the SBZ. This will limit the number of transport trips required to the site to approximately one per month. At the peak of water treatment, an additional 50 m^3 tank will need to be added to the site. Details regarding the leak detection, monitoring equipment, secondary containment and vapour emissions management will all be worked on in compliance with regulations and based on the recommendations of the methanol supplier for safe storage and handling.

d) Provide a description of the following:

i. potential accidents and malfunctions that could result from the transportation and storage of the carbon source;

Response:

Potential accidents and malfunctions that could result from the transportation and storage of the carbon source are similar to those expected from the transportation and storage of other compounds and reagents. Assessments for these specific accidents and malfunctions were provide in the EIA (CEAR #42) Sections C.9.7 - Transportation and C.9.8 – Spill or more details related to this request.

ii. potential environmental effects that could result from such an accident, and the valued components that could, potentially be affected; and

Response:

As indicated in EIA (CEAR #42) Section C.9.8.3, the primary concern associated with a spill would be adverse impacts to groundwater or surface water quality. The impact of any spill is expected to be confined to the footprint of the Project and the immediate vicinity of the spill, making it unlikely that the spill would interact with the environment and the other VCs. Storage of the carbon source in the CHPP, where additional measures will be in place to mitigate the impact of a potential spill, will be beneficial to the project.

iii. mitigation measures proposed to reduce the probability of such an accident or to mitigate potential environmental effects.

Response:

Mitigation measures include storing the carbon source within double-walled tanks inside of a concrete bermed area. It is proposed that the carbon source is stored in the CHPP and housed

with other reagents and chemicals. Operational safeguards for the entire CHPP will include daily inspections of the storage areas, volume accounting, and spill kits in storage areas and aboard vehicles.

e) If there is still uncertainty in the carbon source that would be used, Benga should provide a comparative table for each technically and economically feasible source of carbon that could be used in the saturated backfill zones to respond to the above questions.

Response:

At this time, methanol has been determined to be the carbon source for the proposed saturated backfill zones. Should a carbon source or combination of carbon sources be identified through future research and development (refer to JRP IR-5.5) that proves to be more effective for the purposes of the SBZs a revisit of the carbon source would be made at that time.

References

AER 2001. Directive 055: Storage Requirements for the Upstream Petroleum Industry. Energy Resources Conservation Board. December 2001.

5.14 Information Request 5.14

Eighth Addendum to the Environmental Impact Assessment. AER-R2-3. (CEAR #89).

The management of runoff water, including potential release, are important to ensure that potential impacts on watersheds in the area are understood. In the response provided to information request AER-R2-3 in Addendum 8 (CEAR #89), Benga provided a general discussion regarding the management of wastes and storm water associated with the Grassy Mountain Explosives Magazine (GMEM). However, specific details related to the materials to be stored at the GMEM and management of runoff water from the GMEM are required.

Provide the following with respect to the Grassy Mountain Explosives Magazine:

a) Describe the oils and fuels to be stored at the GMEM; including the types of storage and secondary containment that will be provided, and the volumes of materials to be stored.

Response:

As an amendment to the information response provided in the Eighth Addendum to the Environmental Impact Assessment. AER-R2-3 (CEAR #89), only oils not fuels will be stored at the GMEM.

Oils used for truck operation will include engine oils, hydraulic oils, and glycol will be stored in original containers and dispensed for use as required. All provincial (*e.g.,* WHMIS) and

operational best practices associated with the use and storage containment would be adhered to based on the size of containers provided. Waste oils would also be disposed according to provincial regulations.

For clarification (as an amendment to AER-R2-3; CEAR #89), diesel fuel used for truck engines and for the ANFO production would be obtained from the Mine Infrastructure Area (MIA) located at the Coal Handling and Processing Plant (CHPP) area and no diesel fuel would be stored at the GMEM area.

b) Describe the anticipated design and configuration of the GMEM including:

i. the location of berms and the location of any industrial wastewater ponds where water from the GMEM can be stored; and

Response:

Site to include an office c/w sanitary facilities, truck maintenance garage with wash facility, raw material storage including Ammonium Nitrate Prill storage tanks, Ammonium Nitrate based Emulsion storage tanks, dry storage containers, waste water storage, wash water collection / evaporator module, and hot work module (Figure 5.14-1).

ii. how water quality for water originating from the GMEM would be tested and monitored.

Response:

The GMEM is anticipated to 150 m x 150 m, would be graded and surrounded by an earth berm, and a chain linked fence (for security). The grading and earth berm will direct surface water run off from the site to a diversion ditch located along the toe of the south waste rock dump. Any run off water from the GMEM would then be directed to either the south east surge pond and/or the raw water pond (RWP). As part of the Project's Water Management Plan (WMP) neither of these ponds discharge directly to the downstream or surrounding environment. Water from the surge pond is either directed to the RWP where it would be used for processing in the CHPP or to a future saturated backfill zone (SBZ). In the case of the SBZ the water would still go through subsequent treatment prior to release to the downstream receiving environments.

c) Identify the plans for water management from the GMEM area including:

i. how runoff water at the GMEM will be collected, managed, and released;

Response:

Please refer to previous response provided in JRP IR-5.14 b) ii.

ii. details on when, during the preparation of ammonium nitrate fuel oil (ANFO) explosives, elevated levels of nitrates (and other contaminants) are anticipated in runoff water;

Response:

No mixing (preparation of ANFO) will be performed at the GMEM. All blending activities are performed at the borehole location in the pit. Ammonium Nitrate, as a raw material, will be loaded into the storage tanks at the GMEM by pneumatic transfer and loaded into the mix truck by means of gravity feed. The Ammonium Nitrate based emulsion will be loaded into the storage tanks by a pump transfer and loaded out of storage into the mix truck by means of gravity feed. During the transfer of raw materials into storage there are no anticipated, elevated levels of nitrates. Any spills that occur during hose decoupling are collected in drip pans and returned for use. Any unexpected spills that become contaminated with foreign materials that can not be used in the manufacturing process are bagged and are disposed of off the GMEM site.

iii. provision of surge ponds and potential release points to the environment for water from the GMEM;

Response:

Please refer to previous response provided in JRP IR-5.14 b) ii.

iv. re-use of water from the GMEM and where this water would be re-used;

Response:

Water used at the GMEM is predominately for washing of the mix trucks. This activity is completed inside the truck maintenance facility that has a concrete floor and a water catchment and containment system. Wash water is screened of solids and is evaporated by means of a heated evaporator system. Solids are bagged and disposed of off the GMEM site. Water is also used for manufacture of trace ingredients for the mixing of the bulk explosives which are loaded on the mix trucks and consumed during the delivery of the bulk explosives at the borehole. Gray and black water are collected from the office facility on the site which are disposed of according to provincial standards.

MIA facility sewage will be collected and treated in a sewage treatment package plant (c/w power, heating, communications and lighting) located on the MIA pad. The treatment plant will treat all sewage produced at the MIA facilities and has been based on an estimated sewage treatment requirement of 30 m^3/day

v. considerations for off-site disposal and treatment of water from the GMEM area; and

Response:

Please refer to previous response provided in JRP IR-5.14 b) ii and iv.

vi. other release, treatment or disposal options considered.

Response:

Please refer to previous response provided in JRP IR-5.14 b) ii and iv.

HYDROLOGY

5.15 Information Request 5.15

Grassy Mountain Coal Project - Updated Environmental Impact Assessment. Consultant Report #4 – Hydrology, Appendix 10b – Water and Load Balance Model Report; Section 8.2. (CEAR #42).

First Addendum to the Environmental Impact Assessment. Consultant Report #6 - Appendix A3 – Instream Flow Assessment; Section 4.1.2.3 and Figure 4-2. (CEAR #44).

Fifth Addendum to the Environmental Impact Assessment. Supplemental Information Request (SIR) 84. (CEAR #69).

Seventh Addendum to the Environmental Impact Assessment. SIR 84. (CEAR #72).

Eighth Addendum to the Environmental Impact Assessment. AER-R2-4; Table AER-R2-4-1, Appendix B-1. (CEAR #89).

Benga was asked to provide information with respect to potential stream flow changes in a series of previous information requests. However, Benga did not provide the information requested in SIR 84 in Addendum 5 (CEAR #69), SIR 84 in Addendum 7 (CEAR #72), and AER-R2-4 in Addendum 8 (CEAR #89). Instead, Benga provided a rationale for why the information was not required.

In the response to AER-R2-4 in Addendum 8 (CEAR #89), Benga stated it has "demonstrated that the hydrology assessment estimated an average watershed yield of 323 mm, as the Mean Annual Runoff (MAR) of 154 mm/year is not representative of overall runoff from the upstream catchments but is an unusually low MAR inferred for that specific location due to pronounced interflow or bypass characteristic of reaches along Blairmore Creek". Benga has hypothesized that the apparent differences in MAR for various sub-watersheds can be completely explained by water flowing within gravel channels. While this may explain some of the variation, Benga has not demonstrated that this phenomenon explains all the observed variation. Furthermore, data provided by Benga in Section 4.1.2.3 and Figure 4-2 of the Instream Flow Assessment (CEAR #44) clearly demonstrates that a disproportionally large fraction of the flow in Gold Creek arises in Morin Creek and especially Caudron Creek. Given that the observed MAR of the entire Gold Creek watershed at the Water Survey of Canada Station is 334 mm (Table AER-R2-4-1 in CEAR #89), this suggests that the MAR in the remainder of the Gold Creek watershed, which includes a large portion of the Grassy Mountain mine site, is significantly less than 323 mm. The information previously requested in AER-R2-4 and SIR 84 is therefore still required.

Response:

IR Response overview

The rationale section of JRP IR-5.15 indicates that uncertainties remain within the spatial pattern of runoff across the Blairmore and Gold Creek watersheds. The initial section of this response is provided to first summarize at a high-level our understanding of some key runoff-generating processes that may be contributing to the spatial runoff differences based on available empirical, spatial and other data. This will help to place the runoff modelling results into context within subsequent sections, each dealing with the individual components (a) – (d) as outlined in the IR.

The empirical runoff estimates across the Gold and Blairmore watersheds were previously presented in Addendum 7 (CEAR #72), Table 84-1, and Addendum 8 (CEAR #89), Table AER-R2-4-1, and are repeated again below (Table 5.15-1).

Table 5.15-1 Mean Annual Flow characteristics estimated for LSA gauging stations.

Watercourse	Study Reach/Station	MAD (m3/s)	Drainage Area (km^2)	Average Annual Unit Runoff (mm/year)	Reference Point
Blairmore	Reach 5	0.110	15.0	231	BC-15/H03
	Reach 4	0.175	19.1	289	BC-12
	Reach 3	0.208	32.7	203	BC-2
	BC-H01	0.235	47.7	154	n/a
Gold	Reach 9	0.047	10.8	137	GC-26
	Reach 8	0.068	14.9	144	GC-22
	Reach 7	0.342	31.5	343	GC-7/H01
	Reach 6	0.105	31.8	104	GC-3
	Reach 5	0.392	44.8	276	GC-1
	WSC gauge	0.669	63.3	334	WSC

1 See Table 3-6 of CR#6 for details

2 Includes a small amount (<10%) for missing winter data

Some key drivers of watershed hydrology are outlined below:

Terrain

The Blairmore Creek watershed is lower in elevation than the Gold Creek watershed, with mean elevations of 1,693 and 1,868 masl respectively (Consultant Report (CR) #4, Section 2.4, CEAR #42,). This is primarily due to the Livingstone Mountain Range, which bounds the entire eastern boundary of Gold Creek watershed (max 2,514 masl) as opposed to a smaller proportion

of Blairmore watershed exceeding 2,000 masl (maximum 2,320 masl). A high-elevation area (local name 'Bluff Mountain') also exceeds 2,100 masl less than 3 km to the north-east of the Town of Blairmore from which all drainage to the east flows exclusively into Gold Creek, but is split between Blairmore Creek and an unnamed tributary watersheds to the south. For reference, the wider Crownest River watershed mean elevation (1,711 masl) is in-between the Gold Creek and Blairmore Creek watershed values, but with higher variability given that much of the headwater region is alpine and extends up to 2,785 masl (*i.e.,* Crowsnest Mountain).

The expected increasing relationship between terrain (elevation) and precipitation inputs account for much of the differences between mean annual runoff (MAR) values presented in Table 5.15-1, with the notable exception of the BC-H01 gauge (Blairmore Creek) and Reach 6 (Lille area, Gold Creek) discussed subsequently. The three runoff values estimated for each study reach on Blairmore Creek (200-300 mm, Table 5.15-1) are generally lower than for Reaches 7, 5 and the WSC gauge on Gold Creek (280-340 mm), which is consistent with the higher tributary inflows to the latter group, each sourced within the alpine zone where precipitation inputs should be higher (*i.e.,* Caudron Creek inflow to Reach 7, Morin Creek inflow to Reach 5, Green Creek to the lowest reach including WSC gauge). The northern portion of Gold Creek watershed, which sources the lower-runoff Reaches 9 and 8, lies almost exclusively below 2,000 masl.

Landcover

There are important differences in landcover between the Gold and Blairmore watersheds, which may contribute to the spatial differences in runoff as outlined above. Land cover changes and maps were comprehensively discussed in Consultant Report (CR) #6, CEAR #44, Appendix A2, Section 3.2, from which a summary is described here.

The Blairmore Creek watershed is forested (Photo 15.5-A), as opposed to the Gold Creek watershed (Photo 15.5-B) where forested areas are generally restricted to the northwest and southwest areas of the watershed (Photo 15.5-C). The relative reduction of forest cover in Gold Creek is due in part to the extensive alpine area of the Livingstone Range, and also due to historical logging and mining activities that were disproportionately concentrated in Gold Creek. In an analysis of land-cover during three different years (1982, 1996 and 2015), 19 % of the project LSA was classified to have perceived activity occurring during any year, including activities such as logging or forest management/replanting in logged areas. Nearly all of this activity occurred on Grassy Mountain Ridge and the western flank of the Gold Creek watershed, as seen by the volume of bare (*i.e.,* logged) areas on satellite imagery (Photo 15.5-C).

The higher incidence of bare areas in the Gold Creek watershed, relative to Blairmore Creek, potentially increases the watershed runoff ratio (*i.e.,* runoff per unit precipitation), given that extra runoff may be generated through processes such as decreased canopy interception, decreased canopy transpiration, and decreased soil permeability through soil compaction.

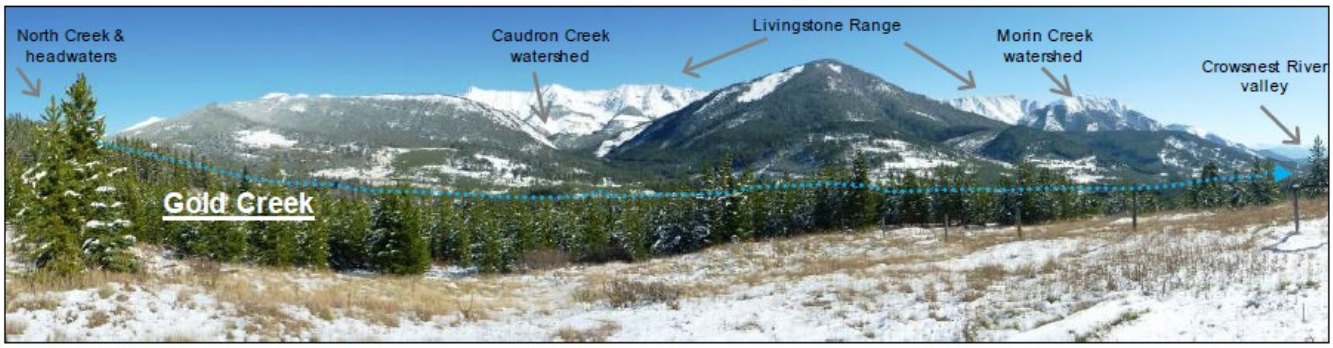
Photo 5.15 Field photos and orthophotos of Gold and Blairmore Creek land-cover

Photo 5.15-A Middle/Upper Blairmore Creek Watershed (looking NW)



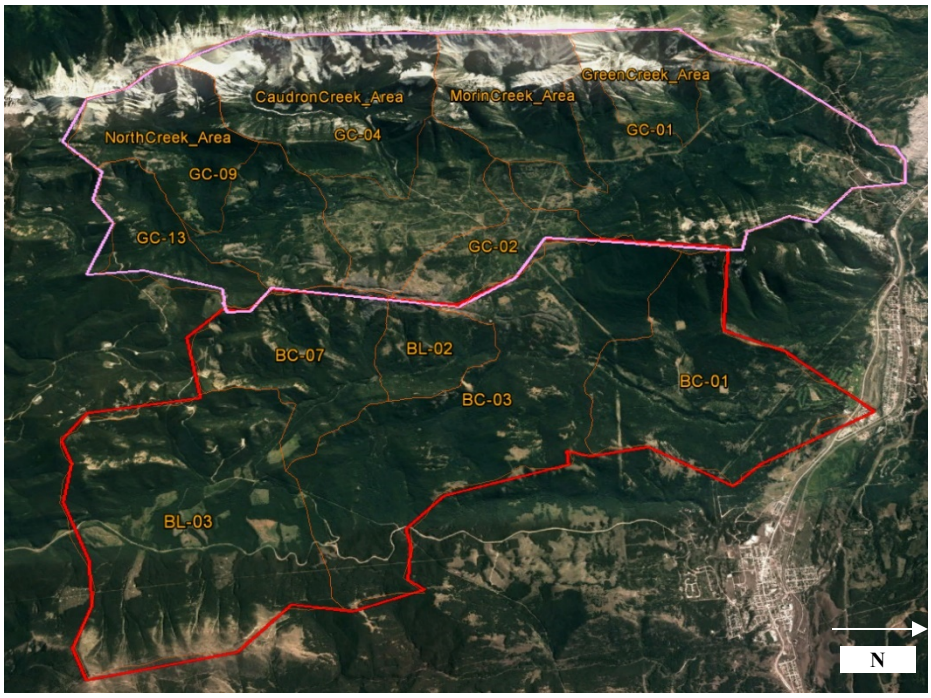
Note: photo looking northwest across Blairmore Creek watershed. Western watershed boundary is the terrain in foreground; Crowsnest Mountain in background is outside of Blairmore Creek Watershed. Source: Mayhood 2015.

Photo 5.15-B Central/Eastern Gold Creek Watershed (looking E)



Note: photo taken on October 12 2016 from eastern slope of Grassy Mountain, looking east across Gold Creek watershed. Gold Creek watercourse (blue dotted line) is approximate and shown for guidance only.

Photo 5.15-C Plan view (Blairmore and Gold creek watersheds)



Hydrogeology

Differences in soil and surficial geology, and ultimately the surface-groundwater interactions, may partly or fully account for the unexpected decreases of surface runoff further downstream both on Blairmore Creek (at BC-H01 gauge, Table 5.15-1) and Gold Creek (Reach 6, Lille area). The hydrogeology characteristics of the study area have been presented within the EIS application (*e.g.,* Consultant Report (CR) #3, Section 4.2, CEAR #42; and Consultant Report (CR) #6, Section 3.1, CEAR #42); however, those details generally refer to spatial scales larger than individual macro-reaches of interest to this specific information request.

As summarized in Consultant Report (CR) #6, Appendix A2, Section 3.1, CEAR #44, a review of regional surficial geology maps shows that surficial material along the channel is predominantly till, with patches of colluvium and exposed bedrock. Unconsolidated materials are generally less than 2 m thick. Closer to its confluence with the Crowsnest River, Blairmore Creek flows through intermittent deposits of finer glaciofluvial material, artificial till and legacy coal mine coal fines (Jackson & Leboe, 1998). Gold Creek flows through sedimentary deposits similar to those within the floodplain of Blairmore Creek, alternating between till and glaciofluvial deposits, with areas of exposed bedrock (Jackson & Leboe, 1998).

Reach 6 Gold Creek

As detailed previously in Consultant Report (CR) #6, Appendix A3, Section 3.3.1.1, CEAR #44, the empirical data collected in support of the Instream Flow Assessment (IFA) identified an area

of localized runoff decrease in Reach 6 of Gold Creek (near Lille) where the surface channel flow was increasingly lost subsurface to the channel bed and bank sediments, which comprise the hyporheic zone. Flow loss through similar 'rock drain' type systems (natural or artificial) have been documented either as targeted studies (*e.g.,* Symons 1987), and in other hydrological assessments (ARD 2011), which support IFA analyses (*e.g.,* Ecofish 2016). The flows measured at sampling transect GC-3 in Reach 6 were 34%, 18% and 36% of the concurrent flows sampled less than 1 kilometre upstream at transect GC-7/H01 in Reach 7, during three IFA field programs with lower flow conditions (July, September and October 2016, respectively). Further downstream in Reach 6, the channel was observed to go completely dry during the fall season visit, implying that the water table dropped below the level of the stream and all flow was conveyed either as interflow or shallow groundwater; please refer to photos in Consultant Report (CR) #6, Section 3.3.1.1, Figure 3-4, CEAR #44, and in the Seventh Addendum Figure 84-2, CEAR #72. Both here and at transect GC-3, nearby side-channels (which could potentially convey the shortfall in surface flow) were observed to be dry.

Since the IFA data was originally published (Consultant Report (CR) #6, Appendix A3, CEAR#44), ongoing monitoring at GC-3 continues to build the hydrometric record and knowledge of relative flow losses during different hydrological conditions. In April 2019, a field visit indicated that the run mesohabitat (GC-3) was frozen to depth, while water was still present in an overwintering pool (transect GC-4) and an adjacent riffle (GC-5) upstream before flowing into the subsurface. In June 2017 during freshet conditions, the entire hyporheic zone was likely saturated, leading to no flow loss at GC-3 (0.81 m^3/s) relative to the measurement at GC-7/H01 one day earlier. Given that the 2016 data were more representative of more typical conditions (*i.e.,* in-between total and zero surface flow-losses relative to adjacent reaches), the Reach 6 estimates of MAR and relative differences to adjacent reaches presented in Table 5.15-1 remain supported while information continues to be collected in this area in support of the habit offsetting plans.

BC-H01 Gauge Blairmore Creek

Flow data collected at the local hydrometric gauges and during the IFA field programs have continued to support a spatial pattern of increasing per unit area runoff downstream from Reach 5 of the IFA (containing gauge BC-15/H03) to Reach 4 of the IFA (containing gauge BC-H02), then a decrease in Reach 3 downstream of the Unnamed Tributary (Reach 3) to a minimum reached at the BC-0/H01 gauge (Table 5.15-1).

An additional review was conducted of available data sources, which may account for some or all of this unit surface runoff loss at BC-H01. Current water licences (both from surface water and groundwater) were queried from the provincial database, and allocated volumes remained negligible along Blairmore Creek.

In a review of hydrogeological information including Consultant Report (CR) #3, Section 4.2, Figure 4.2-2, CEAR#42, and Waterline Resources Inc. (2013), Figure 25, the apparent streamflow decrease is likely attributed to the intersection of Blairmore Creek and Mutz Thrust Fault, a major (regional) thrust fault, intersecting approximately at the intersection of Blairmore Creek and tributary BCT01. Blairmore Creek's orientation is directly along the thrust fault from the confluence of BCT01 through to Blairmore Creek draining into the Crowsnest River, indicating that the creek has been eroding along the fault orientation. Further upstream, the valley bed of Blairmore creek has been mapped as Coarse Stream Alluvium. As the creek drains from the colluvium of Reach 3 into Reach 2 it enters an area mapped as cordilleran moderately leached till (*i.e.,* mountain till type) and into a slightly leached till towards the BC-H01 gauge. Figure 5.15-1 displays the approximate relationship between Blairmore Creek, Mutz Thrust, and BC-H01 gauge.

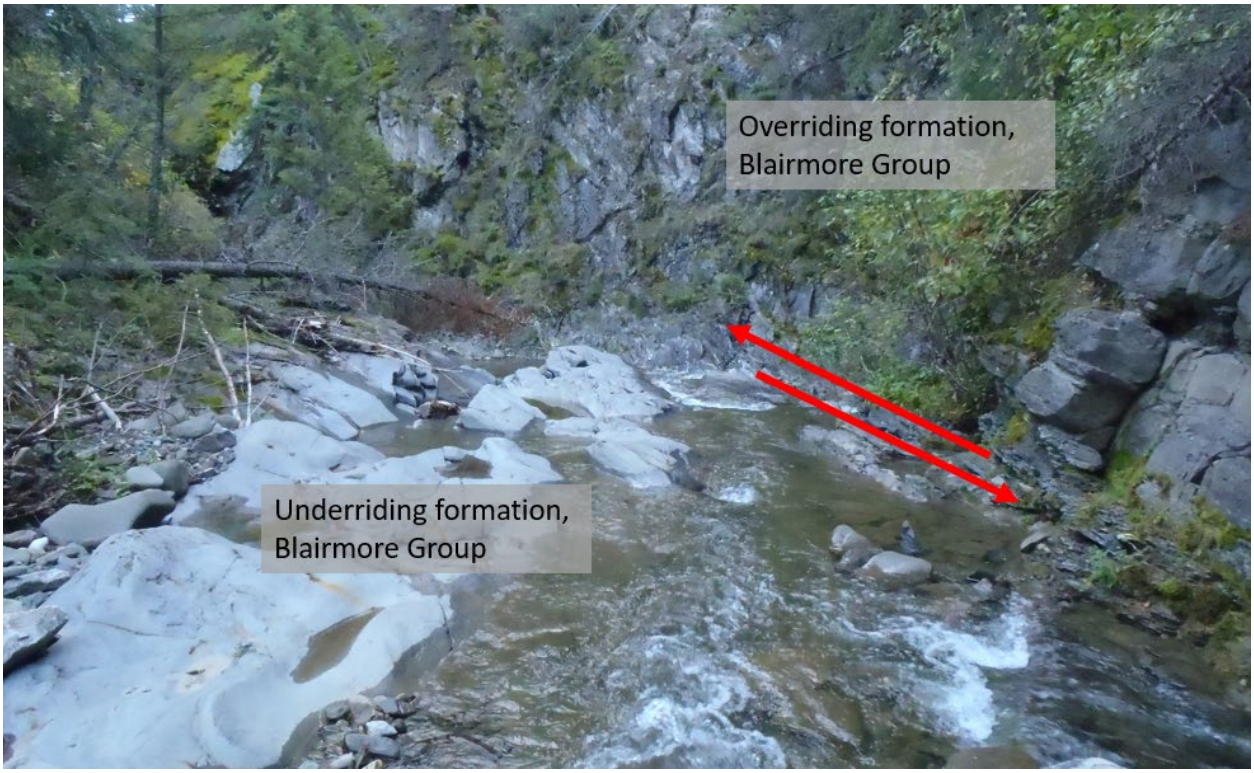
The Mutz Thrust is a regional fault which extends from approximately 6.5 km north of the intersection with Blairmore Creek continuing beyond the map extent (*i.e.,* more than 10 km) as shown on Figure 5.15-1. The Mutz Thrust would have been subject to extremely high tectonic forces, inducing fracturing on either side of the fault, to the extent that Blairmore Creek is a losing stream along this stretch; Blairmore Creek has preferentially followed the Mutz Thrust orientation as the fractured zone represents the easiest weathered formation. At station BC-H01 the Mutz Thrust is overriding Blairmore Group, although the group is undifferentiated on the map and could consist of Beaver Mines Formation (silty mudstone), Gladstone Formation (grey sandstone and shale in the lower part), or Cadomin formation (basal chert and quartzite pebble conglomerate); a conceptual figure of this area is shown in Photo 5.15-D.

Water lost within the Mutz Thrust fault likely will not return as surface channel flow further downstream within Blairmore Creek. Either the water is transferred into the Crowsnest River channel flow, or is lost to the deeper groundwater table. Continued surface flow monitoring at BC-H01 into a future project phase will detect flow changes due to project impacts, but these impacts may be confounded by conditions in the fault and overlying till.

For more robust detection of Project flow impacts, it may be more prudent to move the station approximately 1.5 km upstream along Reach 2, just above the intersection of BC-01 tributary with Blairmore Creek where Mutz Fault is estimated to intersect with Blairmore Creek. This location remains downstream of almost all Project infrastructure. A series of same-day (essentially concurrent) flow measurements, strategically located from the current BC-H01 gauge upstream to the reach break in-between Reaches 2 and 3, will help to confirm where the fault losses begin to occur and where a more reliable station should be located. A period of concurrent monitoring (*e.g.,* 1-year) between the existing BC-H01 and proposed new gauges will help to establish a flow relationship between these sites for purposes of transforming the record at BC-H01 to the new location, not possible through standard methods (*e.g.,* pro-rating based on drainage area).

In summary, the lower value of 154 mm estimated for BC-H01 is impacted by losses to the Mutz fault and would not be a representative value to be applied across the Project area. The higher runoff values from Reaches 3-5 (Table 5.15-1) are more indicative of long-term runoff conditions across the Project area for Blairmore watershed and are more appropriate for use in the hydrological models.

Photo 5.15-D Conceptual diagram of the area around hydrometric gauge BC-H01.



a) Reassess the streamflow changes provided in Section 5.2 of Consultant Report #4 (CEAR #42) using a runoff coefficient for undisturbed and reclaimed areas based on the mean annual discharge of Blairmore Creek.

   i. Update Table 19 and Figures 41, and 43 to 48 accordingly.

   ii. Provide, in table form, all of the monthly flows used to generate Figures 41, and 43 to 48 including the following flow components at each location. Include the information detailed below for the original Figures in Consultant Report #4 and for any updated figures provided in response to the above request.

      I. Stream base flow;
      II. Stream surface runoff (i.e non-base flow stream flow);
      III. Project release rate;
      IV. Change in base flow due to project; and

V. Change in surface runoff due to project.

Response:

As described in the introduction to the IR response above, the unit runoff from the project area is higher than the unit runoff of 154 mm/year measured at the Blairmore hydrometric station BC-H01 since unit runoff in the reaches upstream of this station demonstrably are higher based on flow measurement and monitoring. Therefore, Benga maintains that it would be a mischaracterization of the catchment to use an assumed unit runoff of 154 mm/year to represent the Project area.

The runoff coefficient adopted for the water balance and water quality model assessment for natural ground cover (0.51) was based on yield measured at regional flow monitoring stations. Although the runoff value used appears to be supported by the hydrological monitoring in Blairmore and Gold creeks, the precise applicability of regional flow estimates to specific sub-catchments is difficult to ascertain without a longer hydrological data record. Therefore, Benga completed a sensitivity analysis to evaluate the effects of varying the runoff coefficient for natural ground on the flow regime and water quality in Blairmore and Gold creeks. A runoff coefficient value of 0.41 was selected as the lower limit and 0.61 as the upper limit for the sensitivity analysis. These runoff values correspond to annual unit runoffs of 260 mm/year and 386 mm/year.

The updated figures (as per JRP IR-5.15 i) are presented in Appendix 5.15-1. The data used to generate these figures are included as Appendix 5.15-2. These present the combined changes in surface runoff and base flow due to the Project over the Project life.

The figures were generated using the water and load balance model. Stream base flow and changes to baseflow through the Project were calculated as part of the groundwater modeling. The base flows for each node are included as Appendix 5.15-3.

b) Reassess project impacts on fish habitat in Gold Creek and Blairmore Creek based on the updated project impacts on stream flows discussed in a).

i. If project impacts on fish habitat change as a result of revised stream flows discussed in a), discuss potential changes to fish habitat availability and suitability, provide an updated assessment of Area Weighted Suitability for each bioperiod in Gold and Blairmore Creeks, and provide an updated Fisheries Offsetting Plan presented in Appendix B-1 in Addendum 8 (CEAR #89).

Response:

A wide range of flow conditions were incorporated into estimates of aquatic habitat change, both at the reach scale (Consultant Report (CR) #6, Section 3.5.1, CEAR#44) and for specific critical mesohabitats of concern (DFO-R2-20). A summary of this information is summarized below.

Reach-scale

The IFA independently assessed the change in fish habitat estimated under a wide range of flow conditions and scenarios. For any given combination of project phase, bioperiod, and study reach, the estimates of AWS were also provided for three different flow scenarios of increasing risk to fish habitat, including:

- Average Year conditions;
- 1 in 10 dry year; and
- 1 in 20 dry year.

A visual comparison of MAD estimates between these flow scenarios, for each reach on Gold and Blairmore Creek, was provided in the Consultant Report (CR) #6, CEAR #44, Figure 3.2, indicating that extreme drought values (1 in 20 dry year) were less than half of the average year values. This represents a far wider series of flow scenarios than were generated in the response to 5.15-A above (in which the runoff coefficients were varied by ±0.1 from the natural ground cover (0.51).

The corresponding differences in habitat (AWS) were presented in Consultant Report (CR) #6, (CEAR #44) Tables 4.1-4.3 and 4-7-4.8 for Gold Creek, and Tables 4.4-4.6 and 4.9-4.10 for Blairmore Creek. Drought-period impacts were far greater on Gold Creek, given that these were superimposed onto Project-related flow losses as opposed to Project-related flow gains in Blairmore Creek. Note that the changes in AWS are not necessarily linear with flow and depend heavily on the Habitat Suitability Criteria for each bioperiod and the flow-hydraulic relationships for study reaches (Consultant Report (CR) #6, CEAR #44, Section 4.1.1).

The results suggest that in average conditions for Gold Creek, there were no significant habitat changes of 10% or more when averaged across a given project phase, reach and bioperiod, and only one combination (adult rearing, reach 8 during project operations and decommissioning) yielded habitat changes of 10% for any individual month of a bioperiod. In severe drought conditions, a bioperiod-averaged habitat loss exceeding 10% occurred in two lower flow reaches (9 and 6), and the majority of bioperiods in the lower-flow reaches (9, 8 and 6) experienced individual month losses exceeding 10%.

Mesohabitat-scale

The former Information Request DFO-R2-20 – Ecology (Eighth Addendum to the EIA; CEAR #88) was not referenced within the current IR, but deals specifically with the assessment of flow impacts at spawning gravels and overwintering pools of critical importance to the survival of Westslope Cutthroat Trout.

Reference IR: DFO-R2-20, Eighth Addendum, CEAR #89 (abbreviated for relevance to the current 5.15 IR):

[Further analysis and discussion regarding the impact flow change (less water in Gold Creek and more in Blairmore Creek) will have on limiting critical habitat (i.e., spawning and overwintering) is requested. Under the current AWS assessment, it is difficult to pinpoint impacts on critical habitat as the assessment is a both a reach and bioperiod average result. Limiting critical habitat should involve a more targeted assessment to demonstrate the mine's potential influence on WSCT. 1. Provide specific cross sections through identified overwintering habitat (i.e., deep pools) and an AWS analysis on those specific habitats to clearly demonstrate the impact on overwintering habitat. Currently the AWS shows a reach average and does not appear to target specific field identified critical habitat cross-sections. The same holds true for spawning habitats].

Response to: DFO-R2-20, Eighth Addendum, CEAR #89 (abbreviated for relevance to the current 5.15 IR):

The flow-AWS relationships for each transect are shown in Figure 5.15-2, below (equivalent to DFO-R2-20-1). In each case, the relationship extends from the highest MMD value predicted during baseline conditions in average hydrological conditions (in June for spawning and April or October for overwintering) down to the minimum MMD values estimated at these transects during the following combination of events:

- Months of February and July (minimum MMDs during overwintering and spawning, respectively);
- Year 2041 (when project flow reductions of ~9% are highest); and
- An extreme drought (1-in-20 dry year) hydrologic condition.

Table 5.15-2 tabulates selected AWS values from these relationships, to show the differences resulting from maximum Project flow reductions occurring during average (typical) and extreme drought conditions.

The data indicate that overwintering AWS is extremely insensitive to changes in flow, irrespective of pool and reach. The AWS reductions due to Project effects alone were negligible (few %) and remained limited (<20%) even under extreme drought conditions relative to baseline. These results are consistent with the minimal hydraulic changes outlined above.

Spawning AWS was more sensitive to flow, although the maximum reductions due to Project effects alone remained limited (<10%). Under extreme drought conditions, most of the baseline AWS in average conditions was lost at GC-13 (when both mean velocity and cross-sectional area approximately halved), but almost all of this was natural (*i.e.,* due to drought) rather than due to Project impacts. This is a worst-case scenario which is very unlikely to occur; not only is the probability of a 1-in-20 year low flow year (*i.e.,* with 5% probability of occurrence in any one year) unlikely to coincide with the period of highest predicted Project-related flow losses (2038-

2042), but no short-term mitigation measures have been assumed for supplementing flows during dry years.

Table 5.15-2 Flow-AWS relationships at overwintering and spawning transects on Reaches 7-8

Reach	7 (below Caudron Creek)		8 (above Caudron Creek)	
	Flow (m^3/s)	**AWS (m^2/m)**	**Flow (m^3/s)**	**AWS (m^2/m)**
Overwintering	**GC-11**		**GC-17**	
February (baseline, average conditions)	0.133	0.551	0.008	0.311
February (2041, average conditions)	0.124	0.541	0.007	0.309
February (2041, 1-in-20 dry year conditions)	0.049	0.456	0.002	0.292
Spawning	**GC-10**		**GC-13**	
July (baseline, average conditions)	0.467	1.498	0.114	1.152
July (2041, average conditions)	0.436	1.463	0.104	1.075
July (2041, 1-in-20 dry year conditions)	0.189	0.779	0.027	0.084

c) Provide the Gold Creek and Blairmore Creek flows and release volumes used in the Water and Load Balance Model to calculate instream concentrations of water quality parameters.

Response:

The release volumes used in the water and load balance model to calculate concentrations are the same flows as those included as Appendix 5.15-2.

d) Present the results of sensitivity tests of the Water and Load Balance Model in the same manner presented in Section 8.2 of the Water and Load Balance Model report for a range of potential runoff coefficients for undisturbed and reclaimed areas, specifically:

i. the 0.51 value used in the report;

ii. a value based on the runoff coefficient derived from runoff and precipitation data in the Blairmore Creek watershed (that is, the value derived above).

Response:

As described in the response to Part A, a sensitivity analysis of model results was conducted using runoff coefficients for natural ground of 0.41 (lower range) and 0.61 (upper range). Scenarios were run for each of the three runoff coefficients: 0.41, 0.51, and 0.61.

The analysis included variations in:

- capture efficiency applied to contact water from the ex-pit waste rock disposal areas;
- attenuation factor applied in the SZs;
- pit wall thickness used to calculate the volume dependant generation rates of sulphate and selenium from the pit walls;
- yield coefficient for reclaimed areas which, in the base case, assumes the objective of reclamation is stability only and not reduction in infiltration; and
- leakage rates from the pit lake and leakage rates from the SZs, input for both are based on the groundwater analysis.

Table 5.15-1 summarizes the scenarios modelled in the sensitivity analysis. The sensitivity range describes how much the variable that is being changed differs from the base case value. All of the sensitivity analysis scenarios were run under average hydrological conditions.

Table 5.15-1 Sensitivity Cases Modelled

Variable	Case	Description	Sensitivity Range
Capture Efficiency	1A	Base case capture efficiency	95% efficiency
	1B	Upper case capture efficiency	100% efficiency
	1C	Lower case capture efficiency	80% efficiency
Attenuation Factor	2A	Base case SZ attenuation factor	99% Se removal
	2B	Upper case SZ attenuation factor	99.9% Se removal
	2C	Lower case SZ attenuation factor	90% Se removal
Pit Wall Thickness	3A	Base case pit wall thickness	1 m
	3B	Upper case pit wall thickness	2 m
	3C	Lower case pit wall thickness	0.5 m
Leakage Rate from Saturation Zone	4A	Base case SZ leakage rate	x 1
	4B	Upper case SZ leakage rate	x 1.25
	4C	Lower case SZ leakage rate	x 0.75
Leakage Rate from Pit Lake	5A	Base case Pit Lake leakage rate	x 1
	5B	Upper case Pit Lake leakage rate	x 1.25
	5C	Lower case Pit Lake leakage rate	x 0.75

Capture Efficiency

The model sensitivity to the capture efficiency of ex-pit waste rock contact water was evaluated in the water quality at prediction node BC03 in Blairmore Creek. This prediction node is downstream of where contact water that has bypassed the capture system from the North, Central, and South rock disposal areas reports.

Figure 5.15-3 to Figure 5.15-5 present the results of the sensitivity test.

- Selenium concentrations at BC03 were higher with a runoff coefficient of 0.41 than they were with a runoff coefficient of 0.51.
- Selenium concentrations at BC03 were lower with a runoff coefficient of 0.61 than they were with a runoff coefficient of 0.51.
- The differences in the results using different runoff coefficients was less than the difference between the three scenarios presented as part of the sensitivity test.

The sensitivity of instream water quality to the ex-pit waste rock contact water capture efficiency demonstrates the need for this mitigation to work very well to achieve compliance. This remains the case with the different runoff coefficients.

Attenuation Factor

The attenuation factor for selenium impacts the concentration leaving the SZs. The model assumes that a maximum selenium concentration of 0.015 mg/L for the SZ effluent will be attained through engineering and addition of a carbon source if required. This maximum concentration was removed for this sensitivity analysis.

The sensitivity of the model evaluated selenium concentrations in Blairmore Creek at prediction node BC03 which is downstream of all effluent discharge from the water treatment plant. The concentration leaving the SZs is not changed by the runoff coefficient of natural and reclaimed areas, and this sensitivity is not presented here.

Attenuation factors of 99% (Case 2A), 99.9% (Case 2B) and 90% (Case 2C) were evaluated.

Figure 5.15-6 to Figure 5.15-8 present the results of the sensitivity tests.

- Selenium concentrations at BC03 were higher with a runoff coefficient of 0.41 than they were with a runoff coefficient of 0.51.
- Selenium concentrations at BC03 were lower with a runoff coefficient of 0.61 than they were with a runoff coefficient of 0.51.
- The differences in the results using different runoff coefficients was less than the difference between the three scenarios presented as part of the sensitivity test.

The SZ concentration is very sensitive to the attenuation factor. SZ water is a major source of selenium loads to Blairmore Creek *via* two flow paths: direct leakage from the SZs and *via* the water treatment plant effluent.

Pit Wall Thickness

The sensitivity of model results to a change in pit wall thickness is evaluated for parameters for which generation rates are dependent on rock volume (*i.e.,* parameters associated with blasting residues). Results are evaluated downstream at node GC10 for pit wall rubble thicknesses of 1 m (Case 3A), 2 m (Case 3B) and 0.5 m (Case 3C).

Figure 5.15-9 to Figure 5.15-11 present the results of the sensitivity test.

- Selenium concentrations at GC03 were higher with a runoff coefficient of 0.41 than they were with a runoff coefficient of 0.51.
- Selenium concentrations at GC03 were lower with a runoff coefficient of 0.61 than they were with a runoff coefficient of 0.51.
- The differences in the results using different runoff coefficients was less than the difference between the three scenarios presented as part of the sensitivity test.

The sensitivity of instream water quality to the ex-pit waste rock contact water capture efficiency demonstrates the need for this mitigation to work very well to achieve compliance. This remains the case with the different runoff coefficients.

The nitrate concentrations in the creek are highly sensitive to the pit wall thickness. The predicted concentrations at the prediction node remain low even with a pit wall thickness of 2 m and a runoff coefficient of 0.41.

Leakage Rate from Saturation Zones

The sensitivity of model results to a change in leakage rate from the SZs of 25% from base case conditions is evaluated for sulphate in Blairmore Creek at prediction node BC03, immediately downstream of the mine area. The results are presented for the base case SZ leakage (Case 4A), an increase in leakage of 25% (Case 4B) and a decrease in leakage of 25% (Case 4C).

Figure 5.15-12 to Figure 5.15-14 present the results of the sensitivity test.

- Selenium concentrations at GC03 were higher with a runoff coefficient of 0.41 than they were with a runoff coefficient of 0.51.
- Selenium concentrations at GC03 were lower with a runoff coefficient of 0.61 than they were with a runoff coefficient of 0.51.

The sulphate concentrations are not very sensitive to the different leakage rates. All sulphate concentrations downstream of the mine area are predicted to be between 500 and 600 mg/L at closure.

Leakage Rate from Pit Lake

The sensitivity of model results to a change in leakage rate from the pit lake is evaluated for sulphate in Gold Creek at prediction node GC10, where pit lake leakage reports. The results are presented in Figure 5.15-15 for the base case pit lake leakage (Case 5A), Figure 5.15-16 for an increase in leakage of 25% (Case 5B) and Figure 5.15-17 for a decrease in leakage of 25% (Case 5C).

The sulphate concentrations are not significantly impacted and the model is not very sensitive to this variable. The sulphate concentrations do not significantly change with the different runoff coefficients in the model.

References

(http://ftp.maps.canada.ca/pub/nrcan_rncan/publications/ess_sst/184/184170/gscmap-a_1829a_e_1993_mn01.pdf).

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https://static1.squarespace.com/static/55775efbe4b02c5614691727/t/5907843f15d5db8f8bc8a882/1493664933861/CRW+Aquifer+Mapping+%26+Groundwater.

5.16 Information Request 5.16

Eighth Addendum to the Environmental Impact Assessment. AER-R2-6 and AER-R2-7. (CEAR #89).

Benga has provided some return flow information through responses to AER-R2-6 and AER-R2-7 in Addendum 8 (CEAR #89). However, there is still an information gap with respect to how return flows will help meet Water Conservation Objectives (WCO) in the Crowsnest River and probable Instream Objectives (IOs) in Blairmore and Gold Creeks. Benga should not assume that Instream Objectives and/or Water Conservation Objectives would not apply to the new licences resulting from the transfers; as these may be necessary as mitigation measures. In the response to AER-R2-7 in Addendum 8 (CEAR #89), Benga noted that "within the surface water management plan, Benga will store significant volumes of water on site and will be able to [release], and plan to release water to Blairmore and Gold Creeks". In addition, Benga stated that "achieving the WCO will be possible as a result of this excess storage of water and ability to release it to either creek". The Panel requires additional details in order to better understand how the Proponent intends to meet the Water Conservation Objectives and Instream Objectives.

With respect to part c of information request AER-R2-7 in Addendum 8 (CEAR #89), the response is in a format (monthly baseline flows) that is not usable by the Panel to recommend minimum flow requirements on Blairmore and Gold Creeks. Determining the Instream Flow Needs (IFN) by calculating weekly Q80 flows using the Alberta Desktop Method will allow the weekly Q80 flow to be used as a minimum flow requirement (cut-off) in service of the instream flow needs.

a) Provide weekly Q80 (IFN) cut-off flows for both Blairmore and Gold Creeks, as per the Alberta Desktop Method.

Response:

The weekly Q80 flows for both Blairmore and Gold creeks were calculated using the Alberta Desktop Method and are provided in Table 5.16-1. The weekly data used for the calculation was derived from a 40-year period of record from 1975 to 2016.

Table 5.16-1 Weekly Q80 (IFN) Cut-off Flows for both Blairmore and Gold Creeks (Alberta Desktop Method)

Week	Blairmore Creek near mouth (BC-H01 hydro station)	Gold Creek near mouth (WSC station, infilled)
	IFN (m^3/sec)	IFN (m^3/sec)
1	0.05295	0.29625
2	0.05180	0.28816
3	0.05164	0.28672
4	0.05144	0.28455
5	0.04972	0.27139
6	0.04909	0.26673
7	0.04846	0.26317
8	0.04863	0.26389
9	0.04983	0.27199
10	0.05047	0.27698
11	0.05444	0.30372
12	0.05546	0.31049
13	0.07035	0.32075
14	0.16643	0.32672
15	0.20288	0.39758
16	0.24376	0.45730
17	0.34125	0.61874
18	0.28756	0.70877
19	0.39940	0.84925
20	0.66564	1.17578
21	0.98249	1.63089
22	1.05673	1.63140
23	1.01045	1.65383
24	0.74372	1.38947
25	0.73104	1.41122
26	0.48097	1.11644
27	0.31235	0.88979
28	0.25235	0.82890
29	0.17354	0.73683
30	0.13866	0.65531
31	0.10829	0.58821

Table 5.16-1 Weekly Q80 (IFN) Cut-off Flows for both Blairmore and Gold Creeks (Alberta Desktop Method)		
Week	**Blairmore Creek near mouth (BC-H01 hydro station)**	**Gold Creek near mouth (WSC station, infilled)**
	IFN (m^3/sec)	**IFN (m^3/sec)**
32	0.12523	0.62806
33	0.09624	0.53813
34	0.08266	0.49982
35	0.07241	0.47578
36	0.06836	0.46434
37	0.07842	0.46521
38	0.07857	0.47391
39	0.06530	0.44812
40	0.07148	0.44484
41	0.06368	0.43719
42	0.07479	0.43002
43	0.06534	0.41594
44	0.05771	0.39979
45	0.06927	0.39155
46	0.07432	0.37494
47	0.05160	0.35091
48	0.04946	0.34116
49	0.05872	0.34208
50	0.05856	0.33928
51	0.05517	0.31188
52		0.30604

b) Provide a comprehensive and detailed water return strategy that describes how water will be returned to both Blairmore and Gold Creeks in order to:

i. achieve the WCO requirement on the Crowsnest River. Include details of return timing, volume and rates that will address the reduction in natural flows due to operations. Benga should use the historical WCO performance of the Crowsnest River to demonstrate when shortfalls are expected.

Response:

The water release points for the Project are planned to be from the sedimentation ponds. The ponds releasing into the Gold Creek drainage are planned to be the northeast sedimentation pond and the east sedimentation pond. The ponds releasing into the Blairmore Creek drainage are

planned to be the west sedimentation pond and the plant site sedimentation pond. The saturated backfill zone is also planned to release into Blairmore Creek. The release points are shown on Figure 5.16-1. Water volumes will be measured at each of the discharge points, as will the quality of water.

There will be no reduction in Crowsnest River natural flows as a result of mine operations, upstream of the confluence of Blairmore and Gold Creeks and below what has already been licenced. This was partially addressed in a previous submission, Addendum 5, AER-R1-207 and 208, provided as Appendix 5.16-1 for ease of reference. The "in good standing" process that was previously completed with Alberta Environment and Parks (AEP), showed the licences that are proposed to be transferred, could be used at their existing locations and were not subject to WCO minimum flows. The transfers to Blairmore and Gold Creeks would therefore result in water travelling further downstream than the initial licenced withdrawal locations further upstream on the Crowsnest River (Figure 5.16-1), which will increase the frequency of the WCO being met between the original upstream diversion points and the Blairmore and Gold Creek confluences, and no change to the Crowsnest River WCO below Frank due to the proposed transfers.

The WCO on the Crowsnest River below Frank may only be affected by the new application/allocation on Blairmore and Gold Creeks. For the purpose of understanding how often the new licence may be suspended by the WCO restriction on the Crowsnest River, information was requested from AEP on what the current WCO is for the Crowsnest River and was received in the form of two pieces of data and a formula. The data is a set of naturalized flows at the WSC station "Crowsnest River at Frank" for the years 1928 to 2009, and a set of weekly flows calculated in 1995 using the old and outdated modified Tennant/Tessman minimum flow methodology referred to as an "IO" or Instream Objective.

The formula for the WCO was represented as either 45% of the naturalized flow or the IO plus 10% whichever is greater.

The IO is substantially greater than 45% so a comparison calculation was prepared for the provided naturalized river flow data set and the frequency that the IO plus 10% would equal the naturalized flow. Normally the second step would be to subtract the licenced diversions, in a reasonable proportion to their annual typical pattern of use, from the naturalized river flow to see how often the new licenced diversion would be restricted.

The analysis of the AEP data showed the calculated WCO (previously presented in Addendum 8, AER-R2-6, and AER-R2-7 which are attached as Appendix 5.16-2) often exceeded the naturalized river flow for much of the year, for all modelled years without considering any of the existing licenced diversions. A copy of the data calculations and graph was previously presented in Addendum 7, #207, which has been attached as Appendix 5.16-3. This result is impractical. The reason behind developing a WCO for a watercourse in Alberta was to identify a reasonable

portion of a stream flow that must remain in the stream to protect the instream environment. (*Water Act* sec 1(1)(hhh)). A formula that frequently identifies more water than is naturally available in the stream suggests an error in either data or methodology used to create the naturalized river flow data. The issue was described to AEP, with a request for clarification of any potential data misalignment. No response was received on why the AEP data produced a WCO requirement greater than the natural flow.

The data issues prevent a reasonable analysis of the impact of the new licence on the Crowsnest River WCO; however, it is reasonable to assume that the protection of the instream flow needs on Blairmore and Gold Creeks will ensure the Crowsnest WCO continues to receive at least the WCO equivalent flow from the Blairmore and Gold Creek tributaries for the period of time the mine operates.

ii. achieve the Instream Objectives (IO) based on the Alberta Desktop method. Describe how much water is expected to be returned at times when the IO is not being met at either Blairmore or Gold Creek. Note that return flows are based on the amount of water that would have been expected to flow to the creeks in the absence of a mine development/operation. The response should include the volumes and rates of return as well as the locations where the returns are expected. The location of the return is vital to not only meet the IO at a specific location but to benefit reaches within the creeks.

Response:

This IR refers to the Instream Objectives (IO) based on the Alberta Desktop Method. It is assumed that the reference to IO in this request is meant to be the same values requested in part a) which refers to Q80 (IFN).

Instream Objectives:

There are high uncertainties associated with applying a provincial-scale, desktop-based IFN assessment method. Uncertainties are much reduced using the detailed, field-based method associated with our IFA, in which actual changes in stream hydraulics, and the alterations on habitat suitability, have been assessed specifically for resident species such as WSCT that accounted for the preservation of ecological function requirements.

The detailed IFA executed as part of CR#6 specifically focused on the upper and mid-watershed reaches of both Blairmore and Gold creeks, focusing on defined WSCT critical or conservation status habitat. The results of the IFA, which compared estimated habitat quantity (AWS) during baseline and each Project phase based on flow differences between these periods, indicated that habitat alterations/losses were restricted to Gold Creek (where predicted Project-related total flow losses are predicted) but were generally limited during an average hydrological year (bioperiod-average losses of <10%, classified as not significant). During drought events

(*e.g.,* 1-in-10 or 1-in-20 dry years), bioperiod-average losses of AWS were a maximum of 11% and worst-case habitat losses in individual months remained at or below 20% AWS. Habitat gains are predicted for Blairmore Creek where flow increases are anticipated.

Although the IFA was not conducted near the mouth of these creeks, relative changes in total flow from the project are buffered here given that extra (un-impacted) natural runoff contributes to the creeks downstream of the project infrastructure (*i.e.,* a simulated flow reduction of 10% at GC-01 would imply higher flow reductions of >10% at upstream nodes where the natural flows are lower, and so on). Total flow changes were presented in Figures 43-48 of the EIA (CEAR #42, Consultant Report #4) in which the at or near-mouth assessment nodes are indicated by GC-01 and BC-01 for Gold and Blairmore creeks, respectively.

The IFA results summarized above suggest that even drought-period average losses of up to 11% in upper or mid-reaches of Gold Creek, resulting in (hypothetical) losses of <11% at the mouth and would support the IFN values calculated at the mouth using the Alberta Desktop Method (in which flow losses at or below 15% must be maintained at or above the Q80 ecosystem base flow, and no flow losses are permitted below this Q80 ecosystem base flow). The assumption is made that below the ecosystem base flow (*e.g.,* during droughts), one or more of the proposed adaptive management strategies would be implemented on the Project to conserve losses of flow and ultimately fish habitat.

Delta Stormwater:

It is expected that the calculation of stormwater made available by the hardening of natural surfaces will have an impact on the calculation of the volume of water required to be licenced when the "delta" water is collected and stored.

The Grassy Mountain Project will collect stormwater that otherwise would have been consumed by vegetation, thus "delta" water.

The release of the AEP policy will determine how the amount of water will be calculated as "diverted" from the exposed mine surface, thus making the calculation of the naturalized flows in the above examples more accurate.

Note: AEP has announced that the Delta Stormwater Availability Tool will be available soon. It is expected that this tool will be applicable to the Grassy Mountain Project.

Excerpt from the Alberta Water Council Board of Directors meeting June 25, 2019:

2. *Water Reuse Guidebook*

- *Stakeholder engagement sessions were completed on February 13, 2019. Written and in-person feedback has been compiled and is being considered for the next draft of the guidebook.*

- *The department is now working to determine the number of applications that will be received in the short to medium-term to assess staff capacity and resourcing requirements.*
- *The Delta Stormwater Availability Tool (DWAT) needs to be finalized and made available via the Environment and Parks website for use by interested project proponents.*

Water Diversion:

The volume of water diverted from Blairmore or Gold Creek will vary throughout the life of the mine development, being the smallest at the start when only small areas are cleared/disturbed to being larger as disturbance increases (annual development was shown in the initial application, Figures C.1.3-1 to C.1.3-26). In the initial mine development stages, water will be used or prevented from entering the natural system from existing non-contributing ponds constructed in previous mining operations and from the initial soil or overburden removal areas. The unit runoff from each of the mine development areas has been identified in the hydrology assessment report (CR#4, Section 3.5). The pre-mine development runoff coefficients can be used to calculate the diverted water volume and natural flow rates as the mine development area progresses. Those values (mine diversions) will be used to determine the volume of water not arriving at the stream gauging stations due to the mine operations.

The stream measurement station recorded value will have the mine diversion calculated diversion added to create the naturalized flow value. The naturalized flow value will be compared to the IO value for that period. If the IO is not being met, mine storage ponds will release up to the calculated mine diversion volume and rate for that period up to the volume and rate of flow needed to meet the IO in each stream. The water storage ponds that capture stormwater will include the sedimentation ponds (4), the active mine pits which will hold water from surface runoff and groundwater sources and the saturated backfill areas (3).

Releases will be made from the highest elevation ponds first to ensure as much of the respective streams receive flow as possible.

Flow Augmentation Calculations:

Benga proposes to use the following formula to calculate the volume and rate of release from stormwater storage to each creek:

- Stream gauge flow value + calculated diversion from area developed runoff coefficient = naturalized flow
- Naturalized flow - weekly Q80 cut-off flows = required flow
- Stream gauge flow – required flow = release from storage

Example 1:

Gauge flow is 20

Diversion is 6
Naturalized flow is 26
IO chart requirement is 20.8
Reservoir will release 0.8

Example 2:

Gauge flow is 6
Diversion is 0 (frozen)
Naturalized flow is 6
IO chart requirement 6 (minimum flow condition)
Reservoir release is 0

Return flow will be made first at the highest elevation release point, and then from lower storages as determined by the location of the mine activity and therefore water diversion areas.

Benga suggests that the formula as noted above be accepted in principle, and the specific calculations for this project be developed before project start-up as per the AEP Delta Water policy as it is made available.

iii. meet expected return conditions as a result of transferring licences that may not have been utilized fully in the past or that have return flow requirements such as the municipal licence. Benga should present the best strategy to meet the expected return from licences while helping to meet WCOs and/or IOs.

Response:

The current licences do not have return flow conditions and the transferring of the licences will not have return flow conditions. The "in good standing" process that was completed with AEP showed that both licences could have been fully utilized at their original locations and Benga was prepared to facilitate full use of each licence if it was necessary to show full utilization was possible.

If the licences are not approved for transfer they can still be fully utilized at their current location, therefore there is no disadvantage to the public or the watercourse if the transfers proceed. This is also discussed in Appendix 5.16-1. In fact the watercourse will realize additional flows as the water is allowed to flow downstream to the new diversion locations.

The municipal licence does not have return flow requirements. Most municipal licences have a line on the licence that refers to "estimated return flow" volumes. That line along with losses and consumption were included to indicate where the total diversion volume was calculated from. Neither return flow or losses identified on licences are enforceable volumes intended to be minimum volumes returned. In fact, AEP encourages the reduction of return flow to reduce the impact of water quality on receiving streams. The municipality has advised AEP that it intends to use the municipal licence when it is returned to them at the completion of mine operations for

the golf course irrigation and ski hill snow making so that those purposes will not require the processing of the water through the water treatment plant, thus saving expenses and backwash flow releases and energy and lengthening the period before the water treatment plant capacity is reached. Both water uses do not return water continuously.

Benga is committed to minimizing the impact of the Grassy Mountain Mine water use on both Blairmore and Gold Creeks by ensuring the fully protective IO for both streams is met through the storage of surplus stormwater and its release at critical flow periods. The formula presented above to identify the amount of water diverted by the mine footprint, measure the streamflow, calculate the IO and return diverted water that may reduce the streamflow below an IO, will ensure there is no impact on the instream flow needs of Blairmore and Gold Creeks.

5.17 Information Request 5.17

Grassy Mountain Coal Project - Updated Environmental Impact Assessment. Consultant Report #3 – Hydrogeology. (CEAR #42).

Second Addendum to the Environmental Impact Assessment. (CEAR #53).

In the review of allocations in Benga's hydrogeological Local Study Area and Regional Study Area (RSA), Table B15 of Consultant Report #3 (CEAR #42) showed that there are numerous Traditional Agricultural Registrations in the area. The Traditional Agricultural Registrations are held by Public Land Management. Although Benga provided a list of the Traditional Agricultural Registrations in Consultant Report #3, there is no assessment of effects from the Project on traditional agricultural users.

In Consultant Report #3 Benga stated: "In addition to the 11 groundwater licenses, there are 101 surface water licenses, withdrawing from the Crowsnest River, Gold Creek, Blairmore Creek, Morin Creek, Caudron Creek, York Creek, Pelletier Creek, unnamed tributaries and unnamed lake, within the RSA. The licensed groundwater and surface water user locations are shown in Figure 4.6-3 and details are summarized in Table B15" (CEAR #42).

However, there is no assessment of impact on the surface water licenses (traditional agricultural registrations) along Blairmore Creek, Gold Creek and other surface water creeks and tributaries within the RSA presented in either Section 5.3.2 of Consultant Report #3 or in the Water Act application in Addendum 2 (CEAR #53).

a) Provide an assessment of the Project's effects on the traditional agricultural registrations within the hydrogeological Regional Study Area and propose mitigation measures that take into account the senior right (priority in time) of the traditional agricultural registrations.

Response:

Addendum 2, Appendix 1E (*Water Act* Licencing Application) (CEAR #53), Sections 3.2, 3.3 and 3.4 provided an assessment of the Project's Effects on the other surface water rights holders and traditional agricultural registrations within the hydrogeological RSA and beyond, capturing

the Crowsnest River to the Oldman Reservoir. In summary, there will be positive impacts to rights holders upstream of the confluence of Gold Creek and the Crowsnest River as upstream licenses previously belonging to Devon, and the Municipality of Crowsnest Pass which were being withdrawn at points upstream will now be drawn at Gold Creek. For other rights holders downstream, there will be no impact from these license transfers. The third license Benga has applied for is water reserved and available under the Oldman River Basin Water Allocation Order (the "Order"), Alberta Regulation 319/2003 and amended to 109/2010; this license will be junior with respect to all downstream users and therefore will also have no impact. In terms of mitigation, the Project introduces significant storage capacity that can help to bridge periods when there is a shortage and more senior water rights holders have priority.

b) Describe how these senior priority registrations would affect Benga's water needs and usage.

Response:

Please see response to part JRP IR 5.17 a).

c) Describe how Benga will ensure protection of "Traditional Agriculture User" rights, especially those rights to water from Blairmore Creek, Gold Creek and associated tributaries.

Response:

Please see response to part JRP IR 5.17 a).

HYDROGEOLOGY

5.18 Information Request 5.18

Grassy Mountain Coal Project – Updated Environmental Impact Assessment. Section E – Project Description. (CEAR #42).

Grassy Mountain Coal Project – Updated Environmental Impact Assessment. Consultant Report #3 – Hydrogeology. (CEAR #42).

Fifth Addendum to the Environmental Impact Assessment. Appendix A-3. (CEAR #69).

From the Tsuut'ina Nation to the Joint Review Panel re: Grassy Mountain Coal Project - Comments on Environmental Impact Statement. (CEAR #192).

As stated by Benga in Consultant Report #3 (CEAR #42), rainwater and snow melt will leach minerals (such as selenium) from the fresh surfaces of the rocks stored in the rock pile areas. There are two pathways this leachate can take to reach receptors: surface water run-off and groundwater. For the groundwater pathway, the resulting leachate can infiltrate into the soil and become part of the groundwater beneath the rock pile areas.

Depending on the topography and existing groundwater gradients, pathways and travel-times for contaminated groundwater to reach receptors will vary.

Identifying contaminated groundwater is key in being able to mitigate potential effects to receptors. Groundwater monitoring is commonly implemented immediately downgradient from potential contamination sources, in order to have an "early warning" that contamination exists and has entered a pathway to receptor(s). Once groundwater contamination has been identified, remediation measures can be implemented to remove the contamination, and additional monitoring will be needed to assess the success and efficiency of the remediation measures.

Consultant Report #3 (Section 4.6, CEAR #42) notes that the groundwater flow system in the area is not simplistic as a result of the complex geology, as illustrated by Figures 4.2-1 to 4.2-9. While Benga indicates that major thrust faults are expected to be a control mechanism for lateral groundwater flow and local fractures appear to enhance flow within geological units, rather than across bedding planes, ultimately the consultant report states "the actual behavior of each fault is uncertain, as some may act as barriers, while others may act as conduits likely depending in part on the rock type at a particular location". The complex geology, and potentially groundwater flow system, is further confounded by the presence of historical mine workings (Figure 4.3-1).

In Appendix A-3 in Addendum 5, Benga presented a conceptual groundwater seepage monitoring plan. Although Benga has committed to installing monitoring wells as part of the groundwater monitoring program (Section E in CEAR #42, CEAR #69), the groundwater monitoring plan presented in the updated EIA lacks actual field characterization and may prove inadequate should fractures and/or existing mine tunnels or adits prove to be paths for contaminated groundwater. The potential would then exist for contaminated groundwater to by-pass the downgradient monitoring proposed by Benga. While the existence of specific fractures is unknown, monitoring of water within historical mine tunnels may provide useful data. Protecting receptors is the main goal and monitoring at specific locations upstream of the receptors is necessary in case contamination finds a pathway around the monitoring immediately downgradient to the sources.

a) Update the groundwater transport model and provide detailed information on rock structures, groundwater and a Groundwater Monitoring Plan that addresses the following points:

   i. identify and plot structures (using existing drill logs and rock core) to create a 3D model of water pathways;

   ii. show modeled pathways and travel-times to receptors, acknowledging that there could be shallow and deep pathways, and accounting for historical mine tunnels;

   iii. identify groundwater transport pathways, and any gaps in data, from the sources to the different receptors;

   iv. describe any uncertainty associated with the model and the predicted groundwater transport pathways.

Response:

The groundwater transport model developed for the Project is based on a reasonable, though limited, dataset and acceptable calibration. It was used to determine the potential range of change or to bracket potential effects that may occur due to a given stress. It was constructed using all available information on geological units, geological structures, and groundwater.

Since the submission of the EIS, Benga has conducted additional drilling to improve the characterization of the geology (Figure 5.18-1), and additional drilling will continue to occur as part of final engineering design exercises to assist in determining the aquifer parameters downgradient of selected ponds. On review of the newly acquired geotechnical borehole logs, the information collected since the model construction is consistent with the hydrogeological conditions used in the model construction and does not warrant an update of the groundwater transport model, as it would only result in similar predictions.

With regards to the complete identification and 3D modeling of the groundwater pathways, including the historical mine tunnels, attempts have been made to locate and identify the historical mines without success. In 2014, Benga conducted a drilling program to locate one of the historical mine tunnels and install a potential water supply well into the underground workings. The program consisted in the drilling and completion of one water supply well to a maximum depth of 159 meters below ground level (mbgl). The drilling program did not encounter the historical mine. Underground investigation for historical mines is difficult and uncertain despite the use of available maps. Information regarding the locations of chambers, pillars and walls are not georeferenced and therefore the locations can only be approximated by measurement from known features. Information included in the model were based on the best available information.

Uncertainties within the model and the modelled predictions will be addressed through the use of an adaptive monitoring and management plan. Results from the model were used to select monitoring locations and areas requiring monitoring to confirm the modelling predictions and

ensure all of the associated receptors are effectively monitored prior to any impact associated with the mining activities. Results from the monitoring will be compared with the modelling predictions, and in context with the mining operations and the need for additional monitoring or the implementation of adaptive management re-assessed regularly.

v. identify all planned source locations, i.e. rock pile areas, and any other potential sources of contamination including sources that may arise due to extreme flood events;

Response:

As listed in CR#3 Section 5.1 (CEAR #42), sources that could affect groundwater quality and potential receptors include the surge ponds (northwest surge pond, southwest surge pond and southeast surge pond), sedimentation ponds (northeast sedimentation pond, east sedimentation pond, west sedimentation pond, plant site sedimentation pond and rail loadout sedimentation pond), the saturated fill zones, raw water pond, diversion ditches and drainage controls, and rock pile areas (north rock disposal area, central rock disposal area and south rock disposal area). To a lesser degree, facilities within the CHPP handling or storing waste oil, lubricants and gas & diesel for the site's vehicles are also considered as potential sources.

The end pit lake is not identified as a potential source as the water stored in the lake is located in its own groundwater catchment area.

The metal treatment plant and sewer treatment package plant (treating domestic wastewater) are not considered a source under normal conditions but could become a source following extreme flood events.

vi. identify potential receptors;

Response:

Potential receptors, also identified as valued components in CR#3 (CEAR #42), include:

- bedrock aquifers;
- groundwater discharge to surface water bodies; and
- domestic and municipal water wells.

vii. provide an assessment of where monitoring wells should be placed to protect the receptors should monitoring immediately downgradient from the sources fail to capture impacts due to fractures, and/or existing historical mine tunnels, etc.;

Response:

Monitoring associated with the hydrogeological assessment portion of the Project will be integrated with other groundwater and surface water monitoring programs, such as programs intended to assess surface water quality and quantity near Blairmore Creek and Gold Creek (refer to the Aquatics Monitoring Program JRP IR-5.4) and the selenium management plan. The

objective will be to provide an integrated monitoring and management plan for the Project, providing quality data for the various monitoring programs, including, groundwater, surface, and aquatic life.

With regards to the specific groundwater monitoring program, Section 7.0 of CR#3 (CEAR #42) indicated the following:

> *It is expected that selected locations will change, but will include the following:*
> - *wells (nested sets where possible) in proximity of the pit for water level monitoring to monitor water quantity;*
> - *shallow monitoring wells downgradient of waste rock disposal areas, and surge ponds, primarily for groundwater sampling to monitor water quality; and*
> - *shallow monitoring wells downgradient of surface facilities (at the proposed CHPP) primarily for groundwater sampling to monitor water quality.*

The monitoring wells outlined above will primarily monitor for signs of impact near the sources (listed in Part v., above) to provide early detection and response. Consideration will be given to include wells closer to receptors (listed in Part vi., above), as applicable and if feasible depending on access and ground conditions, to ensure no impact fails to be detected.

Exact location of the monitoring wells will be determined once the site construction activities are completed for a given area to ensure optimal placement of the wells and avoid damage to the wells during construction. The main receptors to be monitored will be the bedrock aquifers and groundwater discharging to surface water. For each pair of source and receptor(s), monitoring wells will be installed near the source, near the receptor (as applicable) and potentially between the source and the receptor, depending on distance between the source and receptor, so the intermediate well(s) can act as a sentinel. For example, at the East Sedimentation Pond, one well or nested pair of wells would be installed directly downgradient of the dam, near the release point and one well would be installed near Gold Creek. Similar combination of monitoring wells would be implemented for other surge ponds, sedimentation ponds, rock disposal areas and the CHPP. Some locations will be installed in nested pair of wells, to assess groundwater quality at various depth interval or to monitor groundwater-surface water interactions. Similar nested pairs are planned to be installed for the Aquatic Monitoring Program (JRP IR-5.4). Information from both the groundwater and aquatic life monitoring programs will be shared to select final locations suitable for both programs, to confirm that there are no gaps between the programs, and ensure the results are interpreted across disciplines to provide an integrated assessment of the groundwater quality and quantity for the Project.

Obvious natural groundwater discharge areas that may exist along the banks of Gold Creek or Blairmore Creek will also be considered as sampling locations, depending on their location within the context of the Project.

The water wells, also considered as receptors, are all located at significant distance from the project, within different catchment or sub-watershed areas (Section 5.4.2.2.2 in CR#3, CEAR #42). Bluff Mountain, located between the Project and the domestic and municipal water wells, acts as a hydraulic barrier as groundwater was modelled to flow radially, including northward towards the project, preventing direct connection between the project and the aquifers in which the water wells are completed. A groundwater divide was also identified within the Greenhill Mine. Since there is no apparent flowpath for impacted groundwater to travel southwards towards the Crowsnest River valley where the domestic wells and municipal water wells are located, no monitoring wells will be installed near these receptors. However, consideration will be given to installing sentinel monitoring wells downgradient from the entire project but within the catchment area of the project (*i.e.,* north of the groundwater divide), to confirm groundwater quality upgradient of the water wells.

viii. predict, using modelling, the concentrations of contaminants at the receptors based on nominal source inputs;

Response:

As per response for Parts i. to iv., the groundwater numerical model is not planned to be updated or re-run at this time as the model has already been used to determine the potential range of change or potential effects that may occur due to a given stress. Results from these simulations have been presented in CR#3 and integrated into the Projects environmental impact assessment.

ix. describe the proposed monitoring and sampling plan (sampling frequency, analytes, triggers, thresholds, etc.);

Response:

The monitoring program will include monitoring wells and surface water sampling locations to provide a complete set of data and allow a complete assessment of the groundwater quantity and quality around and downgradient of the Project, and near surface water receptors.

Monitoring wells will be installed ahead of the mining activities at locations described in vii once nearby construction is completed.

Chemical parameters (analytes) will vary between sampling locations to target specific contaminants of potential concern associated with the specific activities or concerns in each area. Downgradient of surface water features (surge ponds, sedimentation ponds, raw water pond and saturated fill areas), chemical parameters will mostly consist of routine parameters, total suspended solids (TSS) and selected dissolved metals (with an emphasis on selenium, cobalt, zinc and cadmium). The same parameters will be sampled from the surface water features

themselves (*i.e.,* the ponds) and potentially from the receptors (Gold Creek and Blairmore Creek). Downgradient of the CHPP, samples will be primarily analyzed for chloride (salt used for ice control, if applicable), oil, lubricants and petroleum hydrocarbons (BTEX F1-F2).

Baseline data collection will be initiated as soon as the monitoring wells are completed. Baseline will be collected for both groundwater at the monitoring wells, and surface water (creek, ponds, groundwater discharge areas, *etc.*) located near the monitoring wells. Typically, baseline will consist in the collection of eight samples. Frequency of sampling is suggested to be no more than once every 6 months, given the low hydraulic conductivity and slow groundwater movement expected within the Project boundaries. It is anticipated the monitoring would be completed in the Summer or Fall, when groundwater and surface water are free of ice and access to the monitoring locations is the safest.

Baseline data will establish the natural magnitude and variation of groundwater quantity (water levels) and quality in the Project area, near the potential sources and receptors. The baseline dataset will be used to establish specific control limits (calculated as the 95th percentile) for selected indicator parameters that will be used during operational monitoring to compare measured values with the expected range of baseline conditions and assess if the Site's activities are having an impact on groundwater quality. Should the concentrations of potential parameters of concern be detected in the groundwater above the control limits, the Groundwater Response Plan (GRP) will be initiated.

Once all baseline data has been collected, the monitoring program will switch to operational monitoring. Following two years of operational monitoring, the monitoring frequency will be re-evaluated. A review of the monitoring network will be conducted when the annual groundwater monitoring program summary report is prepared. At that time, appropriate changes to improve the monitoring program will be evaluated.

Data collected as part of the groundwater monitoring program will be incorporated with other monitoring programs addressing aquatic life and selenium and metal management at the site, as appropriate, to ensure early detection of upset conditions and review the complete dataset and provide an integrated monitoring and management of groundwater and surface water for the Project.

x. discuss how the Groundwater Monitoring Plan will address any uncertainty identified in the model or predicted groundwater pathways. Discuss how the location of additional monitoring wells will result in an improved understanding of the location of faults, fractures, rock quality, and groundwater and improve confidence in groundwater transport pathways.

Response:

The Project's Groundwater Monitoring Plan will address any uncertainty associated with the model by directly monitoring groundwater quantity and quality near the sources and receptors.

Results from the field monitoring will be compared with the model parameters and predictions. Consideration will be given to updating and/ or rerunning the model as additional data becomes available or if results differ from the model predictions.

Drilling of additional monitoring wells will only result in a limited improved understanding of the location of faults, fractures, or rock quality as approximately 525 drill holes and 19 monitoring wells are already present at the Site. They will however refine the understanding of the site conditions locally, near the targeted sources and receptors.

xi. identify adaptive management actions that could be implemented in the event that concentrations of contaminants in groundwater are found to exceed triggers or guideline values.

Response:

As previously mentioned in Section 7.2 of CR#3 (CEAR #42), a change in groundwater quality near the pit or selenium management control ponds will be addressed as part of the management of the treatment cells. Results from the groundwater monitoring program will be shared with the surface water management team, so that management actions can be adjusted as needed.

An identified change in groundwater chemistry near the CHPP and associated facilities will be investigated for spill or upset conditions that resulted in a discharge of chemicals to the surface or the shallow groundwater. Response measures could include spill investigation, source removal, remediation, risk assessment and/or risk management.

5.19 Information Request 5.19

Canadian Environmental Assessment Agency Operational Policy Statement: "Addressing "Purpose of" and "Alternative Means" under the *Canadian Environmental Assessment Act, 2012*". (March 2015).

Grassy Mountain Coal Project – Updated Environmental Impact Assessment. Appendix 10C, Consultant Report #3 – Hydrogeology. (CEAR #42)

Fifth Addendum to the Environmental Impact Assessment. Supplemental Information Request Responses #105, Appendix A-3. (CEAR #69).

From the Tsuut'ina Nation to the Joint Review Panel re: Grassy Mountain Coal Project - Comments on Environmental Impact Statement. (CEAR #192).

In Appendix 10C in the updated EIA (CEAR #42), Benga proposed that seepage capture wells could be constructed across groundwater flow paths as a means to mitigate contamination of groundwater by capturing seepage from potential contaminant source areas with water being pumped to the surge ponds.

Benga stated in Consultant Report #3 (CEAR #42) that "despite the effort of the regional study to collect all available data and supplement them with additional drilling, the study concludes that the scarcity of water level data, coupled with the significant topographic relief, and the complexity of the flow system makes it impossible to create regional

potentiometric contour maps with any degree of accuracy." Tsuut'ina Nation has noted that due to the complexity of the groundwater regime, it seems unlikely that an extraction system could be adequately designed to collect all potentially contaminated seepage water (CEAR #192).

In the response to SIR 103 in Addendum 5 (CEAR #69), Benga stated that the most suitable methods for intercepting seepage will be determined based on a field assessment, which includes a drilling program. While the use of seepage capture wells may be potentially feasible, it will depend on the location and screened depth of the wells, the removal rate, as well as the hydrogeological regime, including whether the groundwater flow is mainly porous media flow, influenced by fracture flow, or shunted by historical mine tunnels. However, Benga has not carried out a detailed field assessment, and has not yet resolved the uncertainty associated with the effectiveness of the use of seepage capture wells to mitigate potential effects to groundwater quality. Furthermore, in Appendix 10C in the EIA (CEAR #42), Benga stated that capture of seepage is expected to be necessary for many years after the end of operation, which represents a long-term liability.

Tsuut'ina Nation (CEAR #192) proposed lining the dump site with impermeable, engineered liners or use coarse rock underdrains to convey contact water to a drainage system as another solution to groundwater seepage from the waste rock dumps. In Section 1.2.2 in Appendix A-3, Addendum 5 (CEAR #69), Benga provided a brief summary of the use of lining and enhanced foundation drainage at the base of rock coal dumps. However, Benga did not present an alternative means analysis that compares the use of seepage capture wells with the use of impermeable liners and underdrains.

a) Benga is to carry out an alternative means analysis that investigates the technical and economic feasibility of the use of impermeable, engineered liners for the waste rock disposal areas and the use of coarse rock underdrains as an alternative to the use of seepage capture wells to mitigate potential contamination resulting from selenium-enriched groundwater. Benga is encouraged to follow the methodology presented in the Canadian Environmental Assessment Agency guidance entitled "Addressing "Purpose of" and "Alternative Means" under the *Canadian Environmental Assessment Act, 2012*"[9] to carry out its analysis. The alternative means analysis should be substantiated with case studies based on other mines with similar characteristics to the Grassy Mountain Coal Project.

Response:

Benga have applied the Canadian Environmental Assessment Agency Operational Policy Statement: "Addressing "Purpose of" and "Alternative Means" under the Canadian *Environmental Assessment Act*, 2012 (March 2015) as part of the mine planning Feasibility Study (Section A.7 – Project Alternative Means Assessment, CEAR #42). A formal alternative

9 Available online: Operational Policy Statement "Address the "Purpose of" and "Alternative Means" under the *Canadian Environmental Assessment Act, 2012*". https://www.ceaa-acee.gc.ca/default.asp?lang=En&n=1B095C22-1&pedisable=true

means analysis was not conducted as part of this IR response; rather, the following provides clarification on the mitigations that will be implemented as part of the external rock dump design and selenium management plan.

There are four means for seepage capture proposed as part of the Project's Water Management Plan (WMP):

- Surface collection of seepage from the toe of the waste rock dump by:
  (1) Grading the foundation to facilitate effective drainage; and
  (2) Use end-dumping techniques to establish a coarse permeable layer at the base of the dump;
  (3) Use of collection ditches to capture shallow seepage; and
  (4) Installation and pumping of seepage capture wells.

The use of impermeable liners was also considered by Benga but was not proposed for the Project for the reasons indicated in the discussion below.

Technical and Economic Feasibility of Seepage Capture Options

Grading the Foundation: Grading the base of the dump locations to facilitate drainage is both technically and economically feasible, as the equipment required to complete any earthworks will be available on-site early in the mine life. Foundation preparation is expected to include surface re-contouring, localized lining along drainage paths, and effective placement of a sub-base granular layer. Foundation preparation would occur in conjunction with and following topsoil removal.

Impermeable Liners: As part of this seepage capture option, the installation of a geosynthetic liner under the entire waste dump was considered. Liners are considered technically and economically unfeasible for the Project. Liners can only be constructed on slopes less than 3:1 (Appendix 10C, CEAR #42); however, none of the proposed dump bases currently match this specification, and significant contouring would be required to achieve this slope. At angles steeper than 3:1, liners are prone to slippage, applying stress to liner seams and increasing the potential for liner failure. While specific costs were not provided and would vary greatly with the type of liner installed, there is an order of magnitude cost difference between liner installation and the installation of seepage wells.

End Dumping Techniques: Benga proposes to construct all waste rock dumps using industry accepted methods of end-dumping to develop sufficient angular momentum across the tipping face to develop the required gradation. This process results in the development of a permeable, coarse-grained layer of rock at the base of the pile (rock drain) for conveyance of surface water as well as infiltration from the pile above. This method of seepage capture is considered technically and economically feasible.

Drainage Ditches: Drainage ditches are relatively easy to construct, given the equipment and materials on-site, making them technically feasible. Benga proposes to implement these ditches at the toes of waste rock dumps for the Project.

Seepage Wells: Seepage capture wells installed into deeper groundwater formations address the potential for vertical seepage of contact water. The cost of installation of these wells is anticipated to be an order of magnitude lower than constructing a liner beneath the ex-pit waste rock dumps. The intention of the seepage wells is to create enough draw down to capture all vertical seepage from the overlying waste rock. Three areas for seepage capture were identified: southwest of the north ex-pit waste rock dump; west of the south and central waste rock dumps; and southeast of the central waste rock dump. Installation of these seepage capture wells a minimum of 250 m from the toe of the waste rock piles ensures safe, reliable access to the wells.

Summary

As part of planning of the ex-pit waste rock dumps, all elements of seepage capture were considered. Based on the proposed mine plan, as well as geology and hydrogeology in the area, seepage wells, drainage ditches, and end dumping have been identified as seepage capture options. Benga has also identified the potential to grade the foundation of the dump sites; however, the installation of liners beneath waste rock dumps is considered technically and economically unfeasible.

FISH AND FISH HABITAT

5.20 Information Request 5.20

Grassy Mountain Coal Project - Updated Environmental Impact Assessment. Appendix 10b. (CEAR #42).

First Addendum to the Environmental Impact Assessment. Aquatic Ecology Addendum to Consultant Report #6, Appendix A3 – Instream Flow Assessment; Appendix A4 – Water Temperature Modelling. (CEAR #44).

Eighth Addendum to the Environmental Impact Assessment, AER-R2-36 (CEAR #89).

Comments from Jim Rennie. (CEAR #133).

Comments from the Coalition of Alberta Wilderness Association and Grassy Mountain Group, and Shirley Kirby. ("the Coalition") (CEAR #164).

Comments from the Ktunaxa Nation Council. (CEAR #178).

Comments from Tsuut'ina Nation. (CEAR #192).

In the response to AER-R2-36 in Addendum 8 (CEAR #89), Benga confirmed that discharge from sedimentation ponds was modeled to account for 0.1% of base flow in Blairmore Creek at BL-01, and 0.2% of base flow in Gold Creek at GC-02. Benga does not indicate the percentage of base flow sedimentation that pond discharge will account for at the outlet of the ponds, as the referenced modeled node represents the confluence of both Gold and Blairmore Creeks with the Crowsnest River. Given that the proposed sediment ponds are located higher in the watershed of Blairmore Creek and Gold Creek, discharge from these ponds would represent a higher proportion of baseflow at nodes established at the confluence of these ponds and the receiving creek, as compared with the nodes located at the discharge point of the watershed.

In Addendum 1, Appendix A4 in Appendix A3 (CEAR #44), flows in Blairmore Creek are predicted to increase between 6%-35% through the operations, final reclamation and closure phases of the project as a result of discharges from sediment ponds, surge ponds, seepage, and the saturated backfills. While saturated backfills are intended to impound water for prolonged periods of time to allow for treatment of constituents of concern, no analysis of the importance of thermal loading to water impounded within the saturated backfills has been provided to determine the range of temperatures predicted for discharged water prior to entering Blairmore Creek.

In Addendum 1, Appendix A4 in Appendix A3, Benga indicated that the temperature regime in Blairmore Creek was monitored to determine potential thermal changes as a result of the project. Given that the background thermal regime in Blairmore Creek had an observed maximum temperature of 18.52°C prior to any disturbances from the proposed Project, and the established upper incipient lethal temperature for WSCT is 19.6 °C as referenced by Benga in Section 3.1.1 of the Aquatic Ecology Addendum (CEAR #44), any thermal loadings to Blairmore Creek as a result of the Water Management Plan

potentially risk increasing water temperatures beyond the upper incipient lethal temperature. In their submission to the Panel, the Coalition (CEAR #164) stated that water temperature modelling is dependent on the amount of baseline data available and field validation of the model. The participants indicated that Alberta Environment and Parks collected water temperature data for Blairmore Creek mainstem and tributary and noted the water temperature model could benefit from the incorporation of this data.

In Appendix 10b of the updated EIA (CEAR #42), Benga indicated that a pit lake will be permitted to form at the end of mining operations, and that the pit lake will eventually begin to discharge to Gold Creek via the Northeast Sediment pond once the flood elevation is exceeded. Given that the pit lake and the Northeast Sediment pond will impound water and act as a lentic system, water within these structures will undergo prolonged periods of thermal inputs, increasing in situ water temperatures and increasing the importance of thermal impacts to Gold Creek.

Neither the Water and Load Balance Model or modeling within the System for Environmental Flow Analysis (SEFA) determined potential spatial or temporal variability of water temperature along Gold and Blairmore Creeks in response to individual water management activities (e.g. the detention of groundwater in the saturated backfill zones or sedimentation pond releases). Several participants in the environmental assessment (CEAR #133, #178 and #192) noted that discharge from the sedimentation ponds has the potential to affect the thermal regime of Gold and Blairmore Creeks and could result in subsequent effects to Westslope Cutthroat Trout (WSCT).

a) Provide an updated assessment discussing the proportion of base flow that each sediment pond, surge pond, and discharge point from the saturated backfill zone represents at the confluence of the water management structure's discharge outlet in both Gold Creek or Blairmore Creek (depending on which stream is receiving the discharge) in order to accurately assess the zone of influence of these water management structures on changes in stream temperatures.

Response:

The following provides a discussion regarding the portion of baseflow that the Project's water management infrastructure will have and potential changes in stream temperature in Blairmore and Gold creeks.

The Project's Water and Load Balance Model (Appendix 10B, CEAR #42) took into account the water management processes of the four sedimentation ponds (release to Blairmore and Gold creeks), the raw water pond (non-release), the three surge ponds (non-release), and the contact water treatment process associated with the saturated backfill zones.. The change in total flow as a result of the water management infrastructure developments was estimated at a total of five (5) assessment nodes both on Blairmore and Gold creeks, each capturing one or more upstream developments and their corresponding predicted flow changes.

The Water and Load Balance Model indicates that baseflows provide almost all of creek total flow for the majority of the annual hydrograph, except for May, June and July when snowmelt

and higher rainfall sums contribute potentially large surface/overland flow contributions to creek flow. In addition, large rainfall and runoff events are not uncommon in late summer or fall. Related to the Water and Load Balance Model, in response to JRP IR-5.15, Table 8 of Appendix 5.15-3, provides calculated mine contributions to creek baseflows under End of Mine (EOM) conditions.

The results indicate that the proportion of creek baseflows sourced from the Project's water management infrastructure developments were negligible at the mouth of Gold Creek at WSC Station 05AA0030 (*i.e.,* 2.4%). The proportion of creek baseflow sourced from the Project's water management infrastructure near the mouth of Blairmore Creek at hydrometric station BC-H01 were estimated at 23.2% (annual average), which also comprised the groundwater contributions from the:

- saturated backfill zone (21.3%); and
- sediment pond and associated ditch lines (1.9%).

In regards to the water discharged from the saturated backfill zone, as the water will be regulated *via* the thermal reservoir of the backfill zone, temperatures are expected to be lower than surface water in the summer months and slightly warmer than surface water in the winter months.

Based on these predicted proportions of baseflow contributions to both Blairmore and Gold creeks, potential changes in water temperature within these watercourses was assessed using the System for Environmental Flow Assessment (SEFA) modeling software. Changes in water temperature were assessed by taking the difference between predicted water temperature (using baseline flows, temperatures and climate data), and predicted water temperature using forecasted flow changes for each phase of the mine.

Although the model used the five nodes from the Water and Load Balance Model, as potential stream (water) temperature changes are directly related to total stream flow, the model does account for the discharge contributions from the Project's water management infrastructure developments; consequently, providing a reasonable prediction of temperature fluctuations. Those predictions again were presented in Addendum 1, CR#6, Appendix A4 (CEAR #44) and are not significant.

b) Discuss the zone of influence that these water management structures have on stream temperatures using the maximum predicted monthly water temperatures in each water management structure, extending downstream from the confluence of the water management structures' discharge outlets, to the point where stream temperatures

return to background levels after mixing with water discharged from these water management structures.

Response:

As baseflow contributions dominate creek flows both during baseline and at EOM (as indicated in the response to JRP IR-5.15, Table 8, Appendix 5.15-3), stream temperature differences as a result of the Project's water management infrastructure (*i.e.,* the sedimentation ponds) are expected to be negligible. , This is further supported by the fact that groundwater contributions will likely continue to dominate baseflow contributions both during baseline conditions and as mining develops (especially on Blairmore Creek where a large contribution of baseflow originates from the saturated backfill zone). The ponds and ditches, where conditions are more oxic and temperatures may be different, provide less than 2% (annual average) of baseflows on either Blairmore or Gold creeks.

c) Clarify how, or if, pit lake water temperatures were calculated and incorporated into the water temperature model during closure/reclamation. Provide an assessment of the proportion of base flow that the pit lake represents to Gold Creek base flows once the flood elevation is exceeded, measured at the confluence of the discharge outlet from the pit lake through the Northeast sediment pond, in order to accurately assess the zone of influence this discharge will have on stream temperatures within Gold Creek.

Response:

The water temperature modelling of spatial stream temperature differences at the five assessment nodes (as summarized in response to Part A of this IR) did account for potential changes in stream temperature at EOM, as the discharge point from the pit lake would be through the north east sedimentation pond, whose discharge point is above one of the assessment nodes.

d) Discuss the zone of influence that the discharge from the pit lake via the Northeast sediment pond will have on stream temperatures in Gold Creek using the maximum predicted monthly water temperatures discharging from the Northeast sediment pond, extending downstream from the confluence of the Northeast sediment pond discharge outlet into Gold Creek to the point where stream temperatures return to background levels after mixing with the discharged water.

Response:

As stated in Part B of this IR, stream temperature differences as a result of the Project's water management infrastructure (*i.e.,* the sedimentation ponds) are expected to be negligible, as the associated sedimentation ponds (release points) provide less than 2% (annual average) of baseflows on either Blairmore or Gold creeks.

e) Discuss the effects on habitat suitability for WSCT within these zones of influence described in b) and d), and how changes in stream temperatures will impact each biological stanza of WSCT described in the EIA.

Response:

Project-related flow changes (water quantity) and the predicted influence on WSCT Area Weighted Suitability (*i.e.,* habitat area) was simulated for each assessment node on Blairmore and Gold creeks, which account for the planned water management processes from one or more upstream mine infrastructure component. These predicted flow changes on habitat area were quantified in Tables 4-1 to 4-10 (Addendum 1, Appendix A3, Section 4.1.3, CEAR #44). The same changes in flow, at each assessment node, were then integrated within the water temperature model to simulate spatial water temperature changes over the life of the mine; these results were then reported for each WSCT biological stanza/bioperiod in Table 3-8 (Addendum 1, Appendix A3, Section 3.0, CEAR #44). As noted, stream temperatures are not predicted to change noticeably and are not expected to adversely affect WSCT key bioperiods or rise to the noted upper incipient lethal temperature for WSCT (19.6 °C) as described in Addendum 1, CR#6 (CEAR #44).

f) Discuss technically and economically feasible mitigation and adaptive management measures that can be implemented to prevent and/or minimize changes in stream temperatures in Gold Creek and Blairmore Creek as a result of discharges from the water management structures discussed above.

Response:

Based on findings to date, changes to stream temperatures associated with the Project are not expected to be considerable and are anticipated to stay within incipient thresholds for WSCT. To ensure our predictions are valid, continuous stream temperature monitoring will form a key component of the Project Fisheries and Aquatic Monitoring Program (JRP IR-5.4). Stream temperature data has been collected continuously at several location in Gold and Blairmore creeks since 2014 and will continue throughout the monitoring program.

g) Incorporate any additional field temperature data collected by Alberta Environment and Parks from the mainstems of Gold Creek and Blairmore Creek and their respective tributaries in order to provide added precision to the assessment requested above.

Response:

It is Benga's understanding that Alberta Environment and Parks only collects discontinuous (spot) based field temperature data, of limited value for the purpose of analyzing key water temperature statistics such as maximum summer temperatures and minimum winter temperatures.

Benga has been collecting continuous flow and water temperature data in Blairmore Creek since 2016. Figure 5.20-1 provides a comparison of available 15-minute temperature data collected on Blairmore Creek, available for the temperature modelling work (top panel) and monitored during a subsequent period (2016 to early 2018, bottom panel). While water temperatures are strongly controlled by climate conditions, in terms of hydrologic conditions the summer of 2014 was generally wet while 2016 was very dry until September. The runoff during the summer of 2017 was generally in-between these conditions.

Temperatures at BC-H03 (upstream, above planned infrastructure developments) are usually fractionally lower than at BC-H01 (downstream, below planned infrastructure developments), likely due to elevation effects on air temperature and subsequent groundwater runoff; other factors such as shading (canopy cover) differences are also likely contributing. In 2014 and 2017 the temperatures did not exceed 18ºC at either station. In 2016 the water temperatures did not exceed 17 ºC at BC-H03, and only rose above 18 ºC (to a maximum of 18.6 ºC) on two individual days at BC-H01 (a short duration) with stream temperatures below this limit on over 99% of days with data available. Water temperatures are now being collected at the BC-H02 hydrometric station, and these data will further inform baseline stream temperatures in closer proximity to proposed discharge points from centrally-located sedimentation points and saturated backfill zones.

5.21 Information Request 5.21

First Addendum to the Environmental Impact Assessment, Appendix A1; Table A2.1, Appendix A3 – Instream Flow Assessment; Appendix A4 Stream Temperature Memo. (CEAR #44).

Comments from the Coalition of Alberta Wilderness Association and Grassy Mountain Group, and Shirley Kirby ("the Coalition"). (CEAR #164).

From Osler, Hoskin & Harcourt LLP on behalf of Benga Mining Limited - Response to Sufficiency Comments from Non-Indigenous Parties. (CEAR #191).

The Coalition (CEAR #164), identified that temperature and dissolved oxygen are not discussed in the Instream Flow Assessment report in Addendum 1 (CEAR #44); however they are noted in other reports. The Coalition indicated that, changes to temperature and dissolved oxygen as a result of changes in flows should be assessed. Showing how these two parameters change, from baseline through the lifecycle of the project related to flows, in summary format is necessary.

In response to the Coalition's concerns, Benga indicated that (CEAR #191):

- Stream temperature data were provided in Appendix A4 of the Instream Flow Assessment document, including measured data from available stations, and predicted stream temperatures for each project phase as affected by impacted flow levels.

- Dissolved Oxygen data, where measured, were tabulated in raw datasets as presented in the wider EIA document (e.g., Table A2.1 in Appendix A1 in Addendum 1).

Based on Benga's response, it appears that dissolved oxygen predictions during the various phases of the Project have not been quantified. Given the potential influence of dissolved oxygen and temperature on fish and fish habitat suitability, this information is required.

a) Provide for each month, temperature and dissolved oxygen duration curves and tables that compare baseline, construction, operation, final reclamation, and closure flow regimes at reference sites upstream of the project, and at the confluence of each water management structure's discharge outlet within Blairmore Creek and Gold Creek.

Response:

Rapidly moving water, such as in a mountain stream or large river (*i.e.,* lotic environments), tends to contain a lot of dissolved oxygen (DO), whereas stagnant water (*i.e.,* lentic environments) contains less. The concentration of DO in surface water is affected by temperature and has both a seasonal and a daily cycle. Cold water can hold more DO than warm water. In winter and early spring, when the water temperature is low, the DO concentration is generally high. In summer and fall, when the water temperature is typically higher, the DO concentration is often lower. This is reflective in the seasonal baseline stream temperature/DO conditions for Blairmore Creek (CR#5, Table 8, CEAR #42), where DO concentrations are much higher than the short-term (5 mg/L) and long-term (6.5/L) minimums for the protection of aquatic life (AEP 2014).

The Water Temperature Assessment Model (CR#6, Appendix A3, Appendix A4) run as part of the Instream Flow Assessment (CR#6, Appendix A3) predicted whether changes in stream temperature would result in possible residual effects (habitat, stress) on important seasonal bioperiods of westslope cutthroat trout (WSCT). The results of the model projected negligible changes in stream temperature (thus associated trivial changes in dissolved oxygen) in both Gold and Blairmore creeks throughout mine life (construction, operations, reclamation, closure phases). Thus, the modelled water temperature predictions in these mountainous stream environments across the defined bioperiods are considered a reasonable predictor of change in DO. Monitoring of stream temperature at multiple stations within Gold and Blairmore creeks is ongoing and will continue throughout the various mine phases as part of the Project's Aquatic Monitoring Plan (JRP IR-5.4).

b) Provide an assessment of the predicted dissolved oxygen concentrations of the water contained in each of the water management structures, including sediment ponds, surge ponds, and the saturated backfill zones.

Response:

To support suboxic conditions within the SBZ, the DO concentration in water discharged from these structures is expected to be near zero. Based on a literature review of saturated backfill zones, the expected DO concentration is typically less than 2 mg/L (Bianchin *et al.*, 2013). Benga will aerate the discharge water using a cascading feature that leads to a downgradient holding pond, where it will be tested prior to discharge. Typical DO concentrations in surface water are approximately 5 mg/L.

Water from the surge ponds will be routed through either the RWP for use in processing, or through the SBZ for treatment. There will be no direct discharge to the regional surface water bodies from the surge ponds.

The intention of the sedimentation ponds is to manage TSS and turbidity rather than manage dissolved oxygen concentrations. As indicated on Figure C.5.5-1 of the EIA (CEAR #42), the proposed maximum depth for sediment ponds associated with the project is 5 m; a corrugated steel pipe (CSP) pipe will carry water from the surface of the pond through the dam following sediment removal. A similar aeration cascade will be located downgradient of the pond decants; however, the DO concentration from the sediment ponds is not expected to be a challenge at this time. Continued maintenance of the sediment ponds, including regular dredging, will occur to maintain overall water quality within the ponds.

c) Discuss mitigation measures or adaptive management actions that will be undertaken to address water with low dissolved oxygen concentrations, prior to being discharged to Gold Creek or Blairmore Creek.

Response:

Cascading aeration structures have been proposed for the decants of sediment ponds and SBZ structures on-site.

d) Provide a discussion of the assessment results and describe the potential effects of each phase of the Project on fish and fish habitat suitability within the zone of influence extending downstream from the discharge outlet of each water management structure to the point where dissolved oxygen concentrations return to background levels.

Response:

Given the information described in (a), coupled with the mitigation proposed in (b) and (c), the risk to potential effects on near-pure WSCT as a result in changes in DO is considered

negligible. Monitoring of DO at discharge points, including established stations within, Blairmore Creek will confirm that DO concentrations are maintained within the acceptable WSCT optimal range and will continue throughout the defined mine phases as part of the Project's Aquatic Monitoring Plan.

Reference:

[AEP] Alberta Environment and Parks. 2014. Environmental Quality Guidelines for Alberta Surface

Waters. Water Policy Branch, Policy Division. Edmonton. 48 pp.

5.22 Information Request 5.22

First Addendum to the Environmental Impact Assessment, Aquatic Ecology Assessment Addendum to Consultant Report #6; Section 4.2.2.1. (CEAR #44).

Comments from Ktunaxa Nation Council. (CEAR #178).

In the Aquatic Ecology Addendum in Addendum 1 (CEAR #44), Benga stated that "Stream temperatures during overwintering already reach near-freezing temperatures. A further decrease in temperature could be problematic in Gold and Blairmore Creeks given groundwater discharge to surface waterbodies are projected to decrease, which could accentuate the freeze-up of overwintering habitat. Frozen conditions can further exacerbate already stressful conditions with the potential of frazil ice, which can damage gill tissues, and the availability of invertebrate food sources could be compromised (Bradford and Heinonen 2008). The potential effects to overwintering will ultimately be manipulated by the contribution(s) of groundwater influx during mine operations once water management features are implemented on site as the ongoing maintenance of WSCT overwintering habitat may be largely determined by this factor (Brown and MacKay 1995)."

Ktunaxa Nation Council (CEAR #178) indicated that the above paragraph suggests a Project-related effect with a level of uncertainty as to exactly how the mine will manipulate groundwater in Gold and Blairmore Creeks. Furthermore, it does not align with Benga's conclusion that there is no detectable residual effect on fish habitat due to modifications in stream temperature predicted throughout the mine life.

a) Clarify the quoted paragraph in relation to the residual effects conclusion with respect to WSCT habitat.

Response:

The quoted paragraph generally describes the potential effects to WSCT in the event groundwater discharge is reduced and no mitigation is applied. To investigate this potential effect water temperature was modeled for Gold and Blairmore creeks over the lifespan of the Project from pre-construction to post-closure to determine how, during each phase of the mine,

maximum monthly changes in forecasted flow could affect key bioperiods of WSCT (Water Temperature Assessment Model provided in CR#6, Appendix A3, Appendix A4: CEAR #42).

The changes in water temperature predicted by the model were negligible relative to baseline water temperature, thus flow-associated changes in temperature are predicted to have no effect on WSCT in Gold and Blairmore creeks throughout the mine lifespan.

In the Aquatic Ecology Addendum in Addendum 1 (CEAR #44) the effects assessment concluded that "based on the findings from the predicted water temperature modeling assessment the likelihood and extent of stream temperatures to be altered that will potentially affect key WSCT bioperiods is considered negligible. Therefore, no detectable residual effects on fish habitat due to modifications in stream temperature are predicted throughout mine life (construction, operations, reclamation, closure phases)." The modelled predictions will be verified through continuous and ongoing monitoring. A description of the monitoring can be found in the draft Aquatic Monitoring Plan (JRP IR-5.4).

b) Discuss how the reduction in groundwater discharge to surface waterbodies will affect overwintering habitat suitability and availability.

Response:

Both the Water Temperature Assessment Model (CR#6, Appendix A3, Appendix A4) (CEAR #42) and the Instream Flow Assessment (CR#6, Appendix A3) (CEAR #42) applied total flow, which included baseflow (groundwater) and surface flow. Total flow in the overwintering period is comprised solely of baseflow. Thus, the modelled water temperature predictions during the overwintering bioperiod are considered reasonable and reflective of local conditions. Additionally, the Instream Flow Assessment predicted that Project-related hydrology alterations would result in changes of less than 10% in habitat area (area weighted suitability) relative to long-term baseline conditions during the WSCT overwintering period, thus no significant effects are anticipated. The findings of both of these assessments suggest that the reduction in groundwater discharge will have negligible influence on overwintering WSCT habitat suitability and availability.

Additional information to supplement the above response is provided from a previous IR response (DFO-R2-20-1, October 2018) (CEAR #89) where modelled groundwater inputs were spatially aligned with WSCT critical habitat. The response noted that the predicted flux data generated from the Hydrogeological 3D model was used to generate the figures. In Figure DFO-R2-20-2 (baseline), the largest fluxes (blues/green colours) are evident originating from sources along the Livingstone Range and tributaries (Caudron Creek) east of Gold Creek, which does not interact with the proposed mine, while smaller fluxes are predicted elsewhere in Gold Creek and Blairmore Creek watersheds. The negative values represent groundwater to surface losses (*e.g.,* Caudron Creek) and positive values represent surface to groundwater losses (*e.g.,* most other areas). Based on Figure DFO-R2-20-2, most groundwater inputs originate from

the east of Gold Creek (Livingstone Range). This additional information supports the prediction that changes to overwintering habitat suitability and availability due to the Project are considered minimal.

c) Where reductions in overwintering habitat suitability and availability are determined, update the existing Area Weighted Suitability assessment and refine the associated offsetting calculations.

Response:

No reductions in overwintering habitat suitability and availability are predicted, therefore the Area Weighted suitability assessment and offsetting calculations do not require an update. Stream flows and temperature are being monitored continuously at several installed hydrometric stations in Gold and Blairmore creeks. The predicted changes as described in the IFA and temperature modelling will be verified through monitoring. A draft Aquatic Monitoring Plan has been provided in response to the Aquatics Monitoring Program, JRP IR-5.4, Appendix 5.4-1, Section 6.1.

5.23 Information Request 5.23

First Addendum to the Environmental Impact Assessment. Appendix A1 – Fisheries and Aquatics Technical Baseline Report; Section 3.1.6. (CEAR #44).

Comments from Ktunaxa Nation Council. (CEAR #178).

Ktunaxa Nation Council's submission to the Panel (CEAR #178) identified numerous deficiencies regarding the sampling methodology used for the collection of fish tissue samples in Gold and Blairmore Creeks, as well as the information reported on fish tissue contaminant levels presented in Appendix A1 in Addendum 1 (CEAR #44). The following deficiencies and information gaps were identified by Ktunaxa Nation:

- Appendix A1 does not provide any rationale for how sites utilized for tissue sampling were selected;
- The proponent sampled multiple different species of fish in Blairmore Creek, below the waterfall that is a barrier to upstream migration, to form a composite sample of fish for tissue analysis. Using different species of fish in a composite sample may introduce variation in results due to differences in life histories between the species sampled. By sampling species located below the waterfall barrier on Blairmore Creek, the proponent also introduced uncertainty into the analysis as these individuals were capable of migrating between Blairmore Creek and the Crowsnest River, which may have limited their exposure time to the water chemistry parameters of Blairmore Creek. Sampling of individuals should be conducted in a reach of Blairmore Creek upstream of migratory barriers, and upstream and downstream of the project;
- Fish tissue, periphyton tissue, benthic macroinvertebrate, and periphyton biomass sites were not co-located. The sampling sites were spread through the watershed(s) in different locations making it difficult to understand the

relationship between sites, between trophic levels, and trophic transfer up the food chain;

- Fish tissue (2016), periphyton tissue (2016), periphyton biomass (2014), and benthic macroinvertebrates (2014) were each collected within the course of a single year. As a result the data does not account for annual variability;
- No benthic macroinvertebrate tissue samples were collected; and
- Lack of baseline data and reference sites to support Before-after-control-impact (BACI) monitoring design.

An appropriate monitoring and follow-up program is important in the evaluation of potential effects to WSCT, therefore further information is needed to ensure an effective response to any changes that are identified throughout the mine life cycle. Combining sampling locations that enable data collection which supports multiple parameters of interest while also allowing comparison between results, is important in determining how changes in water quality parameters may be impacting the aquatic biota and how biota are responding to changes in their environment. Where possible, spatially and temporally concurrent water, sediment, periphyton, benthic invertebrate and fish tissue sampling is preferred, although it is recognized that fish tissue sampling will be restricted and will also be dependent upon seasonal fish presence. Concurrent sample results allow site-specific monitoring of the uptake of selenium and other trace elements of concern from water and sediment into periphyton, benthic invertebrates and fish. This information can be used to verify food chain modelling assumptions. Furthermore, concurrent data on periphyton and benthic community composition and abundance as well as fish health can be compared and examined for correlations with water and sediment concentrations in order to evaluate cause/effect relationships between Project-related changes versus natural variability. If Project-related uptake or effects exceed adaptive management targets or thresholds, mitigation measures would be triggered.

Given the sensitivity of WSCT, alternatives to fish tissue sampling should be sought to allow sampling of biota within Gold Creek specifically, as all Brook Trout (BKTR) captured in the Gold Creek watershed were sourced from Green Creek, which is not expected to undergo any changes due to the Project. An effective proxy for fish tissue analysis, when the species in question are deemed too sensitive for direct sampling, is to sample dietary sources of Se to infer toxicity thresholds. While not a direct measure of toxicity, dietary Se measurements in prey organisms can provide an alternative to direct monitoring efforts. The BC Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators[10] referenced in Addendum A1 (CEAR #44) recommends targeting macroinvertebrates because 1) they can be frequently sampled with less environmental impact than is associated with gathering fish or bird egg tissues; 2) are not considered charismatic fauna; and, 3) concentrations are a direct reflection of dietary Se

10 The BC Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operations is publically available from: http://www2.gov.bc.ca/assets/gov/environment/waste- management/industrial-waste/industrial-waste/water_air_baseline_monitoring.pdf

levels providing a better indication of localised changes in food web Se, than can be provided by monitoring fish species with large foraging areas.

Response:

The Grassy Mountain Coal Project sampling program has been evolving since baseline characterization commenced in 2013. Important features that fundamentally shape ongoing baseline characterization include:

- Fish community present in Gold and Blairmore creeks (non-native rainbow trout and brook trout, pure-strain westslope cutthroat trout, hybridized westslope-rainbow trout);
- Distribution of the fish community, identification and evaluation of physical barriers, which constrain fish migration; and
- Sensitivity of the pure-strain WSCT population and provincial/federal regulators preference for no active (*e.g.,* electrofishing) or lethal sampling.

The surveys completed to date have adapted to the new information, as it has become available. This site-specific knowledge has been used to develop a draft Fisheries and Aquatics Monitoring Program (JRP IR-5.4) that addresses baseline characterization required for permitting under the relevant regulations. Please refer to this plan for sampling design, target biota, survey methodology, contaminants of potential concern, and methodology to detect potential changes to WSCT.

a) Provide updated information on any additional tissue samples that have been collected since Addendum 1 was submitted to address annual variability. Include tissue samples that were obtained from fish tissue, macroinvertebrate tissue sampling, and periphyton tissue sampling.

Response:

On September 20, 2018 benthic invertebrates were collected from three sites on Blairmore Creek (Table 5.23-1).

Table 5.23-1 Site Locations for Benthic Invertebrate Tissue Chemistry Sampling

Site Name	Coordinates	Description
BLC-DSPOND	11 U 684693E 5506968N	Downstream of proposed Northwest Surge Pond (NWSP) and West Sedimentation Pond (WSP) locations
BLC-MID	11 U 684950E 5505010N	Upstream of confluence with BCT04
BLC-GOLF	11 U 683665E 5499388N	Near the Golf Course, lower Blairmore Creek

Bulk composite samples were collected using a kick net and disturbing the substrate for three to five minutes. The net contents were emptied into a plastic tray and benthic macroinvertebrates were separated visually. All organisms were collected in a glass jar, frozen and shipped to ALS Environmental for metals (including ultra-trace mercury) analyses. The tissue chemistry results are provided in Table 5.23-2.

Table 5.23-2 Benthic Invertebrate Tissue Chemistry for Blairmore Creek, September 2018

Parameter	Units	BLC-DSPOND	BLC-MID	BLC-GOLF
Moisture	%	78	81	80
Aluminum (Al)-Total	mg/kg dwt	325	259	714
Antimony (Sb)-Total	mg/kg dwt	0.03	0.03	0.04
Arsenic (As)-Total	mg/kg dwt	0.28	0.38	0.83
Barium (Ba)-Total	mg/kg dwt	15.8	16.4	44.5
Beryllium (Be)-Total	mg/kg dwt	0.02	0.02	0.08
Bismuth (Bi)-Total	mg/kg dwt	<0.0020	<0.0020	<0.0020
Boron (B)-Total	mg/kg dwt	3.66	3.28	6.78
Cadmium (Cd)-Total	mg/kg dwt	0.85	0.92	0.71
Calcium (Ca)-Total	mg/kg dwt	2,500	3,308	11,558
Cesium (Cs)-Total	mg/kg dwt	0.05	0.03	0.12
Chromium (Cr)-Total	mg/kg dwt	1.17	0.62	1.38
Cobalt (Co)-Total	mg/kg dwt	0.25	0.28	2.19
Copper (Cu)-Total	mg/kg dwt	23.3	29.2	27.3
Iron (Fe)-Total	mg/kg dwt	342	364	1,372
Lead (Pb)-Total	mg/kg dwt	2.13	1.17	1.80

Table 5.23-2 Benthic Invertebrate Tissue Chemistry for Blairmore Creek, September 2018

Parameter	Units	BLC-DSPOND	BLC-MID	BLC-GOLF
Lithium (Li)-Total	mg/kg dwt	<0.10	<0.10	0.80
Magnesium (Mg)-Total	mg/kg dwt	670	1,379	1,111
Manganese (Mn)-Total	mg/kg dwt	24.9	37.2	134.7
Mercury (Hg)-Total	mg/kg dwt	0.04	0.05	0.04
Molybdenum (Mo)-Total	mg/kg dwt	0.29	0.23	0.33
Nickel (Ni)-Total	mg/kg dwt	1.12	1.06	4.11
Phosphorus (P)-Total	mg/kg dwt	4,201	6,462	5,126
Potassium (K)-Total	mg/kg dwt	3,987	4,810	4,342
Rubidium (Rb)-Total	mg/kg dwt	1.01	0.94	1.91
Selenium (Se)-Total	mg/kg dwt	2.59	2.66	2.74
Sodium (Na)-Total	mg/kg dwt	1,661	2,333	2,090
Strontium (Sr)-Total	mg/kg dwt	11.7	14.3	33.0
Tellurium (Te)-Total	mg/kg dwt	<0.0040	<0.0040	<0.0040
Thallium (Tl)-Total	mg/kg dwt	0.01	0.01	0.02
Tin (Sn)-Total	mg/kg dwt	0.24	0.17	0.12
Uranium (U)-Total	mg/kg dwt	0.08	0.05	0.12
Vanadium (V)-Total	mg/kg dwt	0.85	0.83	2.13
Zinc (Zn)-Total	mg/kg dwt	150	171	137
Zirconium (Zr)-Total	mg/kg dwt	0.33	<0.040	0.84

b) Discuss the methodology used to determine the sampling locations for the collection of fish tissue samples, periphyton tissue, benthic macroinvertebrates and periphyton biomass. Explain why these sampling locations were not located in the same locations in each watershed to allow comparisons between results.

Response:

The site-specific knowledge of the Project has been growing since commencement of baseline studies in 2013. This information has been used to adjust sampling locations and inform the draft Fisheries and Aquatics Monitoring Program (JRP IR-5.4) that proposes monitoring of multiple metrics to monitor and validate effect predictions on westslope cutthroat trout (WSCT). Rationale for the selection of sampling locations is provided in the draft Fisheries and Aquatics Monitoring Program.

c) Discuss how using multiple species of trout with different life histories to characterize tissue contamination within Blairmore Creek provides an accurate assessment of baseline tissue contamination levels. Discuss any biases introduced by using this approach.

Response:

One of the many challenges of understanding tissue contamination is the variation of accumulation across different environments and between species. Baseline surveys have only detected non-native rainbow trout, non-native brook trout, and WSCT x rainbow trout hybrids in lower Blairmore Creek (CR#6 Appendix A1), all of which have low site fidelity. As a supplement to this data, periphyton and benthic invertebrate tissue chemistry samples have been collected. Baseline studies have also been constrained by the provincial 'conservation' status of WSCT in upper Blairmore Creek and Species at Risk and Provincial 'Core' status assigned to the Gold Creek WSCT population. Regulators prefer species with these classifications not be sacrificed for tissue analysis or be actively sampled (*e.g.,* electrofishing). The draft Fisheries and Aquatics Monitoring Program (JRP IR-5.4) further expands on the approach taken to characterize baseline tissue contamination levels.

d) Discuss Benga's plans to establish an accurate baseline assessment prior to mining operations to ensure monitoring is sufficiently sensitive to detect impacts to water quality that may result in changes to fish health.

Response:

Section 6.5 of the Fisheries and Aquatics Monitoring Program (JRP IR-5.4) describes Benga's plans to establish an accurate baseline assessment prior to mining operations to detect impacts to water quality that may result in changes to fish health.

e) Explain why fish tissue sampling in Blairmore Creek was conducted downstream of the waterfall barrier. Discuss whether tissue samples are representative of water

quality conditions in Blairmore Creek given that fish collected for tissue samples were not permanent residents of Blairmore Creek for their entire life cycle.

Response:

All WSCT above the waterfall barrier on Blairmore Creek are designated as a 'conservation' population by the Government of Alberta. Sacrificing fish from this near-pure population of WSCT has not been permitted by the provincial government to date. The mobility and sensitivity of the fish community present in Blairmore Creek was taken into consideration during the baseline study design as well as in the development of the draft Fisheries and Aquatics Monitoring Program (JRP IR-5.4).

f) Explain why Brook Trout were sourced from Green Creek to conduct tissue analysis for Gold Creek, as Green Creek will not be affected by the Project. Discuss whether tissue samples are representative of baseline water quality conditions in Gold Creek given the limited abundance and distribution of Brook Trout captured in Gold Creek during baseline fisheries assessments.

Response:

Non-native Brook Trout from Green Creek were selected for tissue chemistry analysis given: 1) their mobility is limited by the water supply dam on lower Gold Creek (no connectivity to the Crowsnest River), 2) they are a non-native species that competes with WSCT; 3) no effluent discharge is planned/anticipated for Gold Creek, therefore the data contributes to a baseline dataset, and 4) the regulatory limitations imposed to sacrifice pure-strain or near-pure-strain WSCT. Based on multiple seasons of baseline fisheries monitoring in lower Gold Creek, it is believed that Brook Trout spawn in Green Creek and utilize Gold Creek mainstem for rearing and overwintering. Tissue samples represent reasonable baseline water quality conditions in Gold Creek and are representative of WSCT. Based on empirical evidence, we don't anticipate significant differences among trout species (Kuchapski and Rasmussen 2015).

g) Discuss the feasibility, methodology used, assumptions and possible limitations if macroinvertebrate tissue sampling was to replace fish tissue sampling in watersheds where lethal fish sampling is discouraged, as discussed in the BC Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators.

Response:

Additional macroinvertebrate tissue sampling is planned as part of the draft Aquatic Effects Monitoring Plan subcomponent as described in the overarching Fisheries and Aquatics Monitoring Program (JRP IR-5.4). Sampling design will, at minimum, consider guidance provided in BC MOE's (2016) Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators and Environment Canada's (2012) Metal Mining Technical Guidance for Environmental Effects Monitoring in anticipation of the proposed *Coal Mining Effluent Regulation* coming into law in the foreseeable future.

h) Discuss how the results from macroinvertebrate tissue samples would be extrapolated to represent concentrations of contaminants of potential concern (COPCs) in fish tissue and fish ovaries, the expected accuracy of such extrapolations, and the potential risks with extrapolating macroinvertebrate tissue data to an estimate of fish tissue contamination by the COPC associated with all phases of the mine life cycle, and how any risks would be mitigated.

Response:

The request to discuss how the baseline macroinvertebrate tissue samples may provide an indication of COPC concentrations in fish tissue and ovaries, and potential risks, is predominantly relevant to selenium. In general, fish tissue concentrations of most other elements are not a strong indicator of toxicity. In addition to selenium, the other exception is mercury. However, the proposed mining operations are not expected to increase mercury concentrations in receiving waters. Therefore, this response focuses on selenium.

Baseline selenium concentrations in benthic macroinvertebrates, or any other medium, do not by themselves provide any indication of risk under future conditions. Further, the baseline macroinvertebrate selenium concentrations by themselves cannot be extrapolated to estimate selenium concentrations in fish tissue and fish ovaries. However, the macroinvertebrate data can be used to assess how well the bioaccumulation models predict macroinvertebrate selenium concentrations under baseline conditions, which may then provide information on whether the models are conservative.

In developing the site-specific selenium guideline, a sulphate-dependent model for predicting periphyton selenium concentrations from water selenium concentrations was calibrated to baseline periphyton and water selenium data (Figure 5.23-1A). This model allowed for prediction of periphyton selenium concentrations over a range of water selenium and sulphate concentrations. The baseline periphyton selenium concentration of 5.3 mg/kg dw was used to predict macroinvertebrate selenium concentrations using relationships from other sites—these predictions ranged from 6.7 to 9.7 mg/kg dw under baseline conditions (Figure 5.23-1B). For comparison, the mean measured baseline selenium concentration in macroinvertebrates is 2.66 mg/kg dw (2.59-2.74 mg/kg dw). This indicates that the selenium bioaccumulation model may be conservative for Blairmore Creek, which could be due to (1) a baseline periphyton selenium concentration that is conservatively high for the site; (2) conservative models that predict higher trophic transfer of selenium from periphyton to macroinvertebrates; or (3) a combination of the two.

In summary, the baseline macroinvertebrate selenium data cannot be used to extrapolate to selenium concentrations in fish tissue and ovaries, but the data do provide an indication that the selenium bioaccumulation models are conservative for baseline conditions. Future monitoring will be conducted to further evaluate model performance over a range of water selenium and sulphate concentrations as part of the Fisheries and Aquatics Monitoring Program.

i) Discuss how any proposed baseline sampling program undertaken by Benga will be used to detect potential changes to WSCT during the various phases of the Project, and how the baseline sampling conducted to date would support a defensible before-after-control-impact (BACI) monitoring program.

Response:

Section 6.6 of the Fisheries and Aquatics Monitoring Program (JRP IR-5.4) describes how the proposed baseline sampling program will be used to detect potential changes to WSCT during the various phases of the Project.

References

BC MOE. 2016. Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators.

Environment Canada. 2012. Metal Mining Technical Guidance for Environmental Effects Monitoring.

Kuchapski K., Rasmussen J. 2015. Food chain transfer and exposure effects of selenium in salmonid fish communities in two watersheds in the Canadian Rocky Mountains. Canadian Journal of Fisheries and Aquatic Sciences. 72:955-967

5.24 Information Request 5.24

Grassy Mountain Coal Project - Updated Environmental Impact Assessment. Consultant Report #3; Appendix C, Figure 3-22 and Figure 3-25. (CEAR #42).

First Addendum to the Environmental Impact Assessment, Appendix A3 – Instream Flow Assessment. (CEAR #44).

Eighth Addendum to the Environmental Impact Assessment, response to DFO-R2-20; Figures DFO-R2-20- 3 to DFO-R2-20-5. (CEAR #89).

Comments from the Government of Canada - Fisheries and Oceans Canada submission. (CEAR #167).

From Osler, Hoskin & Harcourt LLP on behalf of Benga Mining Limited - Response to Sufficiency Comments from Non-Indigenous Parties. (CEAR #191).

In their submission to the Panel (CEAR #167), Fisheries and Oceans Canada (DFO) indicated that their information request on groundwater flux and WSCT critical habitat was only partially addressed in Benga's response to DFO-R2-20 in Addendum 8 (CEAR #89).

The response provided the requested groundwater flux and critical habitat overlay in a series of figures. Both Figures DFO-R2-20-4 and DFO-R2-20-5 indicate that for Gold Creek, the impacts (reductions) to groundwater flux to the stream are realized primarily within the headwater reaches adjacent to the mine site, with only a few instances of

reduced flux from groundwater system to the streams are predicted to occur along the main branch. This is consistent with the drawdowns in this area identified in Figure 3-22 and Figure 3-25 in Appendix C of Consultant Report #3 (CEAR #42). DFO indicated that based on the overlay of WSCT critical habitat (darker yellow shaded creeks), the impacted headwaters of Gold Creek do not appear to coincide with WSCT critical habitat.

However, there is no discussion regarding Blairmore Creek which, based on the figures provided, appears to show a reduction in groundwater flux both in its tributaries and within the main stem. Figure DFO-R2-20-3 in Addendum 8 shows that within Blairmore Creek there are many nodes which have an absolute flux reduction up to 9 m^3/day within habitat for WSCT, with a provincial conservation designation. Furthermore, DFO indicated that Figure DFO-R2-20-4 shows the same trend for the long term mine closure scenario. The figures for the end of mine (DFO-R2-20-4) and long term closure (DFO-R2-20-5) scenario both show reductions in groundwater flux to streams along the main branch of Blairmore Creek.

Although difficult to determine from the figure, it appears that there is an approximately 4 km stretch of Blairmore Creek (running the length of the proposed mine) along which these reductions appear to consistently fall within the 10 to 50% range for the end of mine and long term closure scenarios. As with Gold Creek, the headwater streams are considerably more impacted with reductions consistently between 75 to 100% of baseline conditions. These portions of the main branch of Blairmore Creek are assigned "Near Pure westslope cutthroat trout Provincial Conservation Designation". DFO indicated that the response does not discuss the reduction of groundwater flux within Blairmore Creek and whether this reduction will impact WSCT and the critical habitat identified within Blairmore Creek

In response to these concerns (CEAR #191), Benga indicated that they did not include Blairmore Creek for the following reasons:

- Blairmore Creek mainstem is currently not designated Critical Habitat for WSCT as per the *Species at Risk Act*. The mid- and upper reaches of Blairmore Creek (adjacent to the Project area) are assigned a provincial Conservation designation.
- The Instream Flow Assessment (First Addendum, Consultant Report #6, Appendix A3) executed for the project, and modelled for the life of the mine, predicted an increase in Area Weighted Suitability (i.e., improvement in overall habitat conditions) for key WSCT bioperiods (overwintering, spawning/incubation, fry/juvenile rearing, adult holding) in key reaches with Blairmore Creek expected to interact with the mine (Reaches 3, 4).

However, regardless of federal designation, provincially WSCT populations within Blairmore Creek are considered crucial to the recovery of the species. Given the provincial conservation designation and the predicted impacts to groundwater discharge to the Blairmore Creek mainstem and its tributaries in the vicinity of the mine, further information on the effects of the reduction in groundwater discharge is required.

a) Provide an assessment and an updated area weighted suitability calculation to determine the effects of the reduction in groundwater discharge to all bioperiods of

WSCT and how this reduction will influence stream temperatures and habitat suitability within Blairmore Creek.

Response:

Both the Water Temperature Assessment Model (CR#6, Appendix A3, Appendix A4) (CEAR #42) and the Instream Flow Assessment (CR#6, Appendix A3) (CEAR#44) applied total flow, which included baseflow (groundwater) and surface flow. Total flow in the overwintering and summer rearing bioperiods (the two bioperiods where groundwater flux is of most importance) is comprised predominantly of baseflow. No detectable residual effects on fish habitat due to modifications in stream temperature are predicted in Blairmore Creek throughout mine life (construction, operations, reclamation, closure phases). Thus, the modelled water temperature predictions during the overwintering and summer rearing bioperiods are considered reasonable and reflective of local conditions. Similarly, the predicted findings from the Instream Flow Assessment remain as described in CR#6 and do not require an adjustment of area weighted suitability. The predictions made during the assessment will be validated during monitoring. A draft Water Resources Monitoring Plan has been provided in response to JRP IR-5.4 (Fisheries and Aquatics Monitoring Program, Section 6.1).

b) Discuss technically and economically feasible mitigation and adaptive management measures that can be implemented to prevent and/or minimize changes in groundwater flux to Blairmore Creek as a result of developing the mine and reducing groundwater discharge to Blairmore Creek and its tributaries.

Response:

Pit dewatering is predicted by the numerical groundwater model to affect watercourse base flow during the mining operations and after closure (Section 5.3.2.2.3 in CR#3, CEAR#42). In the groundwater numerical model, a change in groundwater discharge to watercourse was calculated based on head distribution, which was then interpreted as a change in base flow. It was identified that the impacts (reductions) to groundwater flux to the stream are realized primarily within the headwater reaches adjacent to the mine site, with only a few instances of reduced flux from groundwater system to the streams predicted to occur along the main branch.

The base flow reductions described in CR#3 are calculated using outputs from the numerical model and do not take into account any mitigative measures that will be implemented by the surface water management system as described in in the EIS, Section C.5.3 (CEAR #42). The magnitude of the base flow reduction for both Blairmore and Gold creeks is largely due to the fact that groundwater is captured in the pit, pumped into the sediment ponds and not able to contribute to base flow of the creeks. The numerical model does not recognize that some of the water would be released back to the creeks and contributes to their base flows. As part of the water management system described in Section C.5.3, water will be collected in the sedimentation ponds, treated and discharged back to Blairmore or Gold creeks throughout the

year, which will provide flow to the main stems of Blairmore and Gold creeks and off-set some of the baseflow reduction associated with the pit dewatering and other mining activities.

The impact of the water release, as described above, to Blairmore and Gold creeks was assessed in the EIS, CR#4 (CEAR #42). Base flow reduction values from the groundwater numerical model were incorporated to a surface water flow model (GoldSim) taking into account surface run-off and water discharge from the ponds, pit lake and saturated zones to assess the actual predicted base flow changes for both Gold Creek and Blairmore Creek (CR#3 Section 5.3.2.2.3). Accounting for all sources of water, base flow is estimated to increase for Blairmore Creek (with the amount of decrease or increase varying seasonally and depending of the mining stage).

Active groundwater and surface water monitoring as described in JRP IR-5.18 and JRP IR-5.4 will provide valuable information to validate (or invalidate) the modelling predictions. Continuous monitoring of surface water at selected gauging stations will provide real time information on the amount of base flow and any reduction (or augmentation) associated with the mining activities (including water release from the sedimentation ponds) to ensure suitable water levels are kept to protect the WSCT. If the base flows are becoming too low, the integrated monitoring and management plan in place will ensure additional treated water is released so the baseflow remains at an acceptable level during all of the critical bioperiods.

5.25 Information Request 5.25

First Addendum to the Environmental Impact Assessment, Appendix A3 - Instream Flow Assessment; Section 5. (CEAR #44).

Comments from the Coalition of Alberta Wilderness Association and Grassy Mountain Group, and Shirley Kirby ("the Coalition"). (CEAR #164).

From Osler, Hoskin & Harcourt LLP on behalf of Benga Mining Limited - Response to Sufficiency Comments from Non-Indigenous Parties. (CEAR #191).

In Section 5 of the Instream Flow Assessment in Appendix A3 in Addendum 1 (CEAR #44), Benga stated that short-term mitigation measures have been proposed for supplementing flows during dry years, which are intended to alleviate any elevated risk of causing incremental residual effects to critical habitat. In response to concerns outlined by the Coalition (CEAR #191), Benga stated that flow supplementation, and other adaptive water management techniques, would be considered as part of the Water Management Plans developed during the permitting stage. Details regarding how flow augmentation of Gold Creek during periods of reduced flows will be implemented were not provided for consideration. Given the threatened status of WSCT, details regarding the proposed mitigation must be provided for the Panel's consideration, and not at a later time.

Response:

Additional detail on flow supplementation as a mitigation measure was provided in response to DFO's SIR#2 included in the Sixth Addendum to the Environmental Impact Assessment

(CEAR #70). Predicted habitat alterations/loss due to changes in hydrology are small and hydrological conditions are highly variable, therefore it is proposed that ongoing hydrologic and habitat monitoring be performed as part of the Project's Fisheries and Aquatics Monitoring Program to verify modelling predictions and identify whether upper Gold Creek may require flow augmentation (draft provided in JRP IR-5.4, Section 6.1).

a) Discuss the flow thresholds that will trigger initiation of flow augmentation and who would be involved in making the decision to augment flows. Provide the operational procedures that will be followed, along with the periodicity of flow measurements that will be used in making decisions on whether to augment flows in Gold Creek and for what period of time flows will be augmented;

Response:

Flow augmentation has been proposed as an adaptive management technique should the flow reductions and/or changes in area weighted suitability (AWS) be greater than what was predicted in the Instream Flow Assessment (CR#6, Appendix A3: CEAR #44). Monitoring will be implemented to verify and validate the changes in surface flow predicted by the Instream Flow Assessment. Details on the flow monitoring frequency, methods, and data analysis are provided in Section 6.1 of the draft Fisheries and Aquatics Monitoring Program (response to JRP IR-5.4).

The 10% flow reduction threshold which was applied to Gold Creek in the Project's EIA aquatic effects assessment (CR#6) was used to estimate the corresponding alteration or loss of habitat in upper Gold Creek. The predicted habitat alteration/losses have been accounted for (*i.e.,* counterbalanced) in the Project's Fisheries Offsetting Plan; therefore, flow augmentation is not expected to occur at the flow rates predicted. If the flow reduction in Gold Creek is greater than predicted, flow augmentation will be considered as a potential mitigation measure. To validate the predictions flow monitoring will be implemented as part of the Project's Fisheries and Aquatics Monitoring Program (JRP IR-5.4).

The decision to augment flows would be made by the Projects Operations and Environmental Management teams, and through communication with pertinent provincial regulatory agencies, if necessary, based on the monitoring plan as outlined in JRP IR-5.4.

b) Describe the operational requirements for conducting flow augmentation, including where the water would be sourced from, how it would be moved, and the location of discharge points in Gold Creek throughout all stages of mine development and closure.

Response:

Flow supplementation pumps and piping will not be installed unless and until they are deemed to be necessary based on monitoring results. If required, an assessment will be made to determine the best route for piping water from the sedimentation ponds associated with Blairmore Creek to

appropriate discharge points (to be determined through results of the Monitoring Plan) into Gold Creek. Initially, water will be transported using spare pumps and flexible piping on the surface. If the need for supplementation is determined to be a long-term issue, permanent pumps and pipelines will be constructed. No sedimentation ponds are anticipated to be required as a result of this operation.

c) Provide a discussion on whether flows will need to be augmented post mine closure, and the operational requirements for conducting flow augmentation post mine closure, including the costs to operate the machinery and the staff required to conduct instream flow monitoring and implement flow augmentation.

Response:

Flow supplementation post closure will not be necessary as the interception of surface water drainage and the lowering of ground water and ground water handling within the mine pit will no longer be necessary. Site contours will be re-established to allow natural drainage to occur and ground water levels will return to normal levels. Eventually, an end pit lake will form as part of the new landscape and it will drain through to Gold Creek. Flows in Gold Creek should therefore approach pre-mining levels.

d) Provide a discussion of how water quality parameters from the source location will be analyzed and treated, as necessary, prior to discharging augmented flows into Gold Creek. Include an analysis of all Chemicals Of Potential Concern from the source location, temperature of the source water and sediment load, and proposed mitigation measures and adaptive management actions that are economically and technically feasible to address issues with water quality, temperature or sediment prior to discharging augmented flows to Gold Creek.

Response:

The source water se sedimentation ponds will contain non-contact water and therefore will not contain contaminants other than sediments. These ponds will be treated to precipitate sediment and will be properly tested to ensure compliance with water quality guidelines before being discharged to Gold Creek. It is not anticipated that additional sedimentation pond or settling capacity will be required.

5.26 Information Request 5.26

Recovery Strategy for the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*), Alberta Populations in Canada. (CEAR #101).

Comments from the Government of Canada - Fisheries and Oceans Canada submission. (CEAR #167).

Comments from the Government of Canada – Fisheries and Oceans Canada submission. (CEAR #204).

According to the Recovery Strategy for the Westlope Cutthroat Trout (WSCT) (CEAR #101), identified critical habitat is located within the fisheries and aquatics Local Study Area for the Project with portions in Gold Creek and its tributaries, Morin and Caudron Creeks, and an unnamed tributary to Blairmore Creek. In their submission to the Panel (CEAR #167), Fisheries and Oceans Canada (DFO) indicated that although the existing Recovery Strategy includes the locations described above, an amended list of critical habitats is likely forthcoming within the life of the Project. DFO stated that Benga is encouraged to consider potential additions to critical habitat in their plans.

Further, in response to the Panel's request for clarification with respect to DFO's views on the sufficiency and technical merit of information in relation to the potential for an amended list of waterbodies identified as critical habitat within the life of the Project (CEAR #204), DFO stated that, in recent collaboration with the Province of Alberta (February 2019), scientific information with respect to the genetic status of WSCT has been attained and is the basis for a potential expansion of aquatic critical habitat in Gold Creek and its tributaries. DFO also stated that they have been working actively and cooperatively with Alberta to identify additional critical habitat, including a primary riparian zone around water bodies. Given that WSCT is listed as threatened under the *Species at Risk Act* and the Project has the potential to affect its designated critical habitat, further clarity on Benga's plan to address any future, potential designations of additional critical habitat in the fisheries and aquatics Local Study Area (LSA) is required.

a) Provide a description of how Benga plans to address the potential project effects and cumulative effects on any future additions to WSCT critical habitat within the fisheries and aquatics LSA.

Response:

Fish and aquatic habitat in the LSA and RSA is regulated and protected by two key federal statues: the *Fisheries Act* and the *Species at Risk Act* (Consultant Report #6, Section 2.2, CEAR #44). The *Fisheries Act* prohibits serious harm to fish that are part of a commercial, recreational or Aboriginal (CRA) fishery or fish that support such a fishery, which casts a wider assessment for potential effects than the *Species at Risk Act*, which focuses on specific species (*e.g.,* WSCT). Although the presence of WSCT critical habitat was acknowledged and is a focal point of the aquatic effects assessment, Consultant Report #6 did not weigh Project and

cumulative effects on 'other' (non-critical) fish habitat any differently (Table 5.1, CR #6, CEAR #44).

An updated Recovery/Action Plan for the Alberta Populations of WSCT has been posted for 60-day public comment period (ending July 13, 2019) proposing to designate the Gold Creek watershed in its entirety as critical habitat, including a 30 m riparian area around the watercourses. At present, a 20 m buffer was applied to the non-fish bearing tributaries of Gold Creek (*e.g.,* GCT06) and a 50 m buffer was applied to the mainstem of Gold Creek. Should the updated Recovery/Action Plan be implemented, the amount of riparian habitat affected by the Project will be re-evaluated to consider these potential changes. Given the conservative buffer applied to Gold Creek, changes are expected to be minimal. The draft Fisheries Offsetting Plan (Addendum 8, CEAR #89) has incorporated a number of methods to address uncertainty in potential effects including: 1) gain:loss ratio of 9:1 for aquatic habitat and 2.2:1 for riparian habitat (Section 9), 2) contingency measures (Section 7.1.4), and 3) an adaptive management approach (Section 12).

b) Discuss how the future addition of critical habitat within the fisheries and aquatics LSA may affect the operational plans of the mine, placement of mine infrastructure, utilization of water treatment facilities, management of site water, flow augmentation plans, and/or the closure plans of the mine to achieve reclamation certification.

Response:

Benga recognizes all fish and aquatic habitat as important and is committed to applying mitigation that is technically feasible to avoid, remove, or minimize potential predicted Project and cumulative effects to WSCT. The potential addition of critical habitat within the LSA in not anticipated to affect the operational plans of the mine, placement of mine infrastructure, utilization of water treatment facilities, management of site water, the possibility of flow augmentation planning and/or the closure plans of the mine as every potential mitigation measure has been applied.

c) Provide a list of studies that Benga anticipates will need to be updated and submitted for the Panel's consideration to address any potential additions of WSCT critical habitat within the fisheries and aquatics LSA.

Response:

Benga does not anticipate any additional studies required for the Panel's consideration to address the potential expansion of WSCT critical habitat within the fisheries and aquatics LSA. The baseline and impact assessment studies that have been filed in support of the Project conservatively assumed Gold and Blairmore creeks would be designated as WSCT critical habitat. The calculated (predicted) loss of habitat, the draft Fisheries Offsetting Plan, the draft Fisheries and Aquatics Monitoring Program (JRP IR-5.4), and the Project itself have been designed to ensure the ongoing WSCT survival, recovery and persistence in the LSA. Therefore,

the proposed reclassification of a portion of the LSA as WSCT Critical Habitat has no bearing on the work that has been done or needs to be done to support the Project.

5.27 Information Request 5.27

Fourth Addendum to the Environmental Impact Assessment. IR 4. (CEAR #55).

Eighth Addendum to the Environmental Impact Assessment. Appendix B-1. (CEAR #89).

Recovery Strategy for the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*), Alberta Populations in Canada. (CEAR #101).

Comments from the Government of Canada – Fisheries and Oceans Canada submission. (CEAR #204).

Fisheries and Oceans Canada (DFO) submission to the Panel (CEAR #204) highlighted that Benga's proposed approach to fisheries offsetting presented in Appendix B-1 in Addendum 8 (CEAR #89) involves the use of an equivalency approach to determine the amount and nature of offsets to achieve a fair exchange between Project effects and gains associated with offsetting activities. DFO stated that equivalencies are used to describe the Project's residual effects and the benefits from offsetting activities, and ultimately determine the amount of offsetting required to counterbalance the Project effects.

In the response to IR4 in Addendum 4 (CEAR #55), Benga described how the population and recovery objectives of the Recovery Strategy would be achieved by proposed offsetting for the Project, however at that time the offsetting measures were in the early stages of development.

Benga presented the Detailed Fisheries Offsetting Plan in Appendix B-1 in Addendum 8 (CEAR #89). However, in CEAR #204, DFO indicated that the Detailed Fisheries Offsetting Plan does not demonstrate how the proposed offsetting, which uses loss-creation scenarios based on the equivalency approach, will (a) meet the population and distribution objectives for WSCT specified in the Recovery Strategy, and (b) not jeopardize the survival and recovery of this species.

Benga has still not provided adequate justification for how, specifically, the offsetting approach for the Project meets the population and distribution objectives for WSCT.

a) Having regard for the precautionary approach and the equivalency approach, demonstrate how the proposed offsetting:

Response:

The Precautionary Approach (PA) strives to be cautious when information is less certain, unreliable or inadequate and does not accept the absence of adequate scientific information as a reason for not implementing conservation measures to avoid serious harm to (or jeopardize the survival or recovery of) a resource (DFO 2013). The key element within the PA is the avoidance of irreversible [serious] harm to a resource, in this specific case WSCT and this species critical habitat, including residence. Offsetting approaches proposed depend, in part, on the current

status and knowledge about the species. The overarching goal of the PA is to prevent a stock from declining through rebuilding or recovery strategies for species or populations listed as endangered or threatened.

> i. meets, at a minimum, the population and distribution objectives for Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*), Alberta Populations in Canada as specified in the Recovery Strategy; and,

Response:

The *Species at Risk Act* (SARA) applies the PA in two main areas (DFO 2015):

- The identification of critical habitat, and
- The preparation of recovery strategies, actions plans and/or management plans.

It is recognized by the Recovery Strategy for the Alberta Populations of Westslope Cutthroat Trout (*O. clarkii lewisi*) in Canada (Recovery Strategy; DFO 2014) that given the small numbers of pure-strain populations, the small quantities of individuals in many of the noted populations, and the limited distribution of Westslope Cutthroat Trout in Alberta, areas currently identified as critical habitat are insufficient to achieve their population and distribution objectives. This is because it is not yet possible to identify suitable habitats and determine the feasibility of recovering genetically pure populations or even identify how many pure populations would need to be restored. Thus, empirical population targets (reference points) have not been offered in the Recovery Strategy, which is central for implementing a PA. DFO (2014) outlines a schedule of studies aimed to identify additional critical habitats necessary for survival and recovery of the species, including:

- Studies to identify and describe life-history, movement and habitat use by life-stage (including quality of habitats); and
- Studies to identify suitable habitats and determine feasibility for recovering genetically pure Westslope Cutthroat Trout.

Benga has completed multiple studies of WSCT over several years in Gold Creek and Blairmore Creek watersheds specific to the proposed Grassy Mountain Coal Project, many of which are ongoing, and all of which closely align with the schedule of studies described in DFO (2014) and have been applied in the assessment of predicted potential residual effects as well as the subsequent development of the draft Fisheries Offsetting Plan (Addendum 8, CEAR #89). The information collected aims to understand WSCT population viability, which is central to achieving the population and distribution objectives of the Recovery Strategy. For example, data has provided crucial information on the extension of WSCT critical habitat in the Gold Creek watershed. Additionally, habitat has been characterized in detail to realize its quantity, suitability and identify those habitats of which are limiting and are potentially influencing WSCT survival, recovery and persistence.

ii. ensures the predicted effects of the Project will not jeopardize the survival and recovery of this species.

The draft Fisheries Offsetting Plan was prepared in accordance with the information requirements set out in the *Guidelines for the use of Biodiversity Offsets as Part of an Application for a Species at Risk Act Section 73 Permit* (Government of Canada 2016). The guidance emphasizes the importance to manage risk and uncertainty associated with the offsets. As noted in JRP IR-5.27 a), the ongoing fisheries/aquatic baseline monitoring studies being conducted for the Project not only aims to reduce risk and uncertainty surrounding the population viability of WSCT and the prediction of residual effects, but also in the selection and design of offsets. The offsets that have been selected target the enhancement and/or protection of critical habitat, the residence, and individual WSCT. As part of permitting, the draft Fisheries Offsetting Plan will assess and identify the likelihood of partial and complete failure as well as all uncertainties associated with the proposed offsets and identify, describe, and commit to proposed contingency measures that will be undertaken should the offsets not function as intended. This will ensure that the Project will not jeopardize the survival and recovery of WSCT.

b) Provide an updated offsetting plan incorporating any additional data collected that is relevant to proposed or new offsetting options.

The draft Fisheries Offsetting Plan does not require any updates at this point in the regulatory review. As the Project progresses through a Public Hearing, and into the subsequent permitting phase, as per the permitting process with DFO, Benga will provide an updated Fisheries Offsetting Plan that will include additional biological, ecological, and engineering design plans as required for submission of an Application for Approval/Authorization under the *Species at Risk Act* and/or *Fisheries Act*. In the interim, additional field investigations specific to WSCT ecology continue to be completed that aim to increase certainty in proposed fisheries offsets and further support the overall project.

5.28 Information Request 5.28

First Addendum to the Environmental Impact Assessment. Aquatic Ecology Assessment Addendum to Consultant Report #6; Section 4.2.1.3. (CEAR #44).

In Section 4.2.1.3 of the Aquatic Ecology Addendum (Addendum 1, CEAR #44), Benga indicated that the Project will require the use of explosives during mining which has the potential for creating instantaneous pressure changes greater than 100 kPa (14.5 psi) in swim bladder of a fish (Wright and Hopky 1998). In addition, vibrations from the detonation of explosives may cause damage to incubating eggs. As well, blasts generate both seismic and surface waves (Rayleigh waves).

In Addendum 1 (CEAR #44), Benga stated they are committed to developing and using a blasting regime that will meet the blasting guidelines contained in Wright and Hopky (1998). In addition, as a standard operating procedure for the Project, delays will be used in all blasts to limit the explosive weight charge to one hole within any eight-millisecond

timeframe so as to eliminate any additive effects from blasting due to constructive interference.

Benga stated that implementation of the above-mentioned mitigation actions is expected to effectively manage and reduce the likelihood and extent of direct mortality to WSCT that inhabit both Gold Creek and Blairmore Creek watersheds. Thus, Benga concluded that no detectable changes in WSCT relative abundance due to blasting activities, proportional to baseline conditions, is expected, further determining that this pathway will have no linkage to effects on WSCT.

Benga has indicated that no direct effects are predicted to occur from the proposed use of explosives at the mine site. However, the assessment of impacts regarding the use of explosives only considered the direct effects on fish relating to mortality or internal injury sustained to the swim bladder or damage to incubating eggs, and did not consider the indirect effects of blasting on fish behaviour or their use of habitats as a result of vibrations and noise produced by blasting. Given the limited distribution of habitats critical to WSCT life processes, any avoidance response resulting from blasting activities can impact the survivability of fish populations in Gold and Blairmore Creeks, and would therefore result in a linkage to effects on fish which needs to be assessed.

a) Assess and discuss the pathways of effects on fish behaviour and utilization of habitats within the zone of influence of blasting activities that could result in fish displaying an avoidance response as a result of vibrations and/or noise produced by the use of explosives.

Response:

Best available science has observed a range of behavioural responses in wild fish exposed to anthropogenic sound, such as alarm response, habitat avoidance and interference with sensory orientation and navigation (Knudsen *et al*. 1997, Fay and Popper 2000); however, there are no established quantitative criteria for fish behavioural response to sound. Hastings and Popper (2005) and Popper *et al*. (2006) indicate that no scientifically supported threshold for the onset of behavioural effects from anthropogenic noise can currently be established. Despite no established quantitative criteria for fish behavioral response to sound, Benga is committed to developing and using a blasting regime that will meet the current blasting guidelines which could include monitoring during blasting to confirm whether sound exceed the thresholds as prescribed by DFO contained in Wright and Hopky (1998).

b) Discuss technically and economically feasible mitigation and adaptive management measures that can be implemented to prevent and/or minimize avoidance responses of fish in Gold Creek and Blairmore Creek as a result of blasting activities, to prevent

any impacts on fish populations, and to ensure fish have year round access to all habitats throughout Gold and Blairmore Creeks.

Response:

Mitigation provided in the DFO blasting guidelines (Wright and Hopky 1998) will be incorporated into any blasting plan, including:

- No explosive charge to be detonated near fish habitat that will produce, or is likely to produce, an instantaneous pressure change (*i.e.,* overpressure) greater than 100kPa (14.5 psi) in the swimbladder of a fish. This will be ensured by following the recommended setbacks;
- No explosive charge is to be detonated that produces, or is likely to produce, a peak particle velocity greater than 13 mm/s in a spawning bed during the period of egg incubation. This will be ensured by following the recommended setbacks. Empirically, these setbacks have been shown to be conservative (Faulkner *et al*. 2006);
- Explosive weight charge will be limited to one charge per discrete explosion (delay);
- If multiple charges are required, time-delay detonators will be used to reduce the overall detonation to a series of discrete explosions; and
- Ground vibration monitoring, using specifically designed instruments, of all blasting activities will be conducted when an explosives charge is used within 300m of fish habitat.

5.29 Information Request 5.29

Grassy Mountain Coal Project - Updated Environmental Impact Assessment. Section G, Consultant Report #5 – Surface Water Quality; Figure 3. (CEAR #42).

Joint Review Panel Information Request Package #4. Information Request 4.12 (CEAR #210).

Comments from the Timberwolf Wilderness Society. (CEAR #156).

Comments from Allan Garbutt. (CEAR #158).

Comments from Sierra Dakin Kuiper. (CEAR #170).

Comments from the Canadian Parks and Wilderness Society - Southern Alberta Chapter. (CEAR #176).

Ktunaxa Nation Rights and Interests Study in relation to the Grassy Mountain Coal Project. (CEAR #189).

As stated in the Panel's Information Request 4.12 in Package 4 (CEAR #210), participants have noted contamination of the Koocanusa reservoir in Montana, which lies more than 100 km downstream of the discharge from the five Teck metallurgical coal mines in the Elk Valley (CEAR #156, #158, #170, #176). Participants have also

expressed concerns with respect to potential downstream contamination of the Crowsnest River and Oldman reservoir (CEAR #42 Section G, CEAR #170, CEAR #189). Selenium behaves differently in lentic (lake, reservoir, wetland) habitats and even if water concentrations are very low entering lentic systems, long-term selenium loading can result in increased bioaccumulation in aquatic food chains. Benga's risk assessment of selenium does not however consider the potential transport of selenium downstream to, and accumulation within, the Oldman Reservoir. This is further demonstrated by the omission of the Oldman Reservoir from both the aquatics Local Study Area (LSA) and the Regional Study Area (RSA) presented in Figure 3 of Consultant Report #5 (CEAR #42).

Based on the potential for selenium accumulation in lentic environments, and its potential to bioaccumulate, further information is required to determine the potential effects of the Project on surface water quality, aquatic species (including periphyton invertebrates, and fish), birds, amphibians and mammals that may reside in or use the Oldman Reservoir for feeding, breeding or other important life functions.

a) Provide a summary of recent literature based on case studies, peer-reviewed literature, technical reports, environmental assessments, monitoring reports and published third party reports that describe the potential effects of selenium toxicity in lentic environments and bioaccumulation in aquatic food chains (including algae, invertebrates and fish), birds, amphibians, and mammals, such as Lake Koocanusa.

Response:

Please refer to the full response below in JRP IR-5.29 (f).

b) Provide the following baseline information for the Oldman Reservoir:

i. a characterization of seasonal surface water quality, including analytical results (e.g. water temperature, turbidity, pH, dissolved oxygen profiles, and contaminants of potential concern (COPC) in comparison with established water quality guidelines). Benga is encouraged to use existing data, where available;

ii. a characterization of fish populations and the fish community on the basis of species and life stages, including information on the surveys carried out and the sources of data available;

iii. a characterization of other species that could potentially be affected by bioaccumulation of selenium, including algae, invertebrates, birds, amphibians, and mammals that may use the Oldman Reservoir;

iv. a list of any species listed as "at risk", "may be at risk", or "sensitive" in the General Status of Alberta Wild Species, and/or listed in Schedule 1 of the federal *Species at Risk Act*, and/or listed as "at risk" by the Committee on the

Status of Endangered Wildlife in Canada (COSEWIC) that are known to be present in the Oldman Reservoir.

Response:

The Oldman Reservoir is outside the Project defined spatial boundaries. Baseline information included and characterized those applicable to the Project contained within the defined local and regional study areas. For an assessment of the potential risk to selenium-related effects on fisheries resources in the Oldman Reservoir, please refer to the full response below in JRP IR-5.29 (f).

c) Provide an assessment of the potential effects of selenium bioaccumulation due to the Project on aquatic receptors (algae, invertebrates and fish), birds, amphibians, and mammals in the Oldman Reservoir.

Response:

Please refer to the full response below in JRP IR-5.29 (f).

d) Describe any technically and economically feasible mitigation measures required to ensure that selenium concentrations would not result in exceedances of existing selenium tissue guidelines in the Oldman Reservoir. This must include supporting evidence on the efficacy of proposed mitigation measures. Predicted increases in sulphate must not be included as a mitigating factor in this discussion.

Response:

Please refer to JRP IR-5.1, JRP IR-5.5, JRP IR-5.6, and JRP IR-5.10, all of which provide additional information on selenium, sulphate, selenium and metals treatment mitigations all designed to protect the immediate downstream environments, that drain into the Crowsnest River, and ultimately the Oldman Dam Reservoir.

e) Characterize any residual effects of elevated selenium in the Oldman Reservoir on all potentially affected aquatic and wildlife receptors (i.e. algae, invertebrates, fish, birds, amphibians and mammals) that remain after the implementation of mitigation measures (e.g. magnitude, extent, duration, frequency, etc.) and present a conclusion regarding the significance of any residual effect.

Response:

Please refer to the full response below in JRP IR-5.29 (f).

f) Provide a characterization of any cumulative effects on all potentially affected aquatic and wildlife receptors (i.e. algae, invertebrates, fish, birds, amphibians and mammals), and conclusions regarding the significance of any cumulative effect.

Response:

The following is a general response to JRP IR-5.29 a), JRP IR-5.29 c), JRP IR-5.29 e), and JRP IR-5.29 f). As the rationale notes, selenium bioaccumulation potential in lentic systems is generally greater than in lotic systems. Relative to the more toxic conditions in lotic systems that favor the oxidized selenate species, lentic systems tend to have greater reducing conditions that favor the formation of more bioaccumulative selenium species, such as selenite and organic selenium forms. In addition, selenium cycling is typically greater in lentic systems, which also increases its bioaccumulation potential. As the IR notes, Lake Koocanusa, which straddles the border between British Columba and Montana, is one example of a lentic system (a reservoir) that receives selenium loadings from upstream coal mining operations. This response mainly focuses on Lake Koocanusa as a case study.

Lake Koocanusa is the receiving water for the Elk River, which drains the Elk Valley Watershed. There are five active coal mines in Elk Valley. Selenium loadings to Lake Koocanusa from the Elk River are estimated to average about 25 kg/d, which accounts for about 95% of the loading (Lotic Environmental 2018), while selenium concentrations at the mouth of the Elk River vary between 3 and 8 µg/L (Minnow Environmental 2018; Lotic Environmental 2018). At the Order Station within the reservoir, a sampling station mandated by BCMOE for which site performance objectives have been established, selenium concentrations typically range between 0.5 and 1.5 µg/L, with a mean of about 1 µg/L (Minnow Environmental 2018), which is lower than the BC water quality guideline of 2 µg/L (BCMOE 2014). The Order Station is about 5 km "downstream" from the mouth of the Elk (Figure 5.29-1).

For comparison, maximum surface water selenium concentrations at the furthest downstream nodes for Blairmore Creek (BC-01) and Gold Creek (GC-01) are predicted to be about 5 and 1.6 µg/L, respectively. Both creeks drain into the Crowsnest River, which has predicted selenium concentrations of about 2 µg/L downstream of Blairmore Creek and about 1.6 µg/L downstream of Gold Creek (Hatfield 2016). Accordingly, predicted selenium concentrations in Crowsnest Creek, just downstream of Blairmore and Gold creeks, are already at or below the selenium guideline of 2 µg/L.

Catchment areas for the reservoir can be used to conservatively estimate selenium concentrations in Oldman Reservoir. The effective catchment area of the Crowsnest River at Frank (which was used for the far-field modelling in the EA) is 403 km^2 (Water Survey of Canada hydrometric station 05AA008), while the effective catchment of the Old Man River at Bracket (station 05AA024, downstream of the reservoir outlet and considered representative of the reservoir catchment) is 4,380 km^2. Thus, the Crowsnest River catchment represents about 9% of the reservoir surface water loadings. If it is conservatively assumed that the predicted selenium

concentration of 1.6 µg/L downstream of Gold Creek persisted all the way to Oldman Reservoir, and the mean baseline selenium concentration in the other Oldman Reservoir catchments was 0.5 µg/L, the conservatively estimated selenium concentration in Oldman Reservoir would be 0.6 µg/L (1.6 µg/L × 0.09 + 0.5 µg/L × 0.91 = 0.6 µg/L).

Given that the predicted selenium concentration in Oldman Reservoir is well-below the selenium guideline even when using conservative assumptions, there is negligible selenium risks in the reservoir due to predictions for Blairmore Creek. Further, the predicted selenium concentrations for Blairmore Creek are within the range of those measured at the mouth of the Elk River where it drains into Lake Koocanusa. The Elk River is predicted to contribute 95% of the selenium loadings to Lake Koocanusa, with average concentrations meeting the selenium guideline within the reservoir, while estimated selenium loadings into Oldman Reservoir from Blairmore Creek are much lower and selenium concentration predictions are well-below the selenium guideline. Because the guideline is conservatively designed to be protective across provincial water bodies, no risks to aquatic life in Oldman Reservoir are predicted.

References

BCMOE. 2014. Water quality guidelines for selenium. Technical report update. Water Protection and Sustainability Branch, Environmental Sustainability and Strategic Policy Division, British Columbia Ministry of Environment. 257 pp.

Hatfield. 2016. Riversdale Resources Grassy Mountain Coal Project: Surface water quality assessment report. Calgary, AB.

Lotic Environmental. 2018. Koocanusa Reservoir data compilation report. Version 3. Cranbrook BC.

Minnow Environmental. 2018. Koocanusa Reservoir monitoring report, 2014 to 2016. Georgetown, ON.

CUMULATIVE EFFECTS

5.30 Information Request 5.30

Canadian Environmental Assessment Agency Interim Technical Guidance "Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012". (March 2018).

Eighth Addendum to the Environmental Impact Assessment. Appendix A-1, Table 2-1. (CEAR #89). Comments from the Ktunaxa Nation Council. (CEAR #178).

As explained in the Canadian Environmental Assessment Agency's Interim Technical Guidance, "Assessing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act, 2012"* the environmental assessment should consider cumulative effects from past, existing and future activities that may occur in relation to the Project, including activities such as Crown and private logging operations where the effects of such activities have the potential to combine with residual effects of the Project.

In Table 2-1 in Appendix A-1 in Addendum 8 (CEAR #89), Benga considered Crown Timber Operations in its list of past, existing and future activities. However, the Ktunaxa Nation Council (CEAR #178) expressed concern in their submissions that past, existing and future timber operations due to private logging operations had not been adequately scoped in to the cumulative effects assessment. The submission noted that private logging activities are occurring, and planned, in the Elk Valley, raising concern as to whether such activities, in both Alberta and British Columbia, were considered in the assessment.

Potential effects from past, existing and future timber operations have the potential to affect Project VCs, such as vegetation, surface water quality, aquatic resources, wildlife and current use of lands and resources for traditional purposes. The pathway of effects may include increased sedimentation in watersheds, increased water temperatures, and habitat loss.

Benga did not justify the omission of private logging operations from its cumulative effects assessment. It remains unclear to the Panel whether private logging operations were adequately considered in the cumulative effects assessment for potentially affected VCs.

a) Describe whether or how Benga has accounted for private logging activities in its cumulative effects assessment.

Response:

Private logging activities have been considered in the Project's assessment of cumulative effects, as described below.

Consideration of Private Logging Activities in Alberta

In Alberta, the logging in the vicinity of the Project occurs on public lands that are managed by the C5 Forest Management Unit and are not available for private logging. Figure 5.30-1 shows

the area covered by the C5 FMU that is within the Project Vegetation RSA. It covers most of the forested lands in the Alberta portion of the Vegetation RSA. The lands on the east portion of the Vegetation RSA are largely agricultural, where private logging would not be a substantial activity.

Consideration of Private Logging Activities in BC

It is important to note that only the Project Vegetation RSA and the Grizzly bear RSA (GBRSA) include lands that are located in BC (Figure 5.30-1). The RSAs for aquatic ecology, water quality, and hydrology do not include lands in BC as the provincial border is the main watershed divide with water in Alberta flowing east and water in BC flowing west. The three RSAs include the Crowsnest River watershed located in Alberta, to evaluate potential cumulative effects at the regional level (Figure 5.30-1), and considers that Project effects have the potential to interact with other projects within the Crowsnest River watershed. The Elk Valley watershed in BC is outside the spatial boundaries for the cumulative effects assessments for hydrology, surface water and aquatic resources. Therefore, the potential impacts of sedimentation, increased temperature, or riparian habitat loss occurring in the watersheds from private logging operations in BC would not interact cumulatively with the potential effects of the Grassy Mountain Project.

For wildlife, some species use the LSA as their cumulative effects spatial area (such as Columbia spotted frog, western toad, and great gray owl). All other species (except for grizzly bear) use the Wildlife RSA which is also located only in Alberta (Section 11.1.2.1, Cumulative Effects Assessment, Addendum 8, Appendix A-1, CEAR #89). Thus, the spatial boundaries for the cumulative effects assessments for these species do not include the Elk Valley in BC. It is only the Grizzly Bear VC, Vegetation VCs, and effects on Indigenous peoples that use the GBRSA as the spatial boundaries for the cumulative effects assessment, and contain lands in the BC Elk Valley.

Consideration of past and existing logging in the BC portion of the GBRSA has been taken into account by measuring disturbed areas. The greyed areas on Figure 5.30-1 show existing disturbances (which would include things such as logging, trails or roads), which have been taken into account in the baseline estimates of existing disturbance. As well, logging that would have occurred on existing BC mine sites (as seen on Figure 5.30-1) was also accounted for in the calculation of existing disturbance.

Private logging in the BC is managed under the *Private Managed Forest Land Act* which is administered by the Managed Forest Council. The Ministry of Forests, Lands, Natural Resource Operations and Rural Development produces a map outlining the Private Managed Forest Lands (BC, 2019). The plans, timing and reclamation of these forested areas are not provided, only that they are privately managed forests. In the absence of publicly available development plans for the physical activity of private logging, this map provides a reasonable estimate of what would constitute certain or reasonably foreseeable future private logging activities for evaluation in a

cumulative effects assessment. These areas have been overlayed on the Project Vegetation RSA as seen in Figure 5.30-1, to evaluated future private logging potential. Evaluation of these areas, suggests that not all of these forests are planned for certain logging. For example, one of the privately managed forests is Alexander Creek Conservation Lands, a privately owned area that Teck purchased in the Elk Valley for wildlife and habitat conservation purposes (Teck website) a conservation area, it seems unlikely that this area is planned for logging.

The area to the west of Alexander Creek Conservation Lands is the provincially managed Alexander Creek Access Management Area (AMA). AMAs are designated and regulated under the BC *Wildlife Act* (BC Conservation Officer Service, 2018) for managing public access, for the purposes of wildlife management (http://www.env.gov.bc.ca/kootenay/eco/accessmaps.htm). There are no publicly available documents indicating that logging in this area would be reasonably foreseeable or certain.

The area to the north of Elkview is likely associated with the Teck Elkview Mine and there are no publicly available records indicating expansion northward. As seen by the greyed areas (Figure 5.30-1), some of this area has already been disturbed, and would have been captured in baseline calculations of existing disturbance.

The area to the west of the proposed Michel Creek Coking Coal Project is largely covered by existing disturbance, and as such, has already been considered in the examination of past and present activities.

Therefore, consideration of future private logging with the GBRSA does not result in changes to calculated areas of past or future disturbed areas, and the cumulative effects assessment results remain unchanged.

References:

BC Conservation Officer Service. 2018. Access Management Compliance and Enforcement Program (AMCEP) October/November 2018 Report. (http://www.env.gov.bc.ca/kootenay/eco/reports/AMCEP%20October%20and%20November%20Report%202018.pdf)

BC Ministry of Forests, Lands, and Natural Resource Operations (http://www.env.gov.bc.ca/kootenay/eco/accessmaps.htm. (searched June 17, 2019)

BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development. 2019. Private Managed Forest Lands (PMFL) – Southeast https://engage.gov.bc.ca/app/uploads/sites/491/2019/05/PMFL_Lands_Southeast.pdf (date on map May 24, 2019, website checked June 18, 2019)

Teck. https://www.teck.com/media/CL%20map%20printable%208.5x11%202015.pdf) Teck website (Searched June 17, 2019)

b) If Benga has not accounted for private logging activities in the cumulative effects assessment and private logging does, or may occur in the Project area, revise the cumulative effects assessment using available information on past, existing and future private logging operations.

Response:

Please see the response above in JRP IR-5.30 a).

5.31 Information Request 5.31

Canadian Environmental Assessment Agency Interim Technical Guidance "Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012". (March 2018).

Eighth Addendum to the Environmental Impact Assessment. Appendix A-1, Table A-1-4 to A-1-6. Appendix B-1. (CEAR #89).

Comments from the Coalition of Alberta Wilderness Association and Grassy Mountain Group, and Shirley Kirby ("the Coalition"). (CEAR #164).

Comments from the Ktunaxa Nation Council. (CEAR #178).

The Canadian Environmental Assessment Agency's Interim Technical Guidance,"Assessing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act, 2012"* stipulates that projects and activities do not need to have a significant effect to warrant inclusion in a cumulative effects assessment. All residual effects on VCs should be carried forward to a cumulative effects assessment, irrespective of significance.

In its submission to the Panel (CEAR #164), the Coalition noted a discrepancy between Benga's conclusions and other statements made in Addendum 8. For example, in Appendix B-1, Section 6.1.3.1 of the Detailed Fisheries Offsetting Plan (CEAR #89), Benga states that a number of recreational trails traverse Blairmore Creek and Gold Creek contributing to the alteration of the physical features of the beds and banks. Benga also indicates in Section 8.1.3.1.3 in Appendix A-1 that logging activities are associated with changes in flow and sedimentation (CEAR #89).

In Tables A-1-4 and A-1-5 of the Cumulative Effects Assessment in Addendum 8 (CEAR #89), Benga indicates that past and existing timber operations and recreational activities have no effect on hydrology and surface water quality, and similarly that certain and reasonably foreseeable timber operations had no expected effect on hydrology and surface water quality. In support of these statements, Benga states in Sections 6.1.3.2 and 7.1.3.2 of the Cumulative Effects Assessment (CEAR #89) that future timber operations are assumed to proceed at the same rate as they are currently, and generally do not affect hydrology and surface water.

In addition, Benga also notes a number of past and existing activities in Table A-1-6 in Addendum 8 as having 'no significant effect on the watershed' and therefore no potential to interact with aquatic resources.

For the aquatic resources, hydrology, and surface water quality VCs:

a) Describe the past, present, and future recreational activities and timber operations (Crown and private) that may interact with residual effects from the Project.

Response:

Aquatic Resources:

Past, existing and future timber and recreational activities were discussed appropriately and consistent with CEAA guidance in the cumulative effects assessment for aquatic resources (Appendix A1, Addendum 8, CEAR #89) as referenced below.

Past and existing timber operations were discussed in Section 8.1.3.1.3 and recreational use was discussed in section 8.1.3.1.6, where a discussion of past activities and existing conditions of the watercourses is provided. It states that the effects from the activities of recreation and timber operations are carried forward to the cumulative effects assessment.

Section 8.1.3.2.1 discusses future timber operations where it states "the effects from these timber clearing activities may interact with the Project-residual effects, thus this activity has been carried forward to the cumulative effects assessment."

Future recreational activities were discussed in Section 8.1.3.2.4 where it states "Future plans and access to the 'green area' as defined in the SSRP, as well as the SSRP and Trails are proposed. These activities are not expected within the LSA, therefore there is no potential interaction with the Project residual effects. Thus, these activities have not been carried forward in the cumulative effects assessment." Progressive reclamation of the site will reclaim existing recreation trails within the disturbed mine footprint. As such, the Project will not contribute to any potential cumulative increase of recreation trail density. As well, any future plans for trails in the area are not mapped within the SSRP (May 2018) and as such, can not be added quantitatively to the assessment.

Surface Water Quality and Hydrology

Clarification is provided below as to how recreation and timber operations may interact with Project effects on hydrology and surface water quality.

Past and Existing

Section 7.1.3.1 of the Cumulative Effects Assessment (Appendix A1, CEAR #89) discusses past and existing timber and recreation effects on surface water quality. Timber operations, ranching and other agricultural activities developed in the region (RSA) concurrently with the

establishment of the railroad. A number of sections (patches of land) adjacent to the Project Area (LSA) are dedicated to cattle grazing.

In summary, the RSA has experienced a substantial development as far back as the late 1800s that has resulted in changes to surface water quality and hydrology.

Closer to the Project on Gold Creek and Blairmore Creek (within the LSA), active cattle grazing, and recreational use contributed adverse effects on the watercourses (and select associated tributaries) where banks and stream beds are damaged at crossing points. Cattle crossing both Blairmore Creek and Gold Creek have altered portions of both watercourse banks and riparian vegetation. Related, a number of recreational trails traverse both watercourses, also contributing to the alteration of physical (fish) habitat.

Land use maps indicate that the timber operations and associated activities between 1982 and 1996 characterized the Gold Creek watershed (CR#6 Appendix A2, Addendum 1, CEAR #44) after which there has been essentially no such development in the Gold Creek watershed. In the Blairmore Creek watershed, a smaller amount of timber operation or forest resource management activities occurred from 1996 to 2015 (CR#6 Appendix A2, Addendum 1, CEAR #44). Although timber operations are land-based activities, they may affect flow and sedimentation (Appendix A1, Addendum 8, CEAR #89). Sediment loading is a potential result from these activities, thus baseline concentrations of TSS in Gold and Blairmore creeks were considered cumulatively. TSS levels in both Blairmore Creek and Gold Creek were below detection limits in all seasons except summer, where a high TSS concentration at Blairmore Creek (97 mg/L) and Gold Creek (27 mg/L) was recorded (Tables A3-1 and A3-2, Appendix A3 to CR #5). TSS concentrations below 25 mg/L are generally not considered harmful to aquatic life. Aquatic organisms can withstand low levels of TSS for long periods and higher levels for shorter periods. Watercourses are characterized as low (< 10 mg/L), moderate (10 to 25 mg/L) and high (> 25 mg/L) TSS levels (Section 3.1.6, CR #5, CEAR #42).

Considering the low concentrations of baseline TSS in both Blairmore Creek and Gold Creek, coupled with the effective mitigation available to avoid/minimize sediment releases, TSS is not expected to interact cumulatively with other defined activities, thus won't result in a cumulative residual effect on WSCT and other fish species within the LSA and/or RSA. The Project's reclamation of historic disturbed mine sites and other existing disturbances (such as trails or grazing disturbances) is a positive contribution as it prevents those sites from causing continued water quality issues.

Future Activities

Progressive reclamation of the site will reclaim existing recreation trails within the disturbed mine footprint. As such, the Project will not contribute to any potential cumulative increase of recreation trail density. As well, any future plans for trails in the area are not mapped within the SSRP (May 2018) and as such, cannot be added quantitatively to the assessment.

As noted on Figure 5.30-1 (in response to JRP IR-5.30), timber operations on Crown land to 2032 are expected to occur in the vicinity of Blairmore Creek, which may potentially release sediments to the creek depending on how the timber is harvested and if vegetated buffers are retained.

With mitigation, the Project is not predicted to release sediment laden water to Blairmore and Gold Creeks. Therefore, the Project is not expected to interact cumulatively with potential sedimentation from future timber or recreation activities in Blairmore Creek and Gold Creek.

b) Following Agency guidance on cumulative effects, revise the rationales presented in Table A-1-6 in Appendix A-1 in Addendum 8 for the cumulative effects assessments.

Response:

The revised Table A-1-6 is presented below as Table 5.31-1. Rationale has been revised.

Table 5.31-1 (formerly Table A-1-6, CEAR #89). List of Past, Existing and Future Activities that may Interact with the Project Aquatic Resources VCs

Activity		Potential Interaction with the VC	Rationale
Company	**Activity or Project**		
PAST and EXISTING ACTIVITIES			
Various	Historic mining: Greenhills, Bellevue, Bear Valley	Yes	Within the RSA, near WSCT VC on Gold and Blairmore creeks
Teck	Teck Coal Mountain Operations	No	Not located in the same watershed.
	Teck Elkview Operations and Baldy Ridge Expansion	No	Not located in the same watershed.
Crown	Timber Operations	Yes	Within the RSA
Devon	Multiwell Gas Battery 02-19-011-03 W5M	No	No anticipated residual effects on watershed.
	Compressor Station 04-13-009-04 W5M	No	No anticipated residual effects on watershed.
Harvest Operations Corp.	Burmis Gas Test Battery 12-19-007-02 W5M	No	No anticipated residual effects on watershed.
HOC Energy Corp.	Single Well Gas Battery 10-07-006-02 W5M	No	No anticipated residual effects on watershed.
Legacy Oil & Gas Inc.	Gas Single-Well Battery 13-35-007-03 W5M	No	No anticipated residual effects on watershed.
Nova Gas Transmission Ltd.	Interconnect 01-15-008-05 W5M	No	No anticipated residual effects on watershed.

Table 5.31-1 (formerly Table A-1-6, CEAR #89). List of Past, Existing and Future Activities that may Interact with the Project Aquatic Resources VCs

Activity		Potential Interaction with the VC	Rationale
Company	**Activity or Project**		
Shell Canada Limited	Interconnect 09-11-008-05 W5M	No	No anticipated residual effects on watershed.
	Single Well Gas Battery 10-01-006-03 W5M	No	No anticipated residual effects on watershed.
	Compressor Station 06-12-006-03 W5M	No	No anticipated residual effects on watershed.
	Multiwell Gas Battery 02-20-006-03 W5M	No	No anticipated residual effects on watershed.
	Gas Gathering System 16-07-007-02 W5M	No	No anticipated residual effects on watershed.
Misc.	Access Roads	No	No anticipated residual effects on watershed.
	Pipelines	No	No anticipated residual effects on watershed.
MD of Crowsnest Pass	Community of Coleman	No	No anticipated residual effects on watershed.
	Community of Blairmore	Yes	Effects are included in baseline data.
	Community of Frank	Yes	Effects are included in baseline data.
	Community of Bellevue	Yes	Effects are included in baseline data.
	Community of Hillcrest	Yes	Effects are included in baseline data.
	Roadways, Utility Corridors & Services	Yes	Effects are included in baseline data.
MD of Ranchlands	Roadways, Utility Corridors & Services	No	No anticipated residual effects on watershed.
	Community of Maycroft	No	No anticipated residual effects on watershed.
MD of Pincher Creek	Community of Burmis	Yes	Effects are included in baseline data.
	Community of Lundbreck	Yes	Effects are included in baseline data.
	Community of Cowley	Yes	Effects are included in baseline data.
	Community of Beaver Mines	No	Downstream of RSA
	Roadways, Utility Corridors & Services	No	Downstream of RSA
Alberta Transportation	Roadways and Transportation Corridors	No	No anticipated residual effects on watershed.

Table 5.31-1 (formerly Table A-1-6, CEAR #89). List of Past, Existing and Future Activities that may Interact with the Project Aquatic Resources VCs

Activity		Potential Interaction with the VC	Rationale
Company	**Activity or Project**		
CP Rail	Rail Lines	No	No anticipated residual effects on watershed.
Various Recreation and Tourism Facilities	Hiking, ATV use, horseback riding, Lost Lemon Campground, local ski hills, mountain bike trails, Crowsnest Trail	Yes	Within RSA, no detailed mapping available however these activities are prevalent in the RSA
	Golf course	Yes	
	Helicopter pads or activities	No	No anticipated residual effects on watershed.
Other	Existing dam on Gold Creek	Yes	Taken into account in the discussion of past activities
	Agriculture, and ranching including cattle crossings of creeks and/or tributaries	Yes	No detailed mapping available however, these activities are prevalent in the RSA and are included in the baseline data.
CERTAIN AND REASONABLY FORESEEABLE ACTIVITIES			
North Coal Ltd.	Michel Creek Coking Coal Project	No	Not located in the same watershed.
Crown	Timber Operations	Yes	Within RSA and LSA
Alberta Transportation	Highway 3 Re-Alignment	No	Within RSA, but not near WSCT VC
Altalink	Chapel Rock to Pincher Creek Area Transmission Project	No	Project route not defined. Transmission project will not have anticipated residual effects on watershed.
Other	Future plans and access to the 'green area' defined in the SSRP	No	Within RSA, but not expected within the LSA, therefore will not interact with the Project effects on the WSCT VC.
	Condo and/or residential developments in Blairmore	No	No anticipated residual effects on watershed. Project not defined.
	SSRP and Trails	No	Project not defined. Not expected within the LSA, therefore will not interact with the Project effects on WSCT VC.

c) Where the previously excluded activities or projects may have potential interactions with residual effects from the Project, provide a revised assessment and conclusions regarding the characterization of the potential cumulative effects on VCs, and the significance of these cumulative effects.

Response:

The conclusions of the cumulative effects assessment remain unchanged. Please refer to previous response in JRP IR-5.31 a).

GEOTECHNICAL

5.32 Information Request 5.32

Grassy Mountain Coal Project - Updated Environmental Impact Assessment. Section B – Geology and Geotechnical (CEAR #42).

Grassy Mountain Coal Project - Updated Environmental Impact Assessment. Section E – Environmental Assessment (CEAR #42).

Statements of Concern – Comments from Barbara and Siegfried Sajitz. (CEAR #68).

Sixth Addendum to the Environmental Impact Assessment. (CEAR #70).

Comments from Barbara and Siegfried Sajitz. (CEAR #130).

Comments from Monica Field. (CEAR #105).

Participants have expressed concern over the potential for blasting activities during construction and operation of the Project to affect the geotechnical stability of Turtle Mountain, location of the 1903 Frank Slide event (CEAR #68, #105, #130). Participant submissions noted that the Alberta Geological Survey (AGS) seismic monitoring program on Turtle Mountain has previously detected blasting from operations at the Sparwood and Elkford mines, which are located a greater distance from Turtle Mountain than the proposed Project.

Participants also noted that blasting technologies proposed to be used during operation phase of the Project are likely to be more powerful than blasting used during previous mining operations in the Crowsnest Pass region (CEAR # 105).

In response to the Panel's request of April 2, 2019, the AGS (CEAR #208) confirmed that in 2003 the organization was tasked with understanding potential movements on Turtle Mountain and establishing a monitoring system that would support early warning of a potential large rock mass movement on the mountain. In 2013, the Turtle Mountain Monitoring Program transitioned to near-real-time remote evaluation of movements, including rate of movement, and response. While the AGS has indicated the mountain is in a low-risk (green) state with a low-risk of imminent failure, they have also noted that there have been no studies completed or identified by the AGS that evaluate or quantify the effects of seismic loading (i.e. earthquakes or shaking from nearby blasts or noise) on

the slow-moving rock blocks perched on the cliff face, or the stable parts of the mountain (CEAR #208).

In the updated EIA, Benga identified the Turtle Mountain Fault as a major fault present within the RSA and provided a Terrain Assessment and discussion of landslide risk in the Local Study Area (Appendix E-1 in Addendum 6, CEAR #70). There is no discussion of the risk of landslide or slope failure beyond the LSA, in potentially susceptible areas such as Turtle Mountain.

a) Provide a summary of how concerns related to the geotechnical stability of the Crowsnest area including area beyond/outside the LSA were considered in the EIA and Addenda. Include a discussion specifically on Turtle Mountain.

Response:

Statements of Concern (CEAR #68, 105, and 130) were related to the impacts of blasting activities on the stability of Turtle Mountain. The blasting activities proposed for Grassy Mountain were provided in the updated EIA (CEAR #42), Section C (Project Description; Section C.1.5.2). The Statements of Concern (CEAR #68, 105, and 130) are not believed to be reflective of the improved modern blasting technologies proposed for the Project, as discussed in Section C.1.5.2 (CEAR #42) or the following section B) of this IR response.

In addition, a landslide susceptibility evaluation of the Grassy Mountain consultation zone was provided in Appendix E-1 in Addendum 6 (CEAR #70) for the LSA and upper slopes. A series of mitigation measures were provided in response to identified areas of potential concern; including an annual ground inspection and slope monitoring plan.

Benga notes that there have been no studies done or identified by the Alberta Geological Survey (AGS; CEAR #208) to quantify the potential effects of seismic loading, which includes earthquakes and nearby blasting activities; or in explicit relation to blasting activities proposed for Grassy Mountain, including potential impacts to the areas outside the LSA.

In an effort to manage the risks associated with the stability of Turtle Mountain, the AGS, in conjunction with independent world class experts, have been conducting continuous seismic monitoring and observations since 2003. Turtle Mountain is currently considered to be in a low risk (green) state for large rock block displacement, and has consistently remained low since 2005. The green stage is the lowest risk stage of the four-stage alert system (green, yellow, orange, and red), which is incorporated into the Alberta Emergency Management Agency's emergency response protocol for public safety response (CEAR #208).

Statement of Concern CEAR #50 notes the sensitivity of the Turtle Mountain seismic monitoring system, as being able to detect blasting activities occurring at nearby mining operations in Elk Valley, British Columbia. Indeed, the sensitivity of Turtle Mountain's seismic monitoring is adequately effective to detect mine blasting and larger earthquakes around the world (AGS 2017a).

Furthermore, the AGS notes that there are areas of low displacement (*i.e.,* millimeters per year) and potential for isolated rocks toppling from the crest due to seasonal freeze thaw cycles, chemical weathering and near vertical cliff faces. Certainly, the AGS is monitoring these areas (AGS 2017b; CEAR #208).

b) Clarify whether and how blasting technologies proposed for the Project may result in different risks to geotechnical stability as compared to any former or ongoing blasting operations in Crowsnest Pass.

Response:

The blasting technologies now available to the mining and construction industry have changed considerably since the previous blasting activities in the Crowsnest Pass area. The method of manufacture of explosives and delivery to the blast hole has advanced to the point where very high levels of accuracy regarding the quality, type and quantity can be achieved. Significant advances in the method of detonation using surface and downhole millisecond delays have been made helping to improve blast efficiency, reducing noise and vibration. Finally, the size of the blast can be fine tuned to manage blast noise and vibration to agreed criteria.

Benga is aware that the Municipality of Crowsnest Pass and the Crowsnest Pass Golf Club will be constructing an access road to their new clubhouse, located just north of Highway 3, near the Project. It is Benga's understanding that a part of this construction will or may require some blasting. If blasting occurs, it will provide a valuable opportunity to develop baseline data from small blasts to further refine the construction and operations blasting practices.

Should blasting be required, Benga will be working closely with an expert blast design consultant to ensure the key blasting parameters are managed carefully. Benga will also work closely with the AGS to ensure real time monitoring is in place and comparative data sets are developed. This will help understand the relationship between blast size and design and the vibrations measured on Turtle Mountain and to assist with developing appropriate benchmarks for blast vibration and noise, given that these do not currently exist.

c) Describe the potential risk to the geotechnical stability of Turtle Mountain from blasting operations associated with the proposed Project, as well as cumulative risk to Turtle Mountain posed by project-effects from blasting or noise in combination with other current and proposed mining operations or other activities in the RSA.

Response:

Please refer to previous response JRP IR-5.32 b). Benga will be working to continually refine its blasting practices as real time data is gathered and work with the AGS and other local agencies. Benga is aware of other proposed mining operations in the area, notably Atrum's Elan South Project, however these are in the early stages of resource definition. However, by the time these projects could come online Benga will have assembled a significant database of its blast

performance and associated vibration monitoring to enable an improved scientific assessment on cumulative effects.

Benga is currently completing a geotechnical programme focused on obtaining construction data to accurately quantify the sediments that require blasting, those can be ripped with bulldozers and those that can be "free dug" *(i.e.,* without blasting).

d) Identify mitigation measures, which are technically and economically feasible, proposed by Benga to prevent any future project-triggered occurrence of slope failure at Turtle Mountain throughout project construction and operation.

Response:

Benga will be adopting the latest blasting equipment, products and technology appropriate to its construction and operation requirements and work with the local agencies to ensure all blast related vibration and monitoring data is captured. Benga will also be adopting relatively shallow benches, through seam blasting and using high breakout force equipment *(e.g.,* hydraulic excavators), to ensure blasting powder factors can be minimized while maintaining acceptable levels of productivity.

References:

Alberta Geological Survey. 2017a. Historical Monitoring at Turtle Mountain. Available at: https://ags.aer.ca/activities/historical-monitoring-at-turtle-mountain. Accessed June 2019.

Alberta Geological Survey. 2017b. Turtle Mountain Monitoring Program. Available at: https://ags.aer.ca/activities/turtle-mountain-monitoring-program.htm. Accessed June 2019.

RECLAMATION

5.33 Information Request 5.33

Grassy Mountain Coal Project – Updated Environmental Impact Assessment. Section B – Geology and Geotechnical. (CEAR #42)

Eighth Addendum to the Environmental Impact Assessment. AER-R2-14. (CEAR #89).

The Mine Financial Security Program provides liability coverage for coal mines in Alberta. The fundamental principle of the program is that the approval holder is responsible to carry out suspension, abandonment, remediation and surface reclamation to the standards established by the Province of Alberta until a reclamation certificate has been issued. Benga has provided information on mineral reserves in the updated EIA, Section B Geology and Geotechnical (CEAR #42), however has not differentiated information between proven and probable reserves. Benga has also indicated potential, long-term active management of water is required (see response AER-R2-14 in Addendum 8 (CEAR #89)), which could represent a significant liability. The Panel is requesting additional information to determine the asset value as well as the potential liability associated with required suspension, abandonment, remediation and reclamation of the proposed mine.

a) In the updated EIA, Section B, Table 7.5-1 (CEAR #42) Benga has reported a mineral reserve summary by phase. Provide an updated table that includes the Project's mineral reserve summary by phase in terms of proven and probable reserves. Include a list of the modifying factors used to convert the Project's mineral resources to mineral reserves and explain the rationale.

Response:

The Mineral Reserve by Phase summarised in Table B.7.5-1 represents the rock and coal quantities within the ultimate pit proposed for actual extraction, based on the available geological and mine engineering data at the time. The quantities in that table are summarised below (Table 5.33-1):

Table 5.33-1 Rock and Coal Quantities Within the Ultimate Pit Proposed for Actual Extraction					
Seam	**Rock Volume (000s BCM)**	**In Situ Coal (000s t)**	**ROM Coal (000s t)**	**Product Coal (000s t)**	**Product Strip Ratio (BCM/t)**
1	430,203	19,642	20,464	10,317	
2	153.114	78,124	79,094	47,432	
4	128,585	66.107	68,061	34,867	
Underburden	121,380				
Total	833,281	163,873	167,619	92,616	9.0

Benga has also prepared JORC (Joint Ore Reserves Committee) compliant Resource and Reserve reports. The JORC Code is a professional code of practice that sets minimum standards for Public Reporting of minerals Exploration Results, Mineral Resources and Ore Reserves. The JORC Code provides a mandatory system for the classification of minerals Exploration Results, Mineral Resources (Measured, Indicated and Inferred) and Ore Reserves (Proven and Probable) according to the levels of confidence in geological knowledge and technical and economic considerations in Public Reports. Public Reports prepared in accordance with the JORC Code are reports prepared for the purpose of informing investors or potential investors and their advisors.

The JORC Compliant Resource and Reserve reports have been included to support the response to this information request. The JORC reports have not been done on a phased basis as this is not consistent with the JORC process and can only be compared with the total mineral reserves reported in the updated EIA, Section B, Table 7.5-1 (CEAR #42). The quantities provided in those reports are summarised below.

Coal Resources

Coal Resources at Grassy Mountain were estimated by McElroy Bryan Geological Services (MBGS) using Minex software within a 'data shell' (a broad envelope limited by the depth and areal extent of geological data points) that is constrained by the depth and areal extent of drill holes. Within the data shell coal resources were estimated both inside and outside the planned open cut pit to a maximum depth of 400 m below surface (Table 5.33-2).

Total Insitu Coal Resources are estimated at 195mt, including 85mt Measured Resources and 110mt Indicated Resources. This estimate covers coal within and outside the modeled pit shell. Coal Resources within the pit shell are estimated at 155mt including 75mt Measured and 80mt Indicated Resources.

Table 5.33-2 Coal Resources at Grassy Mountain were estimated by McElroy Bryan Geological Services						
Seam	Depth (m)	Typical Thickness (m)	Coal Resources (Mt)			
			Measured	Indicated	Inferred	Total
1	<400	4	14.4	15.7	0.0	30.1
2		10	39.1	51.7	0.0	90.8
4		8	31.1	40.7	0.0	71.8
Total			84.6	108.1	0.0	192.7
Total (Rounded)			85	110	0	195
Total Within Pit Shell			74.6	78.9	0.0	153.5
Total (Rounded - within Pit Shell)			75	80	0	155
Total Outside Pit Shell			10.0	29.2	0.0	39.2
Total (Rounded - outside Pit Shell)			10	30	0	40

Coal Reserves

Coal Reserves were estimated by Deswik Mining Consultants based on Geological Resource Model and Resource Report provided by MBGS. The October 2015 Feasibility Report compiled by Golder Associates and subsequently revised by Deswik in March 2016 has been used as the foundation for the pit shell and mine planning assumptions. Sedgman and Associates have been continuously involved with coal quality analysis and process design. The modifying factors used are shown in Table 1 of the Reserves report.

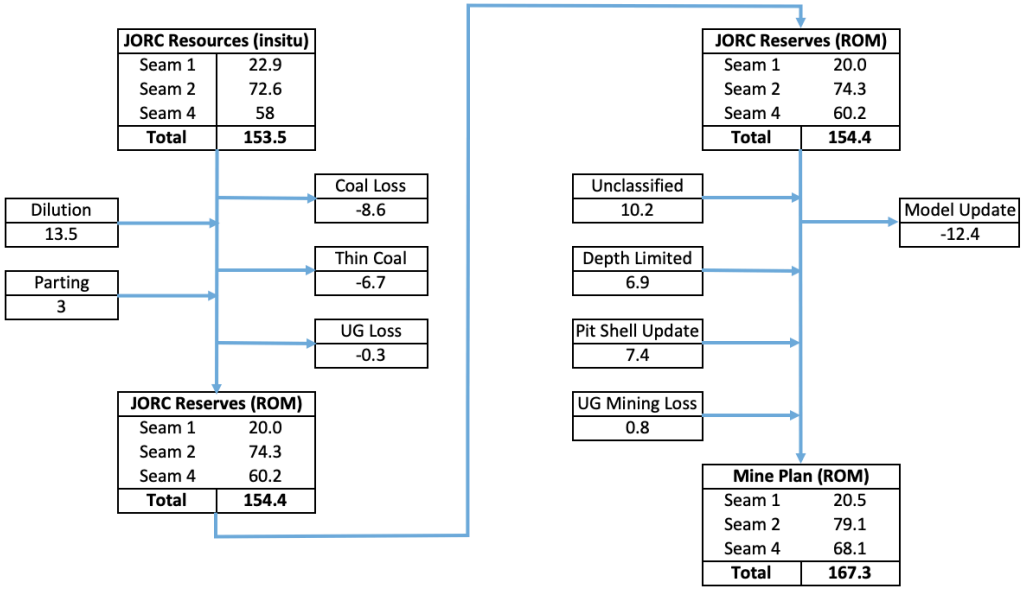
Total ROM Coal Reserves are estimated at 154mt including 65mt Proved and 89mt Probable (Table 5.33-3). Total Marketable (Product) Coal Reserves are estimated at 88mt including 37mt Proved and 51mt Probable.

Table 5.33-3 Total ROM Coal Reserves						
	ROM		MARKETABLE			
	Proved (Mt)	Probable (Mt)	Proved (Mt)	Proved (Ash%)	Probable (Mt)	Probable (Ash%)
Seam 1	10.7	9.2	6.1	9.5%	5.3	9.5%
Seam2	30.5	43.8	18.5	9.7%	26.7	9.7%
Seam4	24.0	36.2	12.6	9.8%	19.1	9.8%
Total (Rounded)	**65**	**89**	**37**	9.7%	**51**	9.7%
Total Proved and Probable	**154**		**88**			

Reconciliation of Proved and Probable Reserves with the Mine Plan Reserves

In comparing the JORC Resource and Reserve estimates with the mine plan reserves it should be noted there are some differences dues to modeling updates and pit shell updates, inclusion of unclassified coal, *etc.* To assist with this comparison reconciliation has been prepared highlighting the source of the differences.

The following flow chart explains the differences between the JORC Insitu Resource (within the pit shell) of 153.5mt, the modifying factors applied to obtain the Rom JORC Reserve and finally the adjustments and modifying factors applied to convert to the Mine Plan ROM reserves of 167.6mt.



b) Provide a detailed cost estimate to suspend, abandon, remediate and reclaim the mine from a point of maximum disturbance to the point of certification for the following categories:

i. project management;
ii. care and custody (include site security, suspension costs);
iii. re-contouring;
iv. topsoil placement;
v. subsoil placement;
vi. seeding;
vii. reforestation;
viii. reclamation and groundwater monitoring prior to certification

ix. decommissioning of the mine and plant site (including water treatment infrastructure and plant(s) construction, maintenance, operation and surface water monitoring for the years until reclamation certification);

x. reclamation and removal of water treatment infrastructure (before reclamation certification); and

xi. contingency.

Response:

For the purpose of this exercise, Benga has prepared a hypothetical cost estimate to reclaim the mine site and associated facilities, consistent with the intent of the Mine Financial Security Program (MFSP). These calculations are similar to other mining projects that are participating in the MSFP. The maximum disturbance for the Project is scheduled to occur in Year 15, which was shown in the original application on Figure C.1.3-16 (Annual Progression Map - EOY 2033 (Year 15). Figure F.3.6-3 (Reclamation Progression Year 11-15) from the Conservation and Reclamation Plan has also been used for reference for the MFSP calculations.

The mine development areas have been broken down into polygons determined by the reclamation status of each polygon. The reclamation status is defined by the amount of work that would be required to complete the reclamation of that specific area. Please refer to Figure 5.33-1 for details on the disturbance and reclamation zones. The required activities status has been broken down into the various components as defined in Table 5.33-4.

Table 5.33-4 Required Activities Status

Activities Status	Remaining Work (activity/area or timing)
Unreclaimed or disturbed	Levelling, soil replacement, revegetation and reforestation (681.4 ha)
Levelling	Soil replacement, revegetation and reforestation (147.9 ha)
Soil replacement	Revegetation and reforestation (61.3 ha)
Revegetation	Reforestation (148.6 ha)
Reforestation	Monitoring only (329.4 ha)
Decommission	Facility removal, Phase 1 and 2 assessments, site decontamination/remediation, conventional reclamation (including levelling, soil replacement, revegetation and reforestation) (64.8 ha).
Conveyor and Access Road	Facility removal, Phase 1 and 2 assessments, site decontamination/remediation, conventional reclamation (including levelling, soil replacement, revegetation and reforestation) (15.2 ha).
Water Management	Manage settling ponds until TSS levels are similar to background levels (for two years), remove facilities, dams and outflow structures, reclaim and stabilize (40.9 ha).

Table 5.33-4 Required Activities Status	
Activities Status	**Remaining Work (activity/area or timing)**
Selenium Management	Manage surge ponds, saturated backfills and pumping systems until Se levels are within guidelines (for two years), then remove facilities, dams and outflow structures, reclaim and stabilize (31.3 ha).
Project Management	Includes administrative duties, field supervision, QA/QC, compliance, monitoring, reporting, oversee water management and selenium management programs (25 yrs).
Care and Custody	Includes site security, maintaining facilities, pumping operations, operating water management and selenium management programs (25 yrs).
Contingency	10% is added to account for unexpected expenditures (calculated yearly).

The components of the reclamation and decommissioning operations are broken down into the following basic activities listing the assumptions and costing that was used. Benga has utilized assumptions and costing from other mine sites that have completed the MFSP exercise. Eventually Benga will develop their own assumptions based on site specific conditions, but for the purpose of this exercise will provide sufficient detail to show how future costing will be calculated. Benga has provided this cost estimate to complete reclamation at the end of Year 15, which is when the maximum site disturbance will have occurred. The key project components have been included along with the best industry practices along with reasonable cost estimates. The main purpose of this exercise was to provide a reasonable understanding of what the total costs to reach site closure and provide an example of how these could be determined and is not meant to be a precise cost estimate. The following information is provided to accomplish this objective.

At the completion of Year 15, the Grassy Mountain Coal Mine will have disturbed approximately 1520.7 ha. The most complete level of disturbance and reclamation is provided in Table 5.33-5. Approximately 839.4 ha (55.2%) has had some level of reclamation completed.

Table 5.33-5 Disturbance Area (at Year 15)		
Reclamation Zone	**Area (ha)**	**% of Total Project Area**
Unreclaimed or disturbed	681.41	44.8%
Levelling	147.9	9.7%
Soil replacement	61.3	4.0%
Revegetation	148.6	9.8%
Reforestation	329.4	21.7%
Decommission	64.8	4.3%
Conveyor and Access Road	15.2	1.0%

Table 5.33-5 Disturbance Area (at Year 15)		
Reclamation Zone	**Area (ha)**	**% of Total Project Area**
Water Management	40.9	2.7%
Selenium Management	31.3	2.1%
Total	**1520.8**	**100%**

[1] includes 29.8 ha of highwall left in place

LEVELLING:

Assumptions:

- disturbed lands are contoured based on the approved reclamation plan;
- slopes for the levelling and contouring operations will vary with the maximum slope angle not to exceed 27° (2:1);
- recontouring operations will consist of final grading with dozers (this plan assumes using a D10 or equivalent; and
- Three main slope categories were used to determine productivities and costs (0-5°, 5-23°, 23-27°) (Table 5.33-6), some highwall was to remain with nil costs associated. These are shown on Figure 5.33-2, which was based on Figure F.4.1-6 in the C&R Plan.

Table 5.33-6 Post Mine Reclamation Slope Categories					
Project Area (ha)	**Slope Categories (degrees)**				
	0° – 5°	**5° – 23°**	**23° - 27°**	**Highwalls**	**Total (ha)**
Unreclaimed or Disturbed	281.6	346.9	23.0	29.8	**681.3**
Decommission	23.3	41.5	0.0	0.0	**64.8**
Conveyor and Access Road	5.7	9.5	0.0	0.0	**15.2**
Water Management	17.2	23.5	0.2	0.0	**40.8**
Selenium Management	23.0	8.3	0.1	0.0	**31.3**
Total (ha)	**350.7**	**429.7**	**23.2**	**29.8**	**833.4**

Costing:

- these categories are based on the use of a D10 bulldozer and three slope classes. The long slope category is for high single lift dumps while the short category is for short

or terraced dumps. The flat category covers flat area such as large flat dump surfaces and shallow slopes;

- the third-party contractor reclamation estimate uses the rate of $419 per hour for a non-current D10 (CAT) based on the 2017 Alberta Roadbuilders & Heavy Construction Association (ARHCA) Equipment Rental Rates Guide & Membership Listings Book;
- non-current is defined as an equipment model that is older than 2014 but is commonly found on sites in Alberta doing production work; and
- post reclamation slope productivities and costs are presented in Table 5.33-7.

Table 5.33-7 Grading Equipment Cost and Productivity Factors (ARHCA)

Slope Category[1]	Productivity Factor (hrs/ha)	Equipment Cost ($/hr)	Unit Cost ($/ha)
0° - 5°	15	419	6,285
5° - 22.5°	33	419	13,827
22.5° - 27°	75	419	31,425

Note: Equipment Rate from the ARHCA 2017 Equipment Rental Rates Guide & Membership Listings book

[1] Dozing distance of 60m is used for the various slope categories.

SOIL REPLACEMENT:

Assumptions:

- suitable and accessible soil materials have been salvaged (in one lift with suitable subsoil material) and stockpiled;
- soil material is accessible and retrievable;
- soil replacement will follow approval requirements, which requires an average of 30 cm replacement depth (3,000 m^3/ha);
- soil will be recovered from stockpiles and hauled to the replacement areas;
- subsoil replacement will not be done, all unsuitable spoil material will have at least one metre of suitable material placed over top; and
- soil will be loaded with large backhoes, transported to the reclaim areas using mine haul trucks and spread using dozers.

Costing:

- the Luscar Mine has developed a task unit cost using small (contractor) equipment of $2.65/$m^3$ has been developed during soil replacement operations;
- the Smoky River Reclamation Project used a task unit cost of $3.00/ m^3;

- based on communication with other industrial facilities, a task unit cost using third-party equipment of $3.25 m^3 has been used, which is what Benga has used in this exercise; and
- total cost per ha is **$9,750**.

REVEGETATION:

Assumptions:

- all disturbed lands will be revegetated once soil materials have been replaced;
- seeding rates for various seed mixes will be 60 kg/ha;
- fertilizer rates will be three times more than grass seed at 180 kg/ha; and
- application of seed and fertilizer will be done using a helicopter and broadcast seeding.

Costing:

- purchasing large volumes of seed in bulk will cost $10/kg;
- bulk fertilizer will cost $0.75/kg;
- helicopter application will cost $250/ha (includes both seed and fertilizer); and
- total cost per ha is **$808.50**.

REFORESTATION:

Assumptions:

- seed for the various coniferous and deciduous seedlings and shrubs was previously collected;
- planting densities will be 2,500 seedlings/ha (consists of coniferous, deciduous and shrubs);
- bulk volumes of seedlings will be grown in contract tree nurseries; and
- bulk volumes of seedlings will be planted by professional tree planters.

Costing:

- contract tree nursery costs will be $0.50/seedling;
- contract tree planting costs will be $0.50/seedling; and
- total cost per ha is **$2,500**.

DECOMMISSION:

Assumptions:

- plant site and associated facilities will be dismantled, some of the costs will be off-set by the salvage or re-use value of the facilities, cost estimate is $2,000,000 (one time cost);
- Phase 1 and 2 evaluations, cost estimate in $75,000 (one time cost);
- decontamination or remediation, cost estimate is $750,000 (one time cost); and
- conventional reclamation will be completed as site is demonstrated to be clean (which includes, levelling, soil replacement, revegetation, reforestation).

Costing:

- total cost to remove facilities, evaluate and remediate is **$2,825,000**; and
- total cost to reclaim the plant site and facilities is **$1.72 million**.

CONVEYOR AND ACCESS ROAD:

Assumptions:

- conveyor will be dismantled, some of the costs will be off-set by the salvage or re-use value of the facilities, cost estimate is $250,000 (one time cost);
- phase 1 and 2 evaluations, cost estimate in $50,000 (one time cost);
- decontamination or remediation, cost estimate is $150,000 (one time cost); and
- conventional reclamation will be completed as site is demonstrated to be clean (which includes, levelling, soil replacement, revegetation, reforestation).

Costing:

- total cost to remove facilities, evaluate and remediate is **$450,000**; and
- total cost to reclaim the conveyor and access road is **$0.4 million**.

WATER MANAGEMENT:

Assumptions:

- if the mine is not operating, dewatering from the pits will not be required;
- settling ponds will remain in place to handle surface runoff;
- ponds can be decommissioned and reclaimed once TSS levels are similar to background concentrations for two years;
- water sampling and monitoring of these facilities will be required, and costs will be captured under the care and custody component; and

- facilities, dam and outflow structures (40.9 ha) will be removed at that time.

Costing:

- total cost to operate the water management system is captured in the Care and Custody section; and
- total cost to remove and reclaim the surface water management infrastructure is **$1.07 million**.

SELENIUM MANAGEMENT:

Assumptions:

- the surge ponds will be required to collect seepage from the surge ponds until the selenium levels are within the guidelines (anticipate taking up to 25 years);
- pumping systems will need to be operational during this period;
- the saturated backfill treatment areas will need to be actively managed during this period;
- water sampling and monitoring will be required during this period, and costs will be captured under the care and custody component;
- if surge ponds are found to have Se levels below the guidelines for two years, the Se management program can be discontinued and the surge pond can be removed and reclaimed, special testing for Se will be required during decommissioning; and
- expect surge ponds to meet guidelines at different times after the mine operations cease.

Costing:

- total cost to operate the Se management system is captured in the Care and Custody section;
- estimate 25 years of operation will be required; and
- total cost to remove and reclaim the selenium management infrastructure (31.3 ha) is **$0.74 million**.

PROJECT MANAGEMENT:

Assumptions:

- overall site management which includes administrative activities, reclamation field supervision, equipment service, purchasing and receiving, environmental monitoring oversight (water sampling, soil salvage/replacement, vegetation seeding & planting);
- direct oversight of the utility crew (see Care and Control); and
- direct oversight of environmental monitoring.

Costing:

- Project or Site Manager will work 40 hours per week with a salary load of $150,000/year (over 25 yrs); and
- total cost for project management is **$3.75 million**.

CARE AND CUSTODY:

Assumptions:

- will include site security, active water monitoring and management, active selenium monitoring and management, maintaining pumping systems, monitor and mitigate erosion, maintain administrative facilities, and general maintenance;
- will act as a site wide utility crew, three people working day shift x 365, with access to heavy equipment (*e.g.,* backhoes, pumps, pipelines, *etc.*);
- will provide road maintenance;
- one person will provide environmental monitoring (40 hrs/week); and
- estimate 25 year effort.

Costing:

- utility crew will have six people (three per shift rotating four days on and off), average salary load is $100,000, total $600,000/year;
- pump and equipment maintenance will be $200,000/year;
- one environmental monitor can cover the site, salary load is $100,000/year;
- monitoring and lab analysis will be $100,000/year; and
- total cost estimate to provide care and custody for the site is **$20 million** for 25 years.

CONTINGENCY:

Assumptions:

- a 10% contingency factor will be added to the total estimate to reclaim the site.

Costing:

- total cost is **$5.41 million**.

SUMMARY

At the end of Year 15 of the Project (point of maximum disturbance), the total reclamation liability for the Project and ongoing maintenance and support has been calculated (Table 5.33-8). Task unit costs have been based on third-party equipment productivities and costs.

Table 5.33-8 Mine Reclamation Cost Summary at End of Year 15

Task	Estimated Cost ($)	% of Total Cost
Unreclaimed or disturbed	$17,750,916	29.8%
Levelling	$2,112,530	3.5%
Soil replacement	$218,015	0.4%
Revegetation	$408,525	0.7%
Reforestation[1]	$0	0.0%
Decommission	$4,825,761	8.1%
Conveyor and Access Road	$896,225	1.5%
Water Management	$1,066,944	1.8%
Selenium Management	$736,179	1.2%
Project Management	$4,125,000	6.9%
Care and Custody	$22,000,000	36.9%
Contingency	$5,414,010	9.1%
Total	$59,554,105	100.0%

[1] assumes that all reclamation is now complete once the area has been reforested, no additional costs

WILDLIFE

5.34 Information Request 5.34

Final Environmental Impact Statement Guidelines. (CEAR #11).

Grassy Mountain Coal Project - Updated Environmental Impact Assessment. Consultant Report #9 – Wildlife. (CEAR #42).

In Consultant Report #9 (CEAR #42), Benga confirmed the presence of four species at risk in the Grizzly Bear Regional Study Area (GBRSA) all of which are listed on the *Species at Risk Act* (SARA) Schedule 1. These four species are the Common nighthawk, the Olive-sided flycatcher, the Little brown myotis and the Short-eared owl.

Since the updated EIA was submitted in 2016, additional species have been listed on the SARA Schedule 1. The Panel understands that Benga has not identified all the species at risk from Schedule 1 as VCs, but rather has provided a high-level assessment of 'special status' species which encompasses those species at risk that were not identified as VCs. Based on this assessment and the recently listed species at risk, information on the following species at risk needs to be included the EIA:

- Baird's sparrow – listed on Schedule 1 as of February 3, 2017.
- American badger (*taxus* subspecies) – listed on Schedule 1 as of February 2, 2018.

As per the EIS guidelines (CEAR #11), the EIA should contain a list of all federal species listed on Schedule 1 of the SARA; any published studies that describe the regional importance, abundance, and distribution of species at risk; residences, seasonal movements, movement corridors, habitat requirements, key habitat areas, identified habitat and/or recovery habitat, and general life history of species at risk; and exposure to relevant contaminants of concern based on data from existing sources. The EIA must also describe direct and indirect effects of the Project on those species and their critical habitat. This includes direct and indirect effects resulting from increased exposure to contaminants of concern; direct and indirect effects on the survival or recovery of federally listed species; and the direct and indirect impacts to existing recovery strategy and action plans including a discussion of how population and distribution objectives set out in those documents would be affected.

Where mitigation measures have been identified in relation to species and/or critical habitat listed under the SARA, the mitigation measures need to be consistent with any applicable recovery strategy and action plans. The EIA should also include a description of any proposed additional mitigation or offsetting measures that would serve to compensate for adverse effect to any critical habitat.

a) Provide an assessment of Baird's sparrow and American badger, recently listed on SARA Schedule 1. This assessment should include:

    i. the regional importance, abundance and distribution of species at risk;

ii. the residences, seasonal movements, movement corridors, habitat requirements, key habitat areas, identified critical habitat and/or recovery habitat, and general life history of species at risk; and

iii. the direct and indirect effects of the Project on those species and their critical habitat including:

- direct and indirect effects resulting from increased exposure to contaminants of concern;
- direct and indirect effects on the survival or recovery of federally listed species; and
- direct and indirect impacts to existing recovery strategy and action plans including a discussion of how population and distribution objectives set out in those documents would be affected.

b) Provide a revised list of mitigation measures adapted to the recently listed species at risk, taking into consideration that:

i. the mitigation measures are consistent with any applicable recovery strategy and action plans; and

ii. the description of any proposed additional mitigation or offsetting measures that would serve to compensate for adverse effect to any critical habitat is included.

c) Carry out a characterization of any residual effects from the Project on the recently listed species at risk that remain after the implementation of mitigation measures (e.g. magnitude, extent, duration, frequency, etc.) and present a conclusion regarding the significance of any residual effect.

Response:

The following addresses information requested in parts a to c for Baird's Sparrow and American Badger.

BAIRD'S SPARROW

The Baird's sparrow is listed as a species of Special Concern by COSEWIC but was recently added as a Schedule 1 species under the *SARA* on February 3, 2017. This occurred after the submission of the updated EIA (CEAR #42) for the Grassy Mountain Coal Project. Detailed descriptions of the vegetation and biophysical features of the local and regional study areas is presented in Consultant Report (CR) #8 – Vegetation and Wetlands (EIA, CEAR #42) and wildlife inventory methods and baseline information are provided in CR #9 – Wildlife (EIA, CEAR #42).

Status

Baird's sparrows are vulnerable to habitat destruction, degradation and fragmentation (COSEWIC 2012). Long-term population declines and continued destruction of the specialized

grassland habitat in both the summer and wintering ranges lead to the protection of Baird's Sparrow under the *Migratory Birds Convention Act* in Canada and the United States. The Baird's Sparrow is currently listed as species Special Concern by COSEWIC and is a Schedule 1 species under the *SARA*. It is also recognized as being at risk on several non-legal status rankings across its range (COSEWIC 2012), including being identified as a priority species for the Bird Conservation Strategy for the Prairie and Northern Subregion (Region 11) of the Prairie Potholes Bird Conservation Region (Environment Canada 2013).

Distribution

Although not endemic to the region, the Baird's sparrow is a grassland species that breeds in native mixed-grass and fescue prairies in southwestern Canada and north-central United States and overwinters in grasslands in Southern Arizona, New Mexico and Texas as far south as north-central Mexico (Figure 1) (COSEWIC 2012, Cornell Lab of Ornithology 2019). In Canada, the breeding range of the Baird's sparrow coincides with the Prairie Ecozone of Alberta, Saskatchewan, and Manitoba, accounting for 45% of the total breeding range available (COSEWIC 2012). The range of the Baird's sparrow in Alberta and Saskatchewan is unchanged from its historical range although periodic range extensions in response to drought conditions have been reported in Manitoba (COSEWIC 2012). The species is now rarely seen beyond the southwestern corner of Manitoba.

Population Trend

The North American Breeding Bird Survey (BBS) is regarded as the primary source of long-term, large-scale population data for breeding birds in North America (Environment and Climate Change Canada 2019) although some limitations exist with some species such as the Baird's sparrow (*e.g.,* road avoidance, clumped distributions, need for core grassland habitat, and relatively small breeding ages) (COSEWIC 2012). The North American Breeding Bird Survey (BBS), estimates global populations of Baird's Sparrow to be 1.2 million individuals with about 60% (715,000 birds) of this population breeding in Canada although the 95% confidence limits are about 50% of the estimate (COSEWIC 2012). Combining long-term BBS data for Canada and the United States estimates a statistically significant population decline of 25% over the last 10 years (Figure 5.34-1).

Life History and Habitat Requirements

Habitat Preferences

The Baird's sparrow prefers native ungrazed or lightly grazed grassland habitats with patches of tall grass and low shrubs, tending to avoid heavily grazed and short grass prairies (Fisher and Acorn 1998). Areas of woody vegetation and cultivated lands generally do not provide suitable habitats this species. Native mixed grass and fescue prairies are preferred as breeding habitats but Baird's sparrow will also nest in areas with features similar to grasslands such as dry wetland basins, wet meadows or grassy agricultural areas (COSEWIC 2012). The highest density breeding ranges are typically patchy, moderate grass height with some cover and low density shrubs. On average, the territory size ranges from 0.4 to 1.5 ha but can be as high as 2.25 ha. Dryer areas are favoured while disturbed areas such as overgrazed rangeland and development are avoided.

Life History

Baird's sparrow can live up to 4.5 years, breeding within the year following their hatch dates (COSEWIC 2012). Nesting begins in late May with a second brood beginning in late June through early August. The Baird's sparrow is partially nomadic, with breeding populations shifting dramatically among locations from year to year which historically, likely evolved in response to the effects of drought, fire, and movements of bison herds over the prairie (Cornell Lab of Ornithology 2019). Brood sizes include 3 to 4 nestlings with 1.5 young fledging on average. Predators of Baird's sparrow are undocumented but it is likely they are preyed upon by carnivorous mammals, medium sized raptors and nest predators such as skunks, ground squirrels, mice, badgers, foxes and coyotes (COSEWIC 2012). Other interspecific threats to Baird's sparrow include brood parasitism by brown-headed cowbirds which can affect up to 77% nests.

Movements and Home Range

Baird's sparrows leave their wintering grounds in the southern United States between March and May, arriving in southern Canada in the first week of May (COSEWIC 2012). The fall migration begins in September through to the end of October, occurring in small flocks or as individuals travelling at night. The breeding range extends along the northern Great Plains with the highest density occurring in Moist Mixed and Mixed Grassland ecoregions and Aspen Parkland and Cypress Hills Ecoregions (COSEWICK 2012). The western edge of their home range extends from west of Edmonton, up to the North Saskatchewan River and southeast to the Assiniboine River in Saskatchewan and southwestern Manitoba (Figure 5.34-2). Baird's sparrow extent of occurrence in Canada is 410,000 km^2 with an area of occupancy greater than 2,000 km^2.

Abundance

Just a single sighting of a Baird's sparrow was recorded in the WLSA during a spring breeding bird survey conducted in 2016 although none were recorded during the 2014 breeding bird survey (Table 2.4-9, Figure 2.4-3, CR#9, EIA). The single individual was observed singing at a survey station located in closed mixedwood forest along Blairmore Creek and adjacent to grassland habitat, just west of the Project footprint. No incidental observations of Baird's sparrows were recorded during other baseline wildlife surveys conducted in the WLSA.

The only additional sources of information that available for the region around the WLSA include the North American BBS and the Alberta Biodiversity Monitoring Institute (ABMI) monitoring program. BBS Route 04-205 (Coleman) extends in a northeast direction from the Town of Coleman along Range Roads 43A, 40A, 35A and 34A (Figure 5.34-3). Although the route generally follows valley bottoms along the west side of the WLSA, it does pass through several patches of grassland habitats that may provide suitable habitat for the Baird's sparrow. The route passes along the west side of the WLSA and does provide a longer term source of information on birds in the region around the Project. The Coleman BBS route was surveyed on 10 occasions during an 18 year period extending from 2000 to 2017 (Table 5.34-1). During these 10 surveys, no Baird's sparrows were recorded. No other BBS survey routes occur in the WRSA. The closest routes are Summerview (BBS 04-304) and Trout Creek (BBS 04-404) which are located 13.5 km east and 7.2 km to the northeast, respectively (Figure 5.34-3). For regional comparison, data recorded for these routes are summarized in Table 5.34-1. Both BBS routes are located at the eastern edge or outside of the GBRSA in areas dominated by grasslands and agriculture (*e.g.,* pasturelands). Thirty-eight Baird's sparrows were recorded along the Trout Creek BBS Route (located 7.2 km northeast of the WLSA) during five of the 12 years this route was surveyed while none were detected during 18 years of surveys along the Summerview BBS Route (Table 5.34-1).

The Alberta Biodiversity Monitoring Institute (ABMI) is an agency that monitors biodiversity throughout Alberta. The ABMI program is widely regarded as one of the most comprehensive programs established for monitoring changes in biodiversity across broad landscapes and can be considered an important tool for evaluating cumulative effects. Although the program was designed primarily to monitor changes in biodiversity over broad landscapes, survey data obtained since the program was implemented in 2007 do represent a potential additional data source for evaluating wildlife use of specific areas of the province. Based on this, a search of the ABMI breeding bird data base within the Foothills and Rocky Mountain Natural Regions in the vicinity of the Project was conducted. The query resulted in only one ABMI sample site (Site 1635, Figure 5.34-3) and although the ABMI data that have been obtained for this region to date are very limited, the data did not confirm use of this monitoring site by the Baird's sparrow.

Based on these data sources, it appears that the Baird's sparrow is uncommon in the WLSA and use of the area is likely intermittent. The species is likely to occur more frequently in grass-land dominated habitats located east and southeast of the WLSA.

Table 5.34-1 Summary of Baird's Sparrow for Breeding Bird Survey Routes in the Vicinity of the Project

Year	Breeding Survey Route			
	Coleman (4-205)	Trout Creek (4-404)	Summerview (4-304)	Totals
2000	0	-	0	0
2001	0	-	0	0
2002	-	-	0	0
2003	-	-	0	0
2004	-	-	0	0
2005	-	-	0	0
2006	-	1	0	1
2007	-	0	0	0
2008	0	0	0	0
2009	0	13	0	13
2010	0	0	0	0
2011	0	0	0	0
2012	-	0	0	0
2013	-	0	0	0
2014	0	0	0	0
2015	0	10	0	10
2016	0	2	0	2
2017	0	12	0	12
Totals	**0**	**38**	**0**	**38**

Regional Importance

Baird's sparrow is a valuable grassland indicator for the northern prairies (COSEWIC 2012).

Application Case Assessment

Change in Habitat Availability

The primary effect of Project development on available Baird's sparrow in the WLSA is related to direct habitat loss. Potential Baird's sparrow habitats in the WLSA include open natural areas

such as grasslands (290.3 ha or 5.1%) and potentially anthropogenic disturbance types that are grass-dominated such as perennial forage crops (37.3 ha or 3.8%), clearings (212.4 ha or 3.8%), and road-sides (124.8 ha or 2.2 %) and seeded well sites and pipeline rights-of-way (65.2 ha or 1.1%) (Table 2.4-1, CR#9, EIA). Overall, potential Baird's sparrow habitats account for 12.9% (730 ha) of the WLSA.

Changes in habitat availability resulting from Project development will result in a net increase in grassland habitat of 20.2% (58.8 ha) at Year 27 for a total of 349.1 ha in the reclaimed landscape (6% of the WLSA). There is a temporary loss of 51.9% (-150.7 ha) of grassland habitat at Year 14 during the time of maximum disturbance (Table 5.1-1, CR#9, EIA). However, existing anthropogenic disturbances (*e.g.,* trails, roads) within the Project footprint will be reclaimed at closure. As reclamation progresses, these grass-dominated reclaimed sites may provide suitable habitat for Baird's sparrows for many years. For example, grassland and open shrubby habitats were rated as high and moderately high for elk (a species that also prefers grassland habitats), respectively (Section 2.8, Appendix C, CR#9, EIA). These habitat types, which provide important foraging habitats for elk throughout the year, are expected to decrease by 46% (-197.0 ha) at Year 14 but increase by 129% (550.1 ha) from baseline as reclamation progresses across the Project footprint (Table 5.3-20, Figure 5.3-46, CR#9, EIA). As much as 17% (977.4 ha) of the WLSA could provide suitable habitat for the Baird's sparrow at Year 27. Overall, Baird's sparrow habitat is predicted to increase from baseline conditions following mitigation and reclamation. Project development is not expected to affect Baird's sparrow habitat in the WRSA since most of the suitable habitat is located east and southeast of the Project footprint.

Effects on Movement

Movements of Baird's sparrows in the WLSA will be affected since this species home range is relatively small (<2.5 ha) and most of the potentially available habitats will be affected by development of the Project footprint (Figure 5.1-1, CR#9, EIA). Any Baird's sparrows occurring in the WLSA will be displaced to other more suitable habitats adjacent to the Project footprint. Since Baird's sparrows tend to avoid roads, movements along the access corridor and the 5.4 km long coal conveyor will not be affected.

Change in Mortality Risk

The primary mortality risk of Project development to Baird's sparrows will be nest destruction associated with vegetation clearing. However, by conducting vegetation clearing outside of the recommended restricted activity period (May to August), this can be avoided. Other potential sources of mortality associated with Project development include collisions with vehicles and Project infrastructure such as buildings and transmission lines. These mortalities can be reduced by establishing and enforcing a low speed limit on the access road, using visual markers on windows and placing large 'floats' or other markers on transmission lines (APLIC 2012).

Project-related effects are unlikely to affect the abundance of the Baird's sparrow because they appear to be uncommon in the WLSA.

Change in Relative Abundance

Although the Baird's sparrow was identified as a wildlife species that could potentially occur in the WLSA, its presence within the WLSA was confirmed during a breeding bird survey conducted in June 2016 (Section 2.4.3.2.1.2, CR#9, EIA, CEAR #42). This was the only sighting of this species recorded either incidentally or through baseline wildlife inventories conducted in the WLSA between 2013 and 2016. It appears that the Baird's sparrow is an uncommon songbird species at baseline in the WLSA, although should the Project be approved, pre-disturbance surveys will be conducted to further confirm species presence and relative abundance.

Mitigation Measures

Benga will implement the appropriate best management practices, Project features and mitigation measures in order to minimize risk on federally-listed (*SARA*) species at risk. Although critical habitat has not been identified for the Baird's sparrow in Alberta, any future federal action plans including any species-specific mitigation and monitoring plans developed by ECCC and applicable to the taxus DU will be implemented. In the interim, if any Baird's sparrow are detected during pre-disturbance surveys that will be conducted in the WLSA should the Project be approved, specific mitigation measures will be developed in consultation with AEP and ECCC.

Many of the Project effects associated with wildlife habitat loss (including Baird's sparrow habitat) will be minimized by implementing the Project's reclamation plan which includes the following:

- minimize the overall disturbance footprint through the mine planning process to avoid critical breeding habitats, nesting and denning sites, and movement corridors to the extent possible;
- preserve remnant forest patches within the development areas where feasible to provide habitat, habitat connectivity and hide cover for wildlife species;
- remnant patches should protect known essential raptor habitat features by incorporating these habitat features (*i.e.,* mature balsam poplar and aspen) where possible;
- maximize the direct placement of salvaged soil to enhance native plant development;
- retain slash and large woody debris in the salvaged soil to provide microsites for native plant and hide cover for wildlife;
- establish a variety of vegetation species and communities suitable for wildlife, and encourage structural complexity within the forests;

- encourage understory complexity in reclaimed forests by planting native shrubs such as alder and willow;
- ensure that core security areas are provided for wildlife;
- provide water management program that ensures the surface water quality is maintained; and
- limit sight lines by maintaining mature forest stands as buffers between roads and reclamation areas.

To support the reclamation plan mitigation measures, the following will be implemented to mitigate potential direct and indirect Project effects on wildlife habitat availability:

- Incorporate existing legacy mining disturbances into the development and reclamation plans for the Project, and other proposed land use activities to the best extent possible so that habitat loss, habitat fragmentation, linear disturbance features, and cumulative habitat loss are minimized.
- Pre-disturbance surveys (wildlife sweeps) will be conducted in the development area prior to any construction activities during Project development to determine the occurrence of any important wildlife habitat features such as migratory bird nests, mineral licks, active dens, bat habitat and hibernacula, active raptor nest sites, and essential raptor habitat features (*i.e.,* mature balsam poplar, platform/stick nests) that could indicate the presence of species at risk.
- Protect all important wildlife habitat features in areas of suitable wildlife habitat (on the edge of the Project footprint boundary) appropriate setback distances (or buffer zones) will be considered.
- Clearing and equipment use/storage/cleaning in undisturbed areas within and adjacent to the Project footprint will be avoided.
- Vegetation adjacent to high-activity linear corridors (*e.g.,* access roads, coal conveyor) will be retained to reduce the extent of noise and visual sensory disturbances to the extent possible.
- The overland coal conveyor system was designed in such a manner to prevent any deposition of coal product along the route from the CHPP to the rail load-out area. This includes a cover for the length of the conveyor to reduce dust, and motor specifications to reduce industrial noise levels.
- Where appropriate, vegetated buffer zones (100 m or minimum of 30 m; pending topography constraints) will be maintained between Project infrastructure and wetlands, creeks, and streams to the best extent possible.
- As required by the *Weed Control Act* and Regulations, all identified noxious and invasive weed species populations will be controlled prior to any site disturbance and

mine operation to prevent the further spread of weeds. Noxious weed management will occur in compliance with R&R/03-4 *Weeds on Industrial Development Sites*.

- As the presence of artificial lighting can potentially affect bird and bat use of nearby habitats, Benga has developed a visual impact mitigation plan that reduces stray and non-essential artificial lighting to minimize wildlife effects and that will comply with OH&S safety requirements (CR #1 – Air Quality, EIA, CEAR #42).
- To mitigate the potential effects of sensory disturbance (acoustic and visual) on effective habitat availability in the southeast portion of the Gold Creek valley, Benga will install and maintain a 15-m tall earth berm along the eastern edge of the south disposal area (CR #2 – Noise Impact Assessment, EIA, CEAR #42). The earth berm will be constructed/maintained during the day-time when required and will grow in elevation as the height of the disposal area increases.
- Sensory disturbance from the active mine site will be further mitigated through the use of mufflers on all internal combustion engines, utilizing mine pit topography to shield noise generated from haul trucks, and conducting blasting during daylight hours (CR #2 – Noise Impact Assessment, EIA, CEAR #42).

The following general wildlife mitigation measures will be implemented to minimize potential disruption to daily and seasonal wildlife movements:

- A minimum of six wildlife crossings (underpasses and overpasses) will be incorporated into the design of the coal conveyor (the conveyor route is approximately 5.4 km in length):
  - will be strategically placed in locations that will maximize wildlife use (*e.g.,* presence of well used trails, suitable habitats, and terrain features such as valleys and depressions that act as natural crossings);
  - additional pre-disturbance surveys will be conducted to identify important wildlife habitats and trails along the access road and conveyor corridor;
  - natural underpasses using topography are preferred; and
  - above-ground crossings may be required when topography isn't favourable, conveyor will likely be raised higher above the ground to allow wildlife movement under it.
- Surface water management ponds and ditches located in undisturbed areas of the Project footprint will be designed to allow wildlife to move around or cross safely.
- Road plowing and grading will be conducted in a manner that does not restrict wildlife from crossing access roads or accessing wildlife crossings.
- Measures to control dust and other air emissions (*e.g.,* watering of roads and use of dust suppressants, minimizing engine idling, *etc.*) within the Project footprint will be

implemented to minimize effects on adjacent wildlife habitats (CR #1 – Air Quality, EIA, CEAR #42).

Project-specific mitigations targeted to carnivore species have been incorporated into the reclamation planning. Many of these will also support habitat connectivity for migratory birds, raptors, and species at risk, and include:

- minimize the overall disturbance footprint through the mine planning process;
- preserve remnant forest patches in the development areas to provide essential habitat, habitat connectivity, and hide cover for wildlife species;
- retain slash and large woody debris in the replaced soil landscape;
- plant native shrubs early in the reclamation process to initiate hiding cover;
- establish mixed wood forest stands and high density coniferous tree stands;
- provide understory complexity in the reclaimed forests by planting native shrubs such as alder and willow to provide security cover for the carnivores and their prey;
- maximize the amount of ungulate habitat;
- prior to final reclamation, disrupt linear disturbances and sight lines by mounding surface soils, piling brush; and
- limit sight lines by maintaining mature forest stands or by planting high density coniferous stands to act as buffers between roads, project disturbance boundaries and the reclaimed mine areas.

For migratory birds, additional relevant mitigations include:

- retain slash and large woody debris in the salvaged soil to provide microsites for native plant and hide cover and perches for wildlife; and
- ensure reclaimed areas promote the re-establishment of woody species and are on a trajectory for reforestation.

Wildlife mortality risk may increase as a result of increased traffic, wildlife encountering equipment, or elements of the Project footprint, and wildlife being attracted to Project facilities or humans. The Grassy Mountain area currently has a considerable network of trails and roads that are heavily used. Plans are already being implemented to reduce this level of access and with the approval of this Project, the levels will be reduced considerably more. Mitigation measures that will be implemented to reduce wildlife mortality risk include:

- All access to the Mine Permit will be controlled, no uncontrolled access will be permitted. Common operational practices will include:
  - prohibiting use of snowmobiles and ATVs;
  - prohibiting hunting, harassment, or feeding of wildlife; and
  - implementing a strictly enforced zero tolerance policy on the use of firearms.

- Timing vegetation site clearing activities to occur outside the April 15 to August 31 period to avoid disrupting nesting migratory and resident songbirds and raptors:
  - In the event that vegetation clearing must occur within the restricted activity period, pre-disturbance nesting surveys will be conducted by experienced avian biologists according to established sensitive species inventory guidelines (GoA, 2013b). Establish species-appropriate setback distances around confirmed active nest sites until fledging in consultation with Environment Canada and AEP. If the status of a nest cannot be confirmed, or if a nest is found outside of the breeding season, a setback distance will be implemented until such time as the nest status can be confirmed (GoA, 2013b).
- Confirm the presence/absence of bats in high quality habitats located within the Project footprint prior to the initiation of any clearing activities and develop a mitigation plan if bats are found.
- Conducting pre-disturbance denning (bears, marten, *etc.*) and roosting (bats) surveys prior to vegetation clearing and other high-disturbance activities. Consult with AEP as needed to develop appropriate mitigation and management strategies.
- Conducting pre-disturbance surveys (acoustic surveys and visual searches) to identify wetlands and watercourses used by breeding Columbia spotted frogs and western toads that feed into the protection plans.
- Benga commits to supporting active bear management plans associated with the Project. If a site specific plan is required, it will be developed in consultation with AEP personnel as part of the Wildlife Mitigation and Monitoring Plan. The plan is expected to be a comprehensive document that outlines operational strategies and best practices for addressing concerns related to not only bear-human conflicts but potential risks to ungulates and other wildlife resulting from attraction of bears to the area.
- Developing a Beneficial Management Plan guide to minimize potential Project-specific impacts on migratory birds and their habitat by identifying more site-specific mitigation and monitoring measures following Project approval and in consultation with federal and provincial regulators.
- A detailed Waste Management Plan will be developed and implemented prior to construction and operational activities to minimize the attraction of wildlife. Benga will follow the Best Management Practices for camps, fences, and barriers as described in Bear Smart: Best Management Practices for Camps, and ensure all waste is stored in wildlife-proof containers and disposed of properly. Some of the waste management and bear awareness/Bear Smart guidelines that will be implemented include:
  - ensuring food waste, refuse, and other attractants are securely contained in enclosed and approved bear-proof containers and/or facilities (*e.g.,* hard-sided

buildings, fenced compounds, and bear-proof transfer station) prior to transportation to a disposal facility to prevent access by scavenging bears;
    - providing adequate signage to inform employees of the location and proper use of bear-proof storage containers/facilities;
    - ensuring waste storage containers/facilities are not filled beyond capacity;
    - ensuring regular inspection and maintenance of waste storage containers/facilities is carried out;
    - ensuring measures contained in the bear management plan are diligently followed by all employees and contractors;
    - all on-site staff will receive Bear Awareness Training; and
    - bear warning signs will be installed to advise staff of locations where problem bears have been reported.
- Implementing an Emergency Spill Response Plan to limit the effect of accidental spills. Spills will be minimized by restricting fuel storage and filling to designated areas that are at least 100 m from wetlands and watercourses as well as Project drainage ditches, sediment control ponds, and pit lakes.
- Storing all hazardous materials, including those used for blasting, in secure areas that are inaccessible to wildlife (*e.g.,* buildings, storage areas surrounded by wildlife-proof fencing). In addition, proper handling and storage of industrial materials and debris within the Project footprint will be maintained to minimize potential risks to wildlife.
- Developing procedures to clear blasting areas of large mammals or birds prior to blasting.
- Designing water management ponds and drainage ditches, and pit lakes to minimize potential entrapment of wildlife.
- Developing a strategy to minimize changes in water quality upstream of the mine in conjunction with a water-quality monitoring program.
- Enforcing speed limits (≤50 km/hr) along the main access road and utility corridors, and placing signs at identified wildlife crossings to increase driver diligence to minimize wildlife-vehicle collisions. Vehicles will yield to all wildlife crossing the main access road.
- Bird collisions with buildings will be mitigated by placing visual markers on windows, and collisions with the proposed power line will be mitigated by installing large 'floats' or other markers.

Wildlife monitoring will be used to monitor the effects of the Project on wildlife species at risk or species of management concern during construction and operation of the Project and post-closure. In particular, the effects of the Project on wildlife VCs, including disturbance, mortality, and movement will be monitored. Monitoring will consist of a systematic monitoring

program along with incidental observations. The wildlife monitoring program will serve a number of important functions including:

- verifying impact predictions and monitoring the effectiveness of mitigation measures;
- improving Benga's understanding of the effects of Project construction and operation on wildlife within the WLSA and surrounding area to enable the implementation of adaptive management practices when required; and
- ensuring compliance with the terms and conditions of the Operating Approval and Project environmental standards once the Project has been approved by AER and CEAA.

Details of the monitoring plan have been developed and are presented in the Wildlife Mitigation and Monitoring Plan (Appendix 5.39-1 in response to JRP IR-5.39).

Effects Assessment

The primary effect that Project development will have on the Baird's sparrow is likely associated with direct habitat loss. Potential habitat types in the WLSA that provide either suitable foraging or nesting habitats for Baird's sparrows include native grasslands and grass-dominated anthropogenic habitat types (*e.g.,* perennial forage crops, seeded well sites and pipeline rights-of-way, *etc.*). In addition, further indirect habitat loss in habitats adjacent to the Project footprint will also likely occur from increased noise levels associated with construction and operations activities. Any Baird's sparrows present within the immediate vicinity of the Project footprint will be displaced to other more suitable habitats present to the east and southeast until at least progressive reclamation is initiated after Year 14 of the Project.

With Project development, the primary mortality risk to Baird's sparrow will be associated with nest destruction during vegetation clearing. This risk can be avoided by ensuring that vegetation clearing is conducted outside of the March 1 to August 31 restricted activity period for nesting migratory and resident bird species. Other mortality risk such as collisions with vehicles and other Project infrastructure will be minimized by enforcing low speed limits and use of visual markers. Local movements of the Baird's sparrow beyond the Project footprint will likely not be affected by the access corridor and the 5.4 km long coal conveyor.

In regards to potential direct or indirect effects resulting from increased exposure to chemicals of concern as a result of the Project, the screening-level wildlife risk assessment (JRP IR-4.1, Appendix H) evaluated potential adverse population-level effects to terrestrial wildlife associated with chemical emissions from the Project.

The screening level-WRA compared concentrations in the media of investigation (*i.e.,* air, soil and surface water) to concentrations in like media considered protective of wildlife health. Concentrations in air, soil and surface water that were considered protective of wildlife health

were based on recognized methodologies (as described in British Columbia Ministry of Water, Land and Air Protection [BC MWLAP, 1998]), and published guidelines as provided by Alberta Environment and Parks (AEP), the Canadian Council of Ministers of the Environment (CCME), and the United States Environmental Protection Agency (US EPA). The methods and guidelines as provided in the screening level-WRA were established to be protective of population-level adverse effect(s) and exposures to chemical(s) at concentrations lower than those presented in the screening level-WRA would not be expected to cause ill-effect. As such, the TRVs used within the screening-level WRA are considered protective of the Baird's sparrow and the conclusions of the screening-level WRA remain unchanged. Specifically, that chemical concentrations associated with Project emissions would not be expected to cause population level adverse effects on wildlife.

The overall effects of Project development on the Baird's sparrow in the WLSA are predicted to be local in extent, extended in duration, continuous in frequency, low in magnitude, and high in probability. The Project contribution to changes in abundance and habitat availability will be negative during the lifespan of the Project, but will be reversible in the long-term. The confidence rating associated with this assessment is moderate, since although a single Baird's sparrow was recorded, it is likely an uncommon species in the WLSA. In terms of the potential effects of the Project on the persistence of this species in southwestern Alberta, the effects are considered to be not significant. This rating is partly based on the small proportion of grassland habitats that will be lost to the Project, the likelihood that much of this habitat will be replaced or increased over the long term through the proposed reclamation program, and with implementation of the general wildlife and species-specific mitigation and monitoring plans.

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AMERICAN BADGER

The American badger was listed as a Schedule 1 species under the SARA on February 2, 2018 following the submission of the updated EIA for the Grassy Mountain Project in 2016 (CEAR #42). A detailed description of the vegetation and biophysical features of the local and regional study areas is presented , Consultant Report (CR) #8 – Vegetation and Wetlands (EIA, CEAR #42) and wildlife study areas, baseline inventory methods and information on baseline wildlife habitats are provided in, CR #9 – Wildlife (EIA, CEAR #42).

Status

Distribution

Three subspecies of American Badger (*Taxidea taxus)* occur in Canada (*T. t. jacksoni, T. t. taxus and T. t. jeffersonii*). Populations, which occur in four designable units (DU), are distributed throughout southern regions of western and central Canada, inhabiting areas from the eastern slopes of the coastal mountains in British Columbia to the boreal forest of south-eastern Manitoba (COSEWIC 2012). The *taxus* subspecies occurs in the Alberta, Saskatchewan, Manitoba and northwestern Ontario DU. In Alberta, its range extends approximately from the North Saskatchewan border south to the Montana border, and from the Saskatchewan border west to the foothills (Scobie 2002).

Prior to the definition of subspecies boundaries, the American badger was considered to represent a single population in Canada and was classified as "No Designation Required" in 1979 by COSEWIC. The designation was changed to "Not at Risk" when COSEWIC terminology changed in 1995. The populations were then defined by the geographical boundaries in 2000 and reassessed. The status of American badger occurring in Alberta, Saskatchewan and Manitoba was reassessed again in 2012 and designated as Special Concern under COSEWIC (COSEWIC 2012). The *taxus* subspecies was added to Schedule 1 of the SARA and classified as "Special Concern" in February 2018.

There is no evident decline in populations occurring in Alberta and while the estimated number of mature individuals is unknown, badgers continue to be harvested for fur and mortality by landowners in the province is not regulated. The main threats to badger habitat and populations

are land use changes (*e.g.,* intensive agricultural practices), vehicle collisions, use of rodenticides (*e.g.,* in relation to pasture lands, loss of important prey species such as northern pocket gophers and Richardson's ground squirrels), and fire suppression (increasing shrubs and woody vegetation) (Scobie 2002, COSEWIC 2012).

Population Trend

Based on an Alberta wildlife survey in conducted in 1999, COSEWIC estimated that the badger population ranged from 1,000 to 10,000 individuals. There are no reliable population trends over the past 10 years, although fur records suggest a significant historical decline in population levels. For example, 18,000 pelts were recorded in 1928 while recent fur data shows a decrease in pelts sold between 1999 and 2010 with an average of 734 badgers trapped annually (COSEWIC 2012). The west and east DUs have a population of less than 250 and 160 mature individuals, respectively while the south-western Ontario population is estimated at less than 200 adults (COSEWIC 2012). In Alberta, annual fur production of badger based on export permits decreased from 391 in 2013/2014 to 155 in 2017/2018 for a five year average of 244 pelts (GoA 2019).

Life History and Habitat Requirements

Habitat Preferences

Traditional American badger habitat is characterized by grassland, steppe and open forest but recent studies have shown that they will also utilize open or roaded areas within forest environments (COSEWIC 2012). Specifically, badgers require suitable soil conditions for digging and abundant prey within the habitat. The soil must be able to maintain its structure when tunnelled such as course silts, fine sands and low colluvial material. Other suitable habitat includes linear corridors, particularly in forested areas, non-forested or open-forested patches in alpine regions, wetlands and grasslands. Critical habitat for American badger has only been identified for Ontario (Environment Canada 2013) but has not yet been established for the Alberta population. The American badger is carnivorous, feeding on other animals such as voles, deer mice, wood rats, prairie dogs, gophers, squirrels, moles, marmots, birds and even insects.

Life History

Badgers begin mating in July and August. Males do not mature until after their first year and less than half of females will breed during their first summer (COSEWIC 2012). Females give birth to a litter ranging from 1 to 5 kits in March or April. Badgers are adaptable to fluctuating weather conditions and resource availability. They may enter into a shallow torpor during winter and are generally tolerant of humans and certain development. Their diet primarily consists of small rodents such as ground squirrels, marmot and woodchucks. Pocket gophers, voles, mice, insects, birds, reptiles and amphibians also supplement the badger's diet.

Movements and Home Range

Although the home range of the American badger in Alberta is unknown (Scobie 2002), home ranges in British Columbia varies from 33 to 64 km^2 for males and 16 to 18 km^2 for females and varies widely in the United States, depending on the season (COSEWIC 2012). Based on a review of nine studies conducted in North America, the average home range size was 97 km^2 for males and 12 km^2 for females. In Canada, Badgers (*taxus* subspecies) occur in the Prairie Provinces from east of Winnipeg, south of Lake Winnipeg and west to the Alberta Rocky Mountains. Their northern extent is defined into the Boreal Transition ecoregion. For these prairie ranges, the extent of occurrence is estimated at 721,096 km^2 while the index of area of occupancy is approximately 173,000 km^2 (COSEWIC 2012).

Juvenile badgers leave within their first summer and may travel as far as 52 km for females and 110 km for males although the average dispersal rate is 11 km by 106 days of age (COSEWIC 2012). They have the ability to cross major physiogeographic barriers and their home range size is likely dependent on female availability.

Regional Importance

American Badgers are top predators in their specific ecosystems. With their diet mainly consisting of small mammals such as ground squirrels, voles and mice, they have a role in maintaining these populations. Badgers also create patch disturbances in grassland habitats which can influence plant communities by loosening and aerating the soil, promoting humus formation and increasing permeability. Other burrowing species will use badger dens for shelter and nesting such as snakes, pocket gophers, swift fox and burrowing owls. Badgers are also valued for their fur in Alberta and their skins are of importance to the Piikani Nation in the Crowsnest Pass region which are used as traditional garments.

Application Case Assessment

Change in Habitat Availability

The primary effect of Project development on available American badger in the WLSA is related to direct habitat loss. Potential badger habitats in the WLSA include open natural areas such as grasslands (290.3 ha or 5.1%) and potentially anthropogenic disturbance types that are grass-dominated such as perennial forage crops (37.3 ha or 3.8%), clearings (212.4 ha or 3.8%), and road-sides (124.8 ha or 2.2 %) and seeded well sites and pipeline rights-of-way (65.2 ha or 1.1%) (Table 2.4-1, CR#9, EIA). Overall, potential badger habitats account for 12.9% (730 ha) of the WLSA.

Changes in habitat availability resulting from Project development will result in a net increase in grassland habitat of 20.2% (58.8 ha) at Year 27 for a total of 349.1 ha in the reclaimed landscape (6% of the WLSA). There is a temporary loss of 51.9% (-150.7 ha) of grassland habitat at Year 14 during the time of maximum disturbance (Table 5.1-1, CR#9, EIA, CEAR #42).

However, existing anthropogenic disturbances (*e.g.,* trails, roads) within the Project footprint will be reclaimed at closure. As reclamation progresses, these grass-dominated reclaimed sites may provide suitable habitat for badgers for many years. For example, grassland and open shrubby habitats were rated as high and moderately high for elk, respectively (Section 2.8, Appendix C, CR#9, EIA, CEAR #42). These habitat types, which provide important foraging habitats for elk throughout the year, are expected to decrease by 46% (-197.0 ha) at Year 14 but increase by 129% (550.1 ha) from baseline as reclamation progresses across the Project footprint (Table 5.3-20, Figure 5.3-46, CR#9, EIA, CEAR #42). As much as 17% (977.4 ha) of the WLSA could provide suitable habitat for badgers at Year 27. Overall, American badger habitat is predicted to increase from baseline conditions following mitigation and reclamation. Project development is not expected to affect badger habitat in the WRSA since most of the suitable habitat is located east and southeast of the Project footprint.

Change in Movement

Movements of American badgers in the WLSA will be affected since most of the habitat available for badgers will be affected by development of the Project footprint (Figure 5.1-1, CR#9, EIA, CEAR #42). The single badger that was photographed was travelling on a trail at the edge of a moderate mixed coniferous stand and the existing coal mine disturbance in an alpine area of the WLSA. Badgers will be displaced to other more suitable habitats adjacent to the Project footprint. While badgers are relatively tolerant of anthropogenic disturbances, movements along the access corridor and the 5.4 km long coal conveyor may be affected.

Change in Mortality Risk

The American badger is still managed in Alberta as a furbearing species and one of the main anthropogenic risks of mortality in the WLSA and WRSA is trapping. Both the WLSA and WRSA fall within Fur Management Zones (FMZ) 6 where badger trapping can occur from December 1 to April 15. In addition, the badger may be hunted, without a licence and during all seasons, by a resident on privately owned land to which the resident has the right of access AEP (2019). With Project development, hunting and trapping will not be allowed with the Mine Permit Area which should function in minimizing this risk for the American badger.

The badger is also highly susceptible to road-kill. Badger prey are generally attracted to roadside conditions of quality grass and friable soils (Weir *et al*. 2004b, cited in COSEWIC 2012) causing badger to become prone to mortality from vehicles. There is no data collected on road-kill in the Alberta populations but badgers have suffered high rates of road-kill in similar ecosystems such as southern Idaho (Messick and Hornocker 1981). Vehicle collisions can be reduced by establishing and enforcing a low speed limit on the access road. Density of roads are not likely to increase but traffic volume will rise along the access road to the mine.

Change Relative Abundance

Although the American badger was identified as wildlife species that could potentially occur in the WLSA, its presence within the WLSA was confirmed through wildlife camera trapping in August 2015 (Section 2.4.3.3.2.1, CR#9, EIA, CEAR #42). This was the only badger sighting recorded either incidentally or through baseline wildlife inventories conducted in the WLSA between 2013 and 2016. It appears that the American badger is one of the least abundant mustelid species at baseline in the WLSA, although should the Project be approved, pre-disturbance surveys will be conducted to further confirm species presence and relative abundance.

Mitigation Measures

Benga will implement the appropriate best management practices, Project features and mitigation measures to minimize risk on federally-listed (*SARA*) species at risk. Although critical habitat has not been identified for American badger in Alberta, any future federal action plans including any species-specific mitigation and monitoring plans developed by ECCC and applicable to the *taxus* DU will be implemented. In the interim, if any badgers are detected during pre-disturbance surveys that will be conducted in the WLSA should the Project be approved, specific mitigation measures will be developed in consultation with AEP and ECCC.

Many of the Project effects associated with wildlife habitat loss (including badger habitat) will be minimized by implementing the Project's reclamation plan which includes the following:

- minimize the overall disturbance footprint through the mine planning process to avoid critical breeding habitats, nesting and denning sites, and movement corridors to the extent possible;
- preserve remnant forest patches within the development areas where feasible to provide habitat, habitat connectivity and hide cover for wildlife species;
- remnant patches should protect known essential raptor habitat features by incorporating these habitat features (*i.e.,* mature balsam poplar and aspen) where possible;
- maximize the direct placement of salvaged soil to enhance native plant development;
- retain slash and large woody debris in the salvaged soil to provide microsites for native plant and hide cover for wildlife;
- establish a variety of vegetation species and communities suitable for wildlife, and encourage structural complexity within the forests;
- encourage understory complexity in reclaimed forests by planting native shrubs such as alder and willow;
- ensure that core security areas are provided for wildlife;

- provide water management program that ensures the surface water quality is maintained; and
- limit sight lines by maintaining mature forest stands as buffers between roads and reclamation areas.

To support the reclamation plan mitigation measures, the following will be implemented to mitigate potential direct and indirect Project effects on wildlife habitat availability:

- Incorporate existing legacy mining disturbances into the development and reclamation plans for the Project, and other proposed land use activities to the best extent possible so that habitat loss, habitat fragmentation, linear disturbance features, and cumulative habitat loss are minimized.
- Pre-disturbance surveys (wildlife sweeps) will be conducted in the development area prior to any construction activities during Project development to determine the occurrence of any important wildlife habitat features such as migratory bird nests, mineral licks, active dens, bat habitat and hibernacula, active raptor nest sites, and essential raptor habitat features (*i.e.,* mature balsam poplar, platform/stick nests) that could indicate the presence of species at risk.
- Protect all important wildlife habitat features in areas of suitable wildlife habitat (on the edge of the Project footprint boundary) appropriate setback distances (or buffer zones) will be considered.
- Clearing and equipment use/storage/cleaning in undisturbed areas within and adjacent to the Project footprint will be avoided.
- Vegetation adjacent to high-activity linear corridors (*e.g.,* access roads, coal conveyor) will be retained to reduce the extent of noise and visual sensory disturbances to the extent possible.
- The overland coal conveyor system was designed in such a manner to prevent any deposition of coal product along the route from the CHPP to the rail load-out area. This includes a cover for the length of the conveyor to reduce dust, and motor specifications to reduce industrial noise levels.
- Where appropriate, vegetated buffer zones (100 m or minimum of 30 m; pending topography constraints) will be maintained between Project infrastructure and wetlands, creeks, and streams to the best extent possible.
- As required by the *Weed Control Act* and Regulations, all identified noxious and invasive weed species populations will be controlled prior to any site disturbance and mine operation to prevent the further spread of weeds. Noxious weed management will occur in compliance with R&R/03-4 *Weeds on Industrial Development Sites*.
- As the presence of artificial lighting can potentially affect bird and bat use of nearby habitats, Benga has developed a visual impact mitigation plan that reduces stray and

non-essential artificial lighting to minimize wildlife effects and that will comply with OH&S safety requirements (CR #1 – Air Quality, EIA, CEAR #42).

- To mitigate the potential effects of sensory disturbance (acoustic and visual) on effective habitat availability in the southeast portion of the Gold Creek valley, Benga will install and maintain a 15-m tall earth berm along the eastern edge of the south disposal area (CR #2 – Noise Impact Assessment, EIA, CEAR #42). The earth berm will be constructed/maintained during the day-time when required and will grow in elevation as the height of the disposal area increases.
- Sensory disturbance from the active mine site will be further mitigated through the use of mufflers on all internal combustion engines, utilizing mine pit topography to shield noise generated from haul trucks, and conducting blasting during daylight hours (CR #2 – Noise Impact Assessment, EIA, CEAR #42).

The following general wildlife mitigation measures will be implemented to minimize potential disruption to daily and seasonal wildlife movements:

- A minimum of six wildlife crossings (underpasses and overpasses) will be incorporated into the design of the coal conveyor (the conveyor route is approximately 5.4 km in length):
  - will be strategically placed in locations that will maximize wildlife use (*e.g.,* presence of well used trails, suitable habitats, and terrain features such as valleys and depressions that act as natural crossings);
  - additional pre-disturbance surveys will be conducted to identify important wildlife habitats and trails along the access road and conveyor corridor;
  - natural underpasses using topography are preferred; and
  - above-ground crossings may be required when topography isn't favourable, conveyor will likely be raised higher above the ground to allow wildlife movement under it.
- Surface water management ponds and ditches located in undisturbed areas of the Project footprint will be designed to allow wildlife to move around or cross safely.
- Road plowing and grading will be conducted in a manner that does not restrict wildlife from crossing access roads or accessing wildlife crossings.
- Measures to control dust and other air emissions (*e.g.,* watering of roads and use of dust suppressants, minimizing engine idling, *etc.*) within the Project footprint will be implemented to minimize effects on adjacent wildlife habitats (CR #1 – Air Quality, EIA, CEAR #42).

Project-specific mitigations targeted to carnivore species have been incorporated into the reclamation planning. Many of these will also support habitat connectivity for migratory birds, raptors, and species at risk, and include:

- minimize the overall disturbance footprint through the mine planning process;
- preserve remnant forest patches in the development areas to provide essential habitat, habitat connectivity, and hide cover for wildlife species;
- retain slash and large woody debris in the replaced soil landscape;
- plant native shrubs early in the reclamation process to initiate hiding cover;
- establish mixed wood forest stands and high density coniferous tree stands;
- provide understory complexity in the reclaimed forests by planting native shrubs such as alder and willow to provide security cover for the carnivores and their prey;
- maximize the amount of ungulate habitat;
- prior to final reclamation, disrupt linear disturbances and sight lines by mounding surface soils, piling brush; and
- limit sight lines by maintaining mature forest stands or by planting high density coniferous stands to act as buffers between roads, project disturbance boundaries and the reclaimed mine areas.

Wildlife mortality risk may increase as a result of increased traffic, wildlife encountering equipment, or elements of the Project footprint, and wildlife being attracted to Project facilities or humans. The Grassy Mountain area currently has a considerable network of trails and roads that are heavily used. Plans are already being implemented to reduce this level of access and with the approval of this Project, the levels will be reduced considerably more. Mitigation measures that will be implemented to reduce wildlife mortality risk include:

- All access to the Mine Permit will be controlled, no uncontrolled access will be permitted. Common operational practices will include:
  - prohibiting use of snowmobiles and ATVs;
  - prohibiting hunting, harassment, or feeding of wildlife; and
  - implementing a strictly enforced zero tolerance policy on the use of firearms.
- Timing vegetation site clearing activities to occur outside the April 15 to August 31 period to avoid disrupting nesting migratory and resident songbirds and raptors:
  - In the event that vegetation clearing must occur within the restricted activity period, pre-disturbance nesting surveys will be conducted by experienced avian biologists according to established sensitive species inventory guidelines (GoA, 2013b). Establish species-appropriate setback distances around confirmed active nest sites until fledging in consultation with Environment Canada and AEP. If the status of a nest cannot be confirmed, or if a nest is found outside of the breeding

season, a setback distance will be implemented until such time as the nest status can be confirmed (GoA, 2013b).

- Confirm the presence/absence of bats in high quality habitats located within the Project footprint prior to the initiation of any clearing activities and develop a mitigation plan if bats are found.
- Conducting pre-disturbance denning (bears, marten, *etc.*) and roosting (bats) surveys prior to vegetation clearing and other high-disturbance activities. Consult with AEP as needed to develop appropriate mitigation and management strategies.
- Conducting pre-disturbance surveys (acoustic surveys and visual searches) to identify wetlands and watercourses used by breeding Columbia spotted frogs and western toads that feed into the protection plans.
- Benga commits to supporting active bear management plans associated with the Project. If a site specific plan is required, it will be developed in consultation with AEP personnel as part of the Wildlife Mitigation and Monitoring Plan. The plan is expected to be a comprehensive document that outlines operational strategies and best practices for addressing concerns related to not only bear-human conflicts but potential risks to ungulates and other wildlife resulting from attraction of bears to the area.
- Developing a Beneficial Management Plan guide to minimize potential Project-specific impacts on migratory birds and their habitat by identifying more site-specific mitigation and monitoring measures following Project approval and in consultation with federal and provincial regulators.
- A detailed Waste Management Plan will be developed and implemented prior to construction and operational activities to minimize the attraction of wildlife. Benga will follow the Best Management Practices for camps, fences, and barriers as described in Bear Smart: Best Management Practices for Camps, and ensure all waste is stored in wildlife-proof containers and disposed of properly. Some of the waste management and bear awareness/Bear Smart guidelines that will be implemented include:
  - ensuring food waste, refuse, and other attractants are securely contained in enclosed and approved bear-proof containers and/or facilities (*e.g.,* hard-sided buildings, fenced compounds, and bear-proof transfer station) prior to transportation to a disposal facility to prevent access by scavenging bears;
  - providing adequate signage to inform employees of the location and proper use of bear-proof storage containers/facilities;
  - ensuring waste storage containers/facilities are not filled beyond capacity;
  - ensuring regular inspection and maintenance of waste storage containers/facilities is carried out;

  - ensuring measures contained in the bear management plan are diligently followed by all employees and contractors;
  - all on-site staff will receive Bear Awareness Training; and
  - bear warning signs will be installed to advise staff of locations where problem bears have been reported.
- Implementing an Emergency Spill Response Plan to limit the effect of accidental spills. Spills will be minimized by restricting fuel storage and filling to designated areas that are at least 100 m from wetlands and watercourses as well as Project drainage ditches, sediment control ponds, and pit lakes.
- Storing all hazardous materials, including those used for blasting, in secure areas that are inaccessible to wildlife (*e.g.,* buildings, storage areas surrounded by wildlife-proof fencing). In addition, proper handling and storage of industrial materials and debris within the Project footprint will be maintained to minimize potential risks to wildlife.
- Developing procedures to clear blasting areas of large mammals or birds prior to blasting.
- Designing water management ponds and drainage ditches, and pit lakes to minimize potential entrapment of wildlife.
- Developing a strategy to minimize changes in water quality upstream of the mine in conjunction with a water-quality monitoring program.
- Enforcing speed limits (≤50 km/hr) along the main access road and utility corridors, and placing signs at identified wildlife crossings to increase driver diligence to minimize wildlife-vehicle collisions. Vehicles will yield to all wildlife crossing the main access road.
- Bird collisions with buildings will be mitigated by placing visual markers on windows, and collisions with the proposed power line will be mitigated by installing large 'floats' or other markers.

Wildlife monitoring will be used to monitor the effects of the Project on wildlife species at risk or species of management concern during construction and operation of the Project and post-closure. In particular, the effects of the Project on wildlife VCs, including disturbance, mortality, and movement will be monitored. Monitoring will consist of a systematic monitoring program along with incidental observations. The wildlife monitoring program will serve a number of important functions including:

- verifying impact predictions and monitoring the effectiveness of mitigation measures;
- improving Benga's understanding of the effects of Project construction and operation on wildlife within the WLSA and surrounding area to enable the implementation of adaptive management practices when required; and

- ensuring compliance with the terms and conditions of the Operating Approval and Project environmental standards once the Project has been approved by AER and CEAA.

Details of the monitoring plan have been developed and are presented in the Wildlife Mitigation and Monitoring Plan (Appendix 5.39-1 in response to JRP IR-5.39).

Effects Assessment

The primary effect that Project development will have on American badger is likely associated with direct habitat loss. Potential habitat types in the WLSA that provide either suitable foraging or burrowing habitats for badgers includes native grasslands and grass-dominated anthropogenic habitat types (*e.g.,* perennial forage crops, seeded well sites and pipeline rights-of-way, *etc.*). In addition, further indirect habitat loss will occur from increased noise levels associated with construction and operations activities even though the badger can be relatively tolerant of certain anthropogenic activities. Any American badgers present within the immediate vicinity of the Project footprint will be displaced to other more suitable habitats present to the east and south until at least progressive reclamation is initiated.

With Project development, mortality risk associated with hunting and trapping will not be allowed within the Mine Permit Area which should function in minimizing these risks for the American badger. However, the badger is susceptible to collisions with vehicles because of the presence of suitable foraging and burrowing habitats associated with roadsides. The potential for badger-vehicle collisions can be reduced by establishing and enforcing a low speed limit on the access road. Badger movements are not expected to be affected by the Project.

Potential direct or indirect effects resulting from increased exposure to chemicals of concern as a result of the Project were assessed in the screening-level wildlife risk assessment (JRP IR-4.1, Appendix H) evaluated potential adverse population-level effects to terrestrial wildlife associated with chemical emissions from the Project.

As previously mentioned in the Baird's sparrow effects assessment summary, the methods and guidelines as provided in the screening level-WRA were established to be protective of population-level adverse effect(s) and exposures to chemical(s) at concentrations lower than those presented in the screening level-WRA would not be expected to cause ill-effect. As such, the TRVs used within the screening-level WRA are considered protective of the American badger and the conclusions of the screening-level WRA remain unchanged. Specifically, that chemical concentrations associated with Project emissions would not be expected to cause population level adverse effects on wildlife.

The overall effects of Project development on the American badger in the WLSA are predicted to be local in extent, extended in duration, continuous in frequency, low in magnitude, and high in probability. The Project contribution to changes in abundance and habitat availability will be

negative during the lifespan of the Project, but will be reversible in the long-term. The confidence rating associated with this assessment is moderate, since although a single badger was recorded, the American badger is likely an uncommon species in the WLSA. In terms of the potential effects of the Project on the persistence of this species in southwestern Alberta, the effects are considered to be Not Significant. This rating is partly based on the small proportion of grassland habitats that will be lost to the Project, the likelihood that much of this habitat will be replaced or increased over the long term through the proposed reclamation program, and with implementation of the general wildlife and species-specific mitigation and monitoring plans.

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5.35 Information Request 5.35

Grassy Mountain Coal Project – Updated Environmental Impact Assessment. Consultant Report #9 - Wildlife. (CEAR #42).

Comments from Ktunaxa Nation Council. (CEAR #178).

Benga states in Consultant Report #9 (CEAR #42) "Ten wildlife Valued Components (VC) consisting of two amphibian, two avian and six mammalian species were selected for the wildlife Baseline Assessment and Application Assessment. An additional eight species were included in a high level assessment to provide supplemental information to the wildlife assessment. These eight species were chosen based on the same criteria as the VCs, and are considered special status species." Benga also states "VCs with small home range sizes that were not expected to be affected by Project development at the local scale will not be affected by Project development at broader regional scale. As such, an effects assessment at the WRSA and GBRSA level were only considered for selected VCs."

Table 2.4-2 in Consultant Report #9 (CEAR #42) indicated the "probability of occurrence" which confirms that the species occur in the area either through baseline wildlife surveys, incidental observations or other information. Species include Western toad, Barn swallow, Common nighthawk, Olive-sided flycatcher, Short-eared Owl, Little brown myotis, American badger, Wolverine and Grizzly bear. All of these species are SARA- and COSEWIC- listed species that have been confirmed in the GBRSA.

Table 4.6-1 of Consultant Report #9 (CEAR #42) indicates Elk as a VC with similar requirements to Grassland or Open Country Birds, including SARA-listed species such as the Bobolink and Common nighthawk. This table also provides additional selected surrogate species that are used to indicate habitat changes for migratory bird groups, noting for example that the Project effects on habitat availability for the Columbia spotted frog were expected to be similar for shorebirds and other migratory bird species that rely on ponds, streams and wetlands.

Ktunaxa Nation Council (CEAR #178) states the selection of the VCs for wildlife are incomplete noting that the VCs do not adequately represent the range of wildlife guilds and habitats that will be affected by the Project and that emphasis has been placed on choosing VCs that are secure species and/or species that are not specialized in their habitat needs, rather than those that are of conservation concern and have narrow habitat dependencies. Ktunaxa Nation Council also highlights that there are no small mammals (water vole, vagrant shrew, long-tailed weasel), or aquatic furbearers (river otter, beaver, mink) identified as VCs. Many of these species are known to occur in the region, with a probability of occurrence within the GBRSA or the LSA. These species are considered of high importance to Indigenous groups in the region. Ktunaxa Nation Council identified

the following species that should have also been considered: Northern goshawk, American badger, Baird's sparrow and Sprague's pipit.

a) Justify the selected species of Valued Components and discuss how these provide adequate effects assessment and representation for additional migratory bird groups identified and SARA-listed species that have potential or confirmed probability of occurrence on site.

Response:

As it is impractical to assess all wildlife species in detail, Benga selected a set of wildlife VCs that were representative of wildlife in the vicinity of the Project Area. As indicated in Section 3.2.3 (CR#9, EIA, CEAR #42), wildlife VCs were selected based on various criteria including ecological, economic, and traditional use importance. The selected VCs serve as indicator species, which collectively reflect most wildlife species with similar habitat requirements in the WLSA, and to focus the wildlife assessment in accordance with current practice in Alberta and Canada. This was also discussed in Section 3.2.3 of CR#9 Wildlife (EIA CEAR #42) and JRP IR-4.3a.

While Benga recognizes the traditional and cultural value of many wildlife species to Aboriginal Groups, not all species with traditional value identified in the available TU reports or from Aboriginal Consultation sessions are individually assessed.

The approach taken for the Project to identify wildlife VCs focused on the selection of species that are representative species for other wildlife species/groups that exhibit similar use of various habitat types at various spatial (foraging) and temporal (*e.g.,* breeding, overwintering) scales. To determine the representative wildlife species the following criteria were used:

- known or reported occurrence in and overlap with the WLSA;
- reported to have value to traditional (Aboriginal Groups), recreational (hunters), subsistence (trappers), and/or non-consumptive (wildlife viewing) users;
- provincial ("At Risk", "May Be At Risk", or "Sensitive") and/or federal (Schedule 1 SARA species, "Endangered", "Threatened", or "Special Concern") status, or is known to be declining in the region;
- use of major habitats and/or reliance on habitat types that are limited in geographic extent and that may be affected by Project development; and
- is a "keystone" species that has a disproportionate effect on the ecosystems it is found in or other species require its presence to persist in the area.

Based on this approach, ten wildlife VCs consisting of two amphibian, two avian, and six mammalian species were selected for the wildlife Baseline Assessment and Application Assessment.

Before commencing with the assessment based on these 10 VCs, the VCs were presented to the Treaty 7 First Nations groups included in the Indigenous Consultation process for their approval or recommended additions or alternatives. An additional eight species were included in a higher level assessment to provide supplemental information to the wildlife assessment. These eight species were chosen based on the same criteria as the VCs, and are considered special status species. The VCs and the justification for selecting them are outlined in Table 5.35-1 (originally Table 3.2-2 in CR#9: CEAR #42), which has been included below for convenience of the reader.

Table 5.35-1 Summary of Valued Components Used to Assess Project Effects on Wildlife (from CR#9, EIA)

Species	Status	Recorded in WLSA	Rationale for Selection
Amphibians			
Columbian Spotted Frog	**Alberta:** Sensitive	Yes	Known to occur in WLSA; indicator of wetland/aquatic/riparian-dependent species; sensitive to changes in water quality; relies on breeding ponds which are of limited availability and distribution; vulnerable to human disturbance; provincially listed species.
Western Toad	**Alberta:** Sensitive **COSEWIC:** Special Concern	Yes	Known to occur in WLSA; indicator of wetland/aquatic-dependent species; sensitive to changes in water quality, vulnerable to human disturbance; provincially and federally listed species.
Birds			
Olive-sided Flycatcher	**Alberta:** May be at Risk **COSEWIC:** Threatened **SARA:** Schedule 1	Yes	Known to occur in WLSA; indicator of mature coniferous/riparian forests, burned woodlands, and edge habitat bird species; provincially and federally listed species
Great Grey Owl	**Alberta:** Sensitive	Yes	Known to occur in WLSA; indicator of mature and old-growth forest bird species; vulnerable to habitat loss and forestry practices; cultural importance to First Nations; provincially listed species.
Mammals			
Little Brown Myotis	**Alberta:** Secure **COSEWIC:** Endangered **SARA:** Schedule 1	Yes	Known to occur in WLSA; indicator of mature and old growth forest species; federally listed species.
American Marten	**Alberta:** Secure	Yes	Known to occur in WLSA; important fur harvest and First Nations traditional use species, vulnerable to habitat fragmentation and human disturbance; indicator of late succession coniferous forest.
Canada Lynx	**Alberta:** Sensitive	Yes	Known to occur in WLSA; important fur harvest and First Nations traditional use species; vulnerable to habitat fragmentation/human disturbance; indicator of early succession forest species; provincially listed species.

Table 5.35-1 Summary of Valued Components Used to Assess Project Effects on Wildlife (from CR#9, EIA)			
Species	**Status**	**Recorded in WLSA**	**Rationale for Selection**
Grizzly Bear	**Alberta:** Threatened **COSEWIC:** Special Concern **SARA:** Schedule 3	Yes	Known to occur in WLSA; culturally important to First Nations; potentially declining population in the Castle-Livingstone region; susceptible to industrial activities and vulnerable to conflicts with humans; provincially and federally listed species.
Moose	**Alberta:** Secure	Yes	Known to occur in WLSA; important recreational hunting and traditional use species; culturally important to First Nations important prey for large predators; indicator of riparian and early to mid-successional habitats.
Elk	**Alberta:** Secure	Yes	Known to occur in the WLSA; important recreational hunting species; culturally important to First Nations; important prey for large predators; indicator of grassland/early successional habitats.

Species	**Status**	**Recorded in WLSA**	**Rationale for Selection**
Birds			
Barn Swallow	**Alberta:** Sensitive **COSEWIC:** Threatened	Yes	Known to occur in WLSA; indicator of open wetlands, fields, and meadows; provincially and federally listed species
Common Nighthawk	**Alberta:** Sensitive **COSEWIC:** Threatened **SARA:** Schedule 1	Yes	Known to occur in WLSA; vulnerable to habitat loss; provincially and federally listed species.
Short-eared Owl	**Alberta:** May be at Risk **COSEWIC:** Species of Concern **SARA:** Schedule 1	Yes	Known to occur in WLSA; cultural importance to First Nations; provincially and federally listed species.
Bald eagle	**Alberta:** Sensitive **COSEWIC:** Not at Risk	Yes	Significant cultural and spiritual importance to Treaty 7 First Nations
Golden eagle	**Alberta:** Sensitive **COSEWIC:** Not at Risk	Yes	Significant cultural and spiritual importance to Treaty 7 First Nations
Mammals			
Mountain Goat	**Alberta:** Secure	Yes	Prized game species by hunters, traditional value/use (Piikani Nation)

Species	Status	Recorded in WLSA	Rationale for Selection
Bighorn Sheep	**Alberta:** Secure	Yes	Traditional value/use (Kainai, Piikani, and Tsuut'ina, Siksika, Samson Cree Nations); prized game species by hunters
Wolverine	**Alberta:** May be at Risk **COSEWIC:** Special Concern	Yes	Known to occur in the WLSA; provincially and federally listed species, traditional value/use (Samson Cree Nation).

Migratory Birds

A high level assessment for migratory birds was conducted in the EIA (Section 5.5, CR#9, EIA, CEAR #42) based on the potential effects of Project development on habitat loss, habitat fragmentation and connectivity, mortality risk and abundance. This high level assessment was based on the assumption that most migratory bird species have similar habitat requirements to wildlife species selected as VCs (Table 4.6-1, CR#9, EIA, CEAR #42). As indicated in Section 4.6, "coniferous and mixedwood forests cover a large area of the WLSA (~70%), and host the highest species richness and diversity of all habitats occurring in the WLSA". In addition, "Several species prefer habitats that are more limited in the WLSA. The scarcity of these habitats limits the presence and abundance of these species in Baseline conditions. There are only 18 ha of shrubby wetland, 5 ha of treed wetland, and 64 ha of waterbody habitats in the WLSA, limiting the presence and abundance of shorebirds, waterfowl, and other wetland-dependent birds in the WLSA. Similarly, grassland species (*e.g.,* mountain bluebird and vesper sparrow; Table 4.6-1) are also limited in the WLSA due to the relative scarcity of grassland habitat (290 ha) and upland shrub habitat (< 1 ha). Some species display a strong preference for mature and old-growth forests (*e.g.,* woodpeckers), and those that prefer old growth are limited by the presence of only 169 ha of in the WLSA. Species preferring open, rocky habitats, including alpine habitats have 49 ha of suitable habitat in the WLSA." Benga considers that the use of selected indicator wildlife species in the EIA (Section 3.2.3, CR #9, EIA, CEAR #42) in conjunction with the detailed effects assessment conducted for the olive-sided flycatcher, and the high level species assessments conducted for common nighthawk and barn swallow (Section 5.4, CR #9, EIA, CEAR #42) and migratory birds (Section 5.5, CR #9, EIA, CEAR #42) does provide a realistic assessment of the potential Project effects on migratory bird and SARA-listed species with potential or confirmed probability of occurring within the WLSA.

b) Clarify why species listed by Ktunaxa Nation and other Indigenous groups, including small mammals and aquatic furbearers, were not included as VCs.

Response:

See the response to JRP IR-4.3 a) and b).

c) Confirm whether Elk were used as a surrogate VC for Common nighthawk and Bobolink. If so, justify, with supporting research and literature, how Elk can be used as a surrogate VC for these two species.

Response:

As indicated in CR#9, Sections 3.2.3 and 5.4, (EIA, CEAR #42) and the responses to JRP IR-4.3 a and JRP IR-5.35 a), various selection criteria were used to establish the list of wildlife VCs (10) and special status wildlife species (8). These 18 species were considered to be representative of the wildlife communities present in the WLSA and were used to assess potential Project-related effects on habitat use, movements, mortality risk and relative abundance. Elk (as a VC) and common nighthawk (as a special status species) do have similar habitat requirements during the snow-free period as indicated in Sections 4.4.10 and 4.5.2, CR#9, EIA (CEAR #42) and Section 2.8, CR#9, Appendix C, EIA (CEAR #42).

While bobolink is a "Sensitive" species in Alberta and a "Threatened" species in Canada, it's probability of occurrence in the GBRSA was considered to be low, primarily because of its habitat requirements (Table 2.4-2, CR#9, EIA, CEAR #42). In addition, the bobolink was not detected during any of the breeding bird surveys or incidentally observed during other wildlife surveys conducted within the WLSA. The bobolink occurs in central and southern Alberta but is absent from the east slopes of Alberta (Figure 5.35-1). Nesting habitats for the bobolink includes forage crops (*e.g.,* hayfields and pastures dominated by a variety of species, such as clover, Timothy, Kentucky Bluegrass, and broadleaved plants) and various grassland habitats including wet prairie, graminoid peatlands and abandoned fields dominated by tall grasses, remnants of uncultivated virgin prairie (tall-grass prairie), no-till cropland, small-grain fields, restored surface mining sites and irrigated fields in arid regions (COSEWIC 2010). If the bobolink does occur in the WLSA, it would most likely be associated with grassland and grass-dominated anthropogenic habitats (Table 2.4-1, CR#9, EIA) similar to habitats used by both elk and common nighthawk.

References

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d) Provide justification and supporting research and literature for the use of Columbia spotted frog and Western toad as surrogate species for shorebirds and waterfowl. If referring to habitat preferences, provide supporting literature to indicate that these

species have similar requirements. Include requirements such as breeding area, foraging and shelter.

Response:

The Western toad and Columbia spotted frog were used as representative species for other wildlife species that depend on wetlands and watercourses for at least a portion of their life cycle (see Table 3.2-5, CR#9, EIA, CEAR #42 for seasons and life requisites considered). In addition, a high level assessment of potential Project effects on migratory birds was also conducted which included shorebirds and waterfowl (Section 5.5, CR#9, EIA, CEAR #42). Part of the assessment involved assessing changes in wildlife habitat availability under the baseline and application cases (years 14 and 27) which predicted changes in all habitat types, including waterbodies, treed wetlands, and shrubby wetlands (Table 5.1-1, CR#9, EIA, CEAR #42). The wildlife assessment indicated that wetland habitats are scarce (86.6 ha or 1.5% of total habitats) in the WLSA and that shorebirds, waterfowl, and other wetland-dependent birds are expected to be minimally affected by Project development.

Overall, the western toad and Columbia spotted frog were selected as representative wetland species because potential Project-related effects on these two amphibians would be expected to be similar to other wildlife species that are dependent on wetland habitats for a portion of their life cycles, including shorebirds and waterfowl. During wildlife surveys conducted in the WLSA, two shorebird (sora and spotted sandpiper) and two waterfowl (Barrow's goldeneye and ring-necked duck) species were detected. A brief description of the life requisites for these shorebird and waterfowl species is provided below.

Sora forage and breed in wetlands with abundant emergent vegetation and shallow or intermediate depth wetlands (Fisher and Acorn 1998, Zimmerman *et al*. 2002; Niemuth 2005; Melvin and Gibbs 2012). These habitat features are characteristic of a variety of wetland types including graminoid marshes that may be seasonal, semi-permanent or permanent which are also used by western toad and Columbia spotted frog. Although sora may occur less frequently in wetlands with large amounts (>95%) of open water (Zimmerman *et al*. 2002).

Spotted sandpipers always nest within approximately 90 m of various types of waterbodies including rivers, streams, marshes, and wetlands associated with gravel pits, farm dugouts and mining operations (Fisher and Acorn 1998, Cornell Lab of Ornithology 2019). They are active foragers along shorelines feeding on small invertebrates (*e.g.,* midges, mayflies, *etc.*), insects (*e.g.,* grasshoppers, beetles, *etc.*) and small crustaceans (Fisher and Acorn 1998, Cornell Lab of Ornithology 2019). Dense vegetation patches along shorelines provide security for nest sites, providing cover for adults and chicks.

Buffleheads nest near water, often in tree cavities abandoned by flickers and woodpeckers, preferring open water areas of lakes, ponds, watercourses in wooded areas (Fisher and Acorn 1998). They forage by diving for aquatic invertebrates although they will eat snails and small

crustaceans and occasionally small fish (Fisher and Acorn 1998, Cornell Lab of Ornithology 2019).

Ring-necked ducks prefer shallow wetlands (*e.g.,* wooded ponds, swamps, marshes, *etc.*) fringed with emergent, submergent, or floating aquatic vegetation such as bulrushes, pondweed, and pond lilies (Fisher and Acorn 1998, Cornell Lab of Ornithology 2019, Ducks Unlimited 2019). They feed primarily on submerged aquatic vegetation although aquatic invertebrates such as leeches, insects, and snails are also eaten. Ring-necked ducks will nest over water on hummocks or on shorelines on nests made of grass and moss and lined with down (Fisher and Acorn 1998).

It is apparent that breeding (nesting) habitat is the main life requisite for both shorebirds and waterfowl. Breeding habitats not only provide suitable sites for breeding, but also for other life requisites such as foraging, shelter and security. Based on this information, the use of the western toad and Columbia spotted frog as representative species for wetland dependent wildlife reasonably reflects the life requisites of shorebirds and waterfowl in the WLSA and GBRSA.

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5.36 Information Request 5.36

Grassy Mountain Coal Project – Updated Environmental Impact Assessment. Consultant Report #9; Volume 6 Section 3.2.4 Evaluation Criteria for Environmental Effects. (CEAR #42).

Comments from the Ktunaxa Nation Council. (CEAR #178).

Comments from the Tsuut'ina Nation. (CEAR #192).

In Consultant Report #9 (CEAR #42), Benga states that "Some studies suggest that residual thresholds from 10 – 60% may be necessary to prevent rapid population decline (Villard *et al*., 1999; Swift and Hannon, 2002), but a recent review (Swift and Hannon, 2010) concluded that most empirical studies support Andrén's (1994) initial proposed range of 10 – 30%." Benga, choosing the 20% threshold, states that they provide a precautionary approach for assessing habitat change, (i.e. a species will tolerate up to a 20% loss of effective habitat) for valued species at the WRSA and GBRSA levels. Indigenous groups (CEAR #178 and #192) raise the issue that a 20% threshold applied to all VCs is questionable, particularly VCs that are either federally or provincially listed which cannot lose more of their habitat without considerable impact.

a) Provide a literature review that supports using the threshold chosen (20%) across all VCs, including a specific discussion on use of this threshold for species at risk in the WRSA and GBRSA.

Response:

Support for the 20% threshold was previously addressed in Sections 3.2.5.4 and 3.2.5.4.1 of CR#9 and in Addendum 5, Attachment 2, IR 22 (CEAR #69). The response for IR 22 (CEAR #69) has been repeated here for the convenience of the reader.

> *"Benga used the conservative threshold of 20% loss of effective habitat at the regional level for significance of effect of habitat loss on wildlife species. Literature reviews support a threshold of 70% to 90% loss (or 10% to 30% regional landscape remaining effective habitat) for extirpation, with acknowledgment that effects on body condition, reproductive potential, and abundance are likely prior to extirpation (CR #9, Section 3.2.5.4.1). Every species will have a unique area specific threshold for the maintenance of its health, reproductive output, and population size. Although these thresholds are not known for the VCs in general, and the VCs within the region and Project area specifically, Benga believes that the use of 20% loss as a residual effect to determine significance is a conservative threshold at which healthy populations will exist. In addition, other evaluation criteria (CR #9, Section 3.2.4, Table 3.2 4) were considered*

in determining overall significance, particularly the magnitude, reversibility, and duration of the effect on wildlife."

A review of additional literature further supports the 20% threshold that was used for the Project wildlife assessment. For example, van der Hoek *et al.* (2015) reviewed the limitations and future directions of applying habitat thresholds for use as conservation targets in natural resource policies and planning, particularly as it relates to vulnerable species and landscapes. As part of this review, they provided eight examples that specifically mentioned threshold estimates as conservation or management targets (Table 5.36-1). While four of the eight reports tended to over-generalize or simplify habitat thresholds, van der Hoek *et al.* (2015) felt that those reports that considered species-specific thresholds (*e.g.,* Wallace and Tarr 2012, McAlpine *et al.* 2007, and Rosenberg *et al.* 1999 in Table 1) were particularly good examples for informing conservation targets. One of their conclusions to avoid misapplication of habitat thresholds was to derive nominal threshold values through species- and area-specific modelling and careful analyses (including expert opinion) of extensive literature reviews (van der Hoek *et al.* 2015).

Table 5.36-1 Examples of policy/management focused reports and papers with a specific mention of threshold estimates as conservation or management targets (Source: van der Hoek *et al.* 2015).

Country	Title	Excerpt
Canada	Implementing Ecosystem-based Management Approaches in Canada's Forests. A Science-Policy Dialogue (McAfee and Malouin, 2008)	''A less than 30% deviation [from the range of natural variation] is low risk and a greater than 70% deviation is high risk. These figures (30% and 70%) were chosen because some research has shown that habitat supply thresholds around 30% and 70%.''
Canada	How much Habitat is Enough? (Environment Canada, 2013)	''50% forest cover or more at the watershed scale equates to a low risk approach that is likely to support most of the potential species.''
Canada	Suggested Conservation Guidelines for the Identification of Significant Woodlands in Southern Ontario (Ontario Nature, 2004)	''Environment Canada recommends a minimum threshold of 30% forest cover. . . important to note that 30% is a minimum recommendation only. . . the most critical time for land planning and conservation appears to be when the landscape has 60%–90% of its area in natural vegetation.''
Australia	Planning guidelines for koala conservation and recovery: A guide to best planning practice (McAlpine *et al.,* 2007)	''The landscapes discussed here are typical of coastal eastern Australia and these results suggest that the amount of habitat, as a percentage of the landscape, required to sustain viable koala populations may be much higher than the commonly recognized 20%–30% for mammals and birds.''
Australia	Managing Natural Biodiversity in the Western Australian Wheatbelt: A conceptual framework (Wallace *et al.,* 2003)	''Landscapes should contain a minimum of 30% to 40% habitat to minimize the risk of population extinction.''

Table 5.36-1 Examples of policy/management focused reports and papers with a specific mention of threshold estimates as conservation or management targets (Source: van der Hoek *et al.* 2015).

Country	Title	Excerpt
United States	Conservation thresholds for land use planners (Kennedy *et al*., 2003)	''…land use planners should strive to conserve at least 20% up to 50% of the total landscape for wildlife habitat, where possible.''
United States	Conservation Recommendations for Priority Terrestrial Wildlife Species and Habitats in North Carolina (Wallace and Tarr, 2012)	''Longleaf forest patches that are at least 2000 acres are needed to maintain viable populations of many species associated with Longleaf Pine habitats.''
United States	A land managers guide to improving habitat for scarlet tanagers and other forest-interior birds (Rosenberg *et al.,* 1999)	''If a landscape block surrounding a 50-acre forest patch is mostly forested (say, 70%), then it may be much more likely to support tanagers than the same sized patch in a landscape block that is only 20% forested.''

Similarly, Yin and He (2017) mathematically modelled the effects of habitat loss on the distribution and diversity of species populations based on four metrics. Two of the metrics were landscape-based (edge length and number of patches of species distribution) and two were biodiversity-based (endemics-area relationship and half population curve for scenarios of habitat loss for conservation concern) (Yin and He 2017). Based on the modelling results, they concluded that the maximum permissible habitat loss would range between 0 and 40% depending on the pre-disturbed occupancy (or abundance) of the species (Yin and He 2017). Richmond *et al.* (2015) also found that forest bird richness declined abruptly in Ontario when only 4 to 45% of coniferous, deciduous, or mixed wood forest cover was remaining although thresholds varied among different forest types and at different spatial scales.

Use of habitat availability thresholds reflects the ability of the landscape to provide food and cover for wildlife (*i.e.,* habitat suitability and capability). Since different wildlife species will respond differently to use of suitable habitats near or adjacent to anthropogenic disturbances than to similar undisturbed habitats, the effects of direct and indirect losses on wildlife habitat (*i.e.,* habitat effectiveness) must be considered. Certain thresholds of effective habitat are needed to maintain persistence of a species population across the landscape which may reflect the areal extent of specific habitats, habitat patch size, connectivity and distribution, or measures of habitat effectiveness (*i.e.,* proportion of total habitat available that is preferred or needed) depending on the wildlife species involved.

As part of the wildlife assessment conducted for the Project, Benga used a reduction in effective habitat of 20% (*i.e.,* 80% of the effective habitat for a specific species remains with Project development) as a threshold above which wildlife VCs would decline. This threshold, which was used to assess changes in habitat availability between the Baseline Case and the Planned Development Case, was based on species-specific habitat suitability modelling conducted for

four species in the WRSA and one species in the GBRSA (Table 6.3-1, CR #9, EIA, CEAR #42). Four of the five species are at risk in Alberta and/or Canada (olive-sided flycatcher, little brown myotis, Canada lynx, and grizzly bear) while one species (American marten) is secure in Alberta. Benga acknowledges that use of habitat availability thresholds across a wide range of species is not effective since it will typically reflect the habitat requirements of generalist species that are more common and widespread than sensitive species or those species with specialist habitat needs. However, as indicated in Section 3.2.54, CR#9, (EIA, CEAR #42) "Listed species were considered to be more sensitive and therefore more likely to be affected at the population level than more stable, generalist species (Mönkkönen and Reunanen, 1999; Radford *et al.,* 2005). Therefore, threshold values were more stringent for species at risk (*i.e.,* those listed under SARA) than for valued species (*e.g.,* moose, elk)." Based on the VC selection process, habitat suitability modelling for the selected VCs, and reviews of existing information on habitat availability thresholds, the use of a 20% threshold to assess potential Project effects on habitat effectiveness for selected wildlife VCs is reasonable.

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5.37 Information Request 5.37

Grassy Mountain Coal Project – Updated Environmental Impact Assessment. Consultant Report #9 - Appendix C: Wildlife Habitat Suitability Models. (CEAR #42).

Comments from the Ktunaxa Nation Council. (CEAR #178).

Benga provided habitat suitability models for all VCs, with the exception of grizzly bear, in which a separate resource selection function suitability model was used. The modelling process involved the development of species accounts and species-specific ratings tables that summarized the status, ecology, habitat requirements, life requisites and seasonal use patterns in a given area.

Ktunaxa Nation Council (CEAR #178) expressed concerns with the limiting factors selected by Benga, providing example cases for the American marten and Canada lynx. The American marten, according to Ktunaxa Nation Council, requires snag availability for denning, suggesting that the most limiting attribute would be suitable denning sites. This view differs from Benga's selection of winter habitat availability, which they indicate was chosen as American marten are thought to be nutritionally and physiologically stressed during the winter season.

The Canada lynx, according to Ktunaxa Nation Council, occupy dens within mature or old growth stands with a high density of logs which makes habitat much more restrictive for females. Benga's selection suggest that winter is likely the most limiting period for lynx, as their survival tends to be lowest during winter periods.

a) For each of the following species listed: common nighthawk, olive-sided flycatcher, Great Gray Owl, American marten and Canada lynx, describe the selection process for determining the limiting habitat factors used within the Habitat Suitability Model.

Response:

The reviewer's comments can be addressed by the modelling approaches that were used to assess Project-related effects on wildlife. Benga acknowledges that specific habitat features such as snag availability and high densities of downed woody material are important for American marten and Canada lynx, respectively. These features, along with other habitat features important to wildlife VCs that were modelled, were implicitly considered as part of the habitat modelling approach that was used for the Project's wildlife assessment.

As indicated in Section 3.2.5.2.1 of the wildlife assessment (CR #9, EIA, CEAR #42), the habitat suitability modeling approach used was based on an 'expert opinion/literature review-based' process (referred to as habitat capability/suitability or CAPSU modelling) (RIC, 1999; Muir *et al.*, 2011) where professional biologists assigned ratings to ecological or habitat units for each species of interest based on a detailed review of literature and field data. Detailed descriptions of ecosite phases were developed and mapped for the Wildlife Local Study Area (WLSA) (CR#8, EIA) which were then combined into broader more meaningful habitat types that are typically used by wildlife. Polygon attributes such as site modifiers and structural stage codes along with existing literature and professional judgement were used to develop ratings for the CAPSU models for habitat suitability and capability. The resulting wildlife habitat mapping identified areas of the landscape that provide important life requisites (or limiting habitat factors) for a particular wildlife species. Habitat suitability ratings were considered to reflect the ability of a specific habitat type in its current condition to provide the life requisites of a species. These maps and the associated area of each category of habitat can be used to assess the location of important patches of habitat or, in the case of wildlife assessments, to determine the potential level of Project-related effects on high quality wildlife habitat.

CAPSU modelling is one of three modelling approaches often used in assessing the effects of natural resource development on wildlife (Muir *et al.*, 2011). The other two approaches include resource selection function (RSF) and habitat suitability index (HSI) modelling. RSF modelling is a more statistical based approach that provides a relative estimate of the probability that a wildlife species will use a site based the association between its presence on the landscape and selected habitat attributes (Boyce and McDonald 1999, Manly *et al.* 2002; cited in Muir *et al.* 2011). In comparison, the ability of key habitat features to provide the life requisites (*e.g.,* food and cover, factors specific to reproductive success, *etc.*) that directly affect a species' presence

and abundance are characteristic of HSI modelling (Muir *et al.* 2011). With HSI modelling, specific suitability index relationships are combined into a linear HIS such that each SI relationship links a measureable structural, compositional or spatial habitat feature (*e.g.,* herbaceous canopy cover, tree height) to species habitat suitability for a particular life requisite (Roloff and Kernohan, 1999, cited in Muir *et al.* 2011).

The CAPSU modeling approach was used for nine of the 10 VCs selected for the wildlife assessment in the WLSA (Columbia spotted frog, western toad, olive-sided flycatcher, great gray owl, American marten, Canada lynx, moose, and elk) and three of the nine species in the WRSA (Canada lynx, moose, and elk). In the case of the grizzly bear, an existing RSF model developed by the Foothills Resource Institute was used. HSI modelling was not used. The habitat descriptions that informed the seasonality and life requisites presented in Table 3.2-5 (CR#9, EIA, CEAR #42) are described below.

American Marten (winter foraging)

The results of the habitat modelling approach for marten in this EIA are consistent with its preference for mature and old-growth forests that contain snags. As described in 2.6.2 of Appendix C (CR #9, EIA, CEAR #42), the habitat requirements for marten are:

> Throughout their range, American martens are associated with coniferous forests (Koehler and Hornocker, 1977; Raine, 1983; Mowat, 2006; Kirk and Zielinski, 2009). The only exception to this is in northern Wisconsin, where martens may be associated with mature, mixed hardwood forests (Wright, 1999; Dumyahn *et al*., 2007). In the Selkirk and Purcell Mountains of southern British Columbia, Mowat (2006) found evidence of marten use in a variety of habitats, including recently logged areas, regenerating stands, dry Douglas fir forests, and subalpine forests. However, martens did display a preference for older stands with greater crown closure (Mowat, 2006). Several other studies have also indicated that martens prefer mature to old-growth, closed canopy forests (Koehler and Hornocker, 1977; Wilbert *et al*., 2000; Poole *et al*., 2004; Mowat, 2006; Kirk and Zielinski, 2009). Martens also avoid open habitats (Baldwin and Bender, 2008), and unlike fishers, will not travel across frozen lakes and rivers (Raine, 1983).
>
> The preference of martens for mature to old-growth forest is likely related to their use of structures associated with downed, dead woody material, which is likely to be more abundant in old forests. Martens frequently hunt and rest in the subnivean zone during winter (Raine, 1987; Sherburne, 1993; Wright, 1999; Wilbert *et al*., 2000), and they often access the subnivean zone around pieces of dead, woody material (Wright, 1999). They will also rest and hunt in snags and downed logs (Hargis and McCullough, 1984; Kirk and Zielinski, 2009). Wright (1999) and Baldwin and Bender (2008) found a positive association between marten use of a site and the volume of downed woody material.

Olive-sided flycatcher (summer reproduction)

As described in 2.3 of Appendix C (CR#9, EIA, CEAR #42), the habitat requirements for olive-sided flycatcher are:

> Olive-sided flycatchers prefer coniferous over deciduous forests (Kirk *et al*., 1996), and are frequently associated with forest openings and edges, especially those edges created by wetlands (FAN, 2007). They may also be associated with open forests interspersed with patches of meadow or shrub (Wright, 1997). Olive-sided flycatchers can occur in forests of varying seral stages, but appear to prefer young forests. For example, in western North America, Schiek and Song (2006) reported that they were most frequently associated with young forests (<30 years) and post-clearcut forests that contained residual live trees. In Oregon, Betts *et al*. (2010) found that olive-sided flycatchers were associated with the presence of forest patches at early seral stages, indicating the species preference for 'edge' habitat between forests at late and early seral stages. However, olive-sided flycatchers have also been found in old (>125 year) mixedwood forests (Schiek and Song 2006). Even in young forests, they require the presence of some tall trees or snags to use as foraging and singing perches. Olive-sided flycatchers in Alaska preferred dead tree snags as singing perches and require conifers for nesting, preferring to nest in live over dead conifers (Wright, 1997). Their nests are cup-shaped and are usually built on horizontal branches among a cluster of twigs and needles (Baichich and Harrison, 1997).
>
> Olive-sided flycatchers likely prefer open habitats because of their foraging technique, which requires the presence of open air space. They will typically perch and wait for prey items (flying insects) to appear, flying out to capture or attempt to capture an insect, and then returning to the same or nearby perch. Since flycatchers need openings to forage in, they are often associated with newly-burned forests (Hutto and Young, 1999), sometimes becoming more common in burned forests than in adjacent non-burned forests (Bock *et al.,* 1978; Meehan and George, 2003). Smucker *et al*. (2005) also found that olive-sided flycatcher populations increased in forest patches after a fire, particularly in patches that were burned by moderate- or high-intensity fires. Burned forests provide flycatchers with dead tree snags which are used for perching and the open air space for foraging. This implies that wildfire could be beneficial for the species. However, Meehan and George (2003) reported that the probability of nest loss for olive-sided flycatchers was higher in a burned than a non-burned site in northern California. Aerial arthropod biomass and flycatcher foraging rates were also higher in the unburned than the burned forest. Thus, while olive-sided flycatchers may be attracted to post-fire sites, lower prey availability in such sites may have a negative effect on reproduction.
>
> The olive-sided flycatcher overwinters in southern Mexico, Costa Rica, Panama, Colombia, Peru, Venezuela, northern Brazil, southeastern Brazil, and the Guianas (Willis

et al., 1993, Altman and Sallabanks, 2012). It is most abundant in the Andes of Colombia (Altman and Sallabanks, 2012). Olive-sided flycatchers typically depart their wintering grounds from the last week of March to late April. They arrive in the southern areas of their breeding grounds in mid-April to late-May and in the northern areas from mid- to late-May (Altman and Sallabanks, 2012). They begin departing their breeding grounds during early August, and by mid-late September, they are nearly absent from their breeding range. In Alberta, most sightings of olive-sided flycatchers are made from May to August, with very few birds recorded in April, September and October (FAN, 2007).

Habitat ratings were based on habitat suitability during the breeding season in the WLSA, because breeding season is the only time they are present in the WLSA. A four-class rating scheme was used to rate olive-sided flycatcher habitats with ratings based on ecosite phase, structural stage, disturbance type, and proximity to open habitat, the results of which can be seen in Table C1.1-3, and described in Section 2.3.4.1 (Appendix C, CR #9, EIA, CEAR #42).

Great Gray Owl (late spring/early summer reproduction, foraging)

As described in 2.4 of Appendix C (CR #9, EIA, CEAR #42), the habitat requirements for great gray owl are as described below:

Great gray owls prefer nest sites in forests with two or more canopy layers and with a closure of >60% (Bull and Henjum, 1990). They will nest in coniferous forests (Franklin 1988), mixedwood forests (Bull and Duncan, 1993) and deciduous forests (Oeming, 1955). They may use nests located in conifers or deciduous trees (Bull and Duncan, 1993; Stepinsky, 1997). Nests located in forests with cover for nestlings and with some broken, leaning trees present provide the best environment for great gray owl fledglings.

The forests that great gray owls nest in and hunt in often differ in structure. In Oregon, Bull and Henjum (1990) found that male great gray owls (who will feed incubating females and nestlings) preferred to hunt in forests with open understories and with 11 – 59% canopy cover. Great gray owls will also hunt in grassy meadows, bogs, fens, muskegs, and selectively and clear-cut forests (Duncan, 1997). Great gray owls tend to hunt from perches and rarely hunt from the ground or on the wing. Additionally, they tend to avoid hunting in very dense forests and areas with thick shrub cover because of their size (Duncan, 1997). During the breeding season, males tend to hunt within a few kilometers of the nest.

The areas that great gray owls use for hunting are those that provide good habitat for their prey, which tend to be voles or northern pocket gophers.

Based on the summary of gray owl ecology and key habitat requirements, nesting habitat is likely to be the most limiting resource for great gray owls in the WLSA. Thus, ecosite phases that were most likely to have suitable nesting sites were assigned the highest habitat suitability ratings.

The model assumptions are listed in Section 2.4.4.1.1 and the habitat ratings can be seen in Table C1.1-3.

Canada Lynx (winter foraging)

As described in 2.7 of Appendix C (CR #9, CEAR #42), the habitat requirements for Canada lynx are as described below:

Lynx habitat use generally corresponds to the abundance of their primary prey, the snowshoe hare (Murray *et al*., 1994; Poole *et al*., 1996). However, there appears to be a latitudinal gradient in lynx prey specialization, with southern populations supplementing their diet with additional prey species, such as red squirrels (Roth *et al*., 2007). Lynx may prefer early to mid-successional (11 – 26 years old) forests to hunt snowshoe hares during winter (Poole *et al*., 1996; Fuller *et al.,* 2006), although other studies have reported the preferential use of mature forest habitat (Squires *et al*., 2010). In the Alberta Rockies, hare densities are highest in early successional stands (Apps *et al*., 2000), and in Montana, they are highest in closed, young forests (Squires and Laurion, 2000). In Wyoming, Berg *et al*. (2012) found that high levels of horizontal cover, a multi-layered tree canopy, and a high shrub density were the best predictors of snowshoe hare density. Mature, late-seral spruce-fir forests, dense lodgepole pine forests, and multi-storied aspen-spruce-fir stands had the highest hare densities (Berg *et al*., 2012). Squires *et al*. (2010) found that, during winter, Canada lynx in western Montana preferentially hunted in mature, multilayer spruce-fir forests, while they avoided recent clear cuts and other open areas. Similar results were reported by Koehler (1990), who found that Canada lynx in south-central Washington preferred to hunt in lodgepole pine and spruce-fir forest. Snowshoe hares were most abundant in young (20-year old) lodgepole pine stands (Koehler, 1990).

Some sources suggest that mature and old-growth forests are necessary denning habitat for lynx (Westworth Associates Environmental Ltd., 2002), but this may not always be the case (Murray *et al*., 2008). Dens can be established in decaying logs, under tree root systems, and in rock crevices (Koehler and Aubry, 1994). Dense regenerating forests >20 years old provide many good denning opportunities (Koehler and Aubry, 1994; Mowat *et al*., 2000).

Winter is likely the most limiting period for lynx, as their survival tends is lowest during winter (Poole, 1994; O'Donoghue *et al*., 1995). Habitat suitability for lynx was rated for the winter period. Suitable feeding habitat is critical if Canada lynx are to persist in an

area, so suitable feeding habitat was given the highest ratings for ecosite phases in the WLSA (Table C1.1-4) and ELC land cover classes in the WRSA (Table C1.1-5). Snowshoe hare are the preferred prey of Canada lynx, so habitat that is suitable for snowshoe hares was considered suitable Canada lynx habitat. In the mountainous, southwestern part of their range, Canada lynx appear to use forests with a high degree of horizontal cover (Squires *et al*., 2010). Lynx display an aversion to open habitat (Koehler, *et al.* 2008), so sites lacking a canopy were assigned a lower habitat suitability rating than similar sites with an overstory. The winter snowshoe hare diet consists primarily of deciduous browse, such as dwarf birch, willow, and buffaloberry, although some coniferous species are occasionally used. Ecosite phases dominated by conifers and that have high amounts of woody browse were assigned the highest habitat suitability ratings. Many studies also indicate that snowshoe hares prefer conifer-dominated habitat during the winter (reviewed by Hoover *et al*., 1999).

Common Nighthawk – This species was one of 8 species of special concern, and as such, has a high level assessment conducted that did not include Habitat Suitability Modeling.

b) Discuss the role Indigenous community and Traditional Knowledge played in determining the limiting habitat factors within the Habitat Suitability Model.

Response:

Input from Indigenous groups was solicited and received regarding species of traditional importance and the selection of VCs that would be used for modelling. As indicated in the response to part a), the key life requisites, such as availability of suitable denning sites for American marten and the presence of high densities of logs in forest stands for the Canada lynx, along with other habitat features important to the other wildlife VCs selected for, are reflected in the CAPSU modelling approach that was used for the wildlife assessment.

Based on the information provided in the TK/TU reports submitted to Benga, available information regarding important or valued components of the social and physical environment associated with Grassy Mountain was interwoven into the EIA. This information was used to ensure the identification and development of discipline-specific valued components (VCs) (*i.e.,* wildlife and vegetation), definition of assessment of spatial and temporal boundaries, collection of baseline information, identification of potential effects and the development of proposed mitigation and monitoring. This information was woven throughout this document as relevant to the assessment.

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5.38 Information Request 5.38

Grassy Mountain Coal Project – Updated Environmental Impact Assessment. Consultant Report #9 – Wildlife. (CEAR #42).

Comments from the Timberwolf Wilderness Society. (CEAR #156).

Comments from the Canadian Parks and Wilderness Society - Southern Alberta Chapter. (CEAR #176).

In Consultant Report #9 (CEAR #42), Benga provides thresholds related to habitat loss and fragmentation related to linear features, as well as the associated increase in human activity, increasing the risk of wildlife mortality. Table 3.2-9 suggests that road densities >2.4 km/km^2 are high risk to grizzly bear persistence and therefore high impact, while road densities between 0.6-2.4 km/km^2 were considered to be of moderate risk. This coupled with other risk factors, such as low population numbers, low reproductive potential and the expected planned development were also considered.

To mitigate this risk, Benga suggests mitigation measures such as commencing early reclamation with species favourable to grizzly bear forage and species that provide suitable cover (CEAR #42).

Given the federal and provincial status of grizzly bears and their need for movement between patches of habitat to ensure their ecological needs are met, CPAWS (CEAR #176) noted that the construction and operation of an open pit mine at this location has potential to remove a significant amount of habitat. CPAWS states that most research suggests that open road density of 0.6 km/km^2 is a rough threshold above which female grizzly bears may have unsustainable survival rates or levels of habitat avoidance and such areas become population sinks.

Timberwolf Wilderness Society (CEAR #156) states that "the amount of road development in particular (documented by Sawyer *et al.* 1997, Farr *et al.* 2018, among others), a good proxy for human development, has been far above known ecological thresholds (e.g., Lamb *et al.* 2018)." Timberwolf Wilderness Society further notes that "Many of the signs point to ecological limits for this species that have already been crossed and that the impacts need to be greatly reduced to enable the population to recover from their current status within Alberta. The large mine site development can be expected to reduce key habitat and further fragment the bear populations in this region, restricting movements and breeding still more."

a) Provide additional details with supporting literature and research on why 0.6-2.4 km/km^2 is considered moderate risk for grizzly bears.

Response:

Benga notes that there is an error in the Road Density ranges contained in Section 3.2.5.4.3 and paragraph of Section 4.4.8.3, CR#9, EIA (CEAR #42). This error does not change the conclusions drawn in this Section of CR#9. These sections of the EIA have been updated as follows (additions in underline and deletions in ~~strikethrough~~):

3.2.5.4.3 Changes in Wildlife Mortality Risk and Health

"Habitat loss and fragmentation related to linear features, as well as the increased human activity that often accompanies them, can increase the risk of wildlife mortality. Road densities >~~2.4~~ 0.75 km/km^2 were considered to be of high risk to grizzly bear persistence (Table 5.38-1), and therefore of high impact, particularly when in combination with other risk factors such as low population numbers, low reproductive potential, and the expected degree of planned development. All road types were included in calculating disturbance feature densities. Road densities were expressed as km/km^2 within the WLSA, WRSA and GBRSA for each assessment scenario. Wildlife health was assessed on the basis of the air quality assessment (CR #1 – Air Quality) and a screening level wildlife risk assessment (CR #12 – Human Health and Wildlife Screening)."

Table 5.38-1 Mortality Risk Ratings for Grizzly Bear in Relation to Road Density	
Risk Rating	**Road Density**
High	>~~2.4~~ 0.75 km/km²
Moderate	0.6 – ~~2.4~~ 0.75 km/km²
Low	<0.6 km/km²

4.4.8.3 Mortality Risk

"Grizzly bear mortality risk has been correlated with the density of anthropogenic linear features, which act to improve human access and increase the likelihood of grizzly bear encounters with humans (Boulanger and Stenhouse, 2014). Grizzly bear habitat security has been found to decline when road density approaches a critical threshold of ~~2.4~~ 0.6 km/km² (Salmo and Diversified, 2003; Hamilton and Austin, 2004; Nielsen *et al.,* 2009). Boulanger and Stenhouse (2014) suggest that maintaining a 0.75 km/km² road density threshold will be required to ensure viable grizzly bear populations in Alberta. Under baseline conditions, the density of roads in the WLSA is 0.88 km/km², which exceeds the threshold defined by Boulanger and Stenhouse (2014). This suggests that the grizzly bear population in the WLSA may not be capable of supporting a viable grizzly bear population under baseline conditions. The density of roads in the GBRSA was below any of the key established thresholds for road density outlined above (0.53 km/km²) at baseline, suggesting that the GBRSA provides adequate habitat security and has the potential to support a viable grizzly bear population."

Aside from this incorrect information, Benga directs the reviewer to section 5.3.8.3 (CR#9, EIA, CEAA Doc #42) where it outlines expected Project effects on road densities. A portion of that section has been repeated here for the convenience of the reader.

"Over the life of the Project, road densities in the WLSA are estimated to decline from Baseline conditions (0.88 km/km²) to 0.69 km/km² at Year 14 and 0.61 km/km² at Year 27. Grizzly bear habitat security can be maintained at road densities less than 0.6 km/km² (Salmo and Diversified, 2003; Hamilton and Austin, 2004; Nielsen *et al.,* 2009), while a maximum road density of 0.75 km/km² is required to ensure population viability (Boulanger and Stenhouse, 2014). The Project occurs within a core grizzly bear zone within which AEP has specified that open road density is to be kept below 0.6 km/km² (AEP, 2016a). Through progressive reclamation and appropriate end-of-mine land use planning, road densities in the WLSA can be maintained at levels approximating 0.6 km/km² which should maintain habitat security and population viability (AEP, 2016a). If road densities exceed 0.6 km/km² following reclamation, additional decommissioning of

roads is recommended by AEP (2016a). Road densities in the GBRSA are not expected to be affected by Project development. The density of roads in the GBRSA was below any of the key established thresholds for road density outlined above at Baseline (0.53 km/km^2)."

More recent information confirms that a road density of 0.6 km/km^2 is a critical threshold at which point bear densities are affected in many jurisdictions including Alberta although access management can be a viable mitigation strategy (Lamb *et al*. 2018). They further note however, that it is important to maintain large roadless areas (*e.g.,* secure high quality habitat located >500m from roads) (Lamb *et al.* 2018).

b) Provide the road densities predicted in the GBRSA over the life of the mine, taking into consideration any planned progressive reclamation.

Response:

The Project is predicted to result in decreased road density in the LSA by the end of mine at year 27.

Road densities in the GBRSA are not expected to be affected by Project development. The density of roads in the GBRSA was below any of the key established threshold for any of the road densities outlined above at Baseline (0.53 km/km^2). Over the life of mine, road densities are predicted to decrease from 0.88 at Baseline to 0.69 km/km^2 at year 14 and to 0.61 km/km^2 at year 27 in the WLSA. Therefore, the Project is not expected to result in any increase in road density in the GBRSA.

c) Provide examples of where surface coal or other mines, after reclamation efforts, have created suitable grizzly bear habitat in terms of forage and species that provide suitable cover. Include examples of other mines that have used progressive reclamation to mitigate effects to grizzly bear habitat.

Response:

Benga directs the reviewer to Section 5.3.8.1 (CR#9, EIA, CEAA Doc #42) where this question has been addressed. As per this comment in CEAA Doc #156, the reviewer only cites the updated cumulative effects assessment in Addendum 8; the full EIA, especially CR#9, should be read to fully understand the effects of the Project on wildlife. CR#9 provides all the background, context and methodologies upon which the cumulative effects assessment was based. The relevant information from Section 5.3.8.1 has been presented here for the convenience of the reader, along with some additional information on Coal Valley Mine.

"Progressive reclamation is the key mitigation measure and will return the Project footprint to conditions similar to a new harvest cutblock or an open landscape resembling grassland [Conservation and Reclamation Plan (Appendix 2.6-1 in response to JRP IR-2.6)]. Reclaimed grasslands are typically dominated by non-native vegetation

and low plant species richness (Cristescu *et al.,* 2012). Habitat states and RSF values for grizzly bears typically increase in mine reclamation and timber harvest scenarios, because of the increase in forage availability when older, closed-canopy stands or non-critical habitats (*i.e.,* barren rock) are replaced by younger regenerating stands and energetic herbaceous plant material (*e.g.,* clover, thistle) (FRIGBP, 2012; Cristescu *et al.,* 2012). Grizzly bears have been well-documented in their utilization of reclaimed mine areas in Alberta. Reclaimed mines can provide suitable habitat and forage for grizzly bears, particularly during the summer (Cristescu *et al.,* 2012). For instance, the reclaimed Luscar and Gregg River coal mines (which are comparable to the Project) in west-central Alberta have been found to act as primary source habitats for grizzly bears, with high rates of juvenile recruitment into the population and heavier adult bears compared to adjacent areas (Cristescu *et al.,* 2012). Grizzly bears are often heavier in reclaimed mine areas as a result of increased ungulate consumption (Kansas, 2005; Cristescu *et al.,* 2012). Reclaimed mines have been found to support larger populations of ungulates, such as deer and elk, because of the concentrated high-energy forage provided through mine reclamation (BWT, 2010).

The Luscar and Gregg River coal mines were primarily reclaimed to grassland (clover, alfalfa, milkvetch, dandelion, and graminoids) and forest habitats (Cristescu *et al.,* 2012). Pit walls were terraced and several undisturbed areas (*i.e.,* forest islands) were retained during active mining. Hab-Tech Environmental Ltd (2012) states that mine reclamation to grassland and regenerating forest habitat types can be expected to have positive effects on grizzly bear habitat availability within 10 years. Similar reclamation measures will be implemented by Benga, and the RSF and Habitat States modelling results suggest that Project effects on grizzly bears from a habitat alteration perspective will be positive following reclamation (Section 5.3.8.1, CR#9, EIA, CEAR #42)"

The Coal Valley Mine provides an additional example where suitable grizzly bear habitat exists after reclamation is completed. As part of the assessment of mining on grizzly bears for the Robb Trend Project, Hab-Tech Environmental Ltd (2012) stated:

4.5.2 Regional Study Area Habitat Suitability and Supply

"Resource selection function (RSF) mapping for grizzly bears was obtained from FRIGBP (2010 Deliverables). This product combines land cover mapping with GPS locations resulting in maps of the seasonal probability of occurrence of grizzly bears. Map grid cells are rated between 1 (lowest) and 10 (highest) in terms of probability of grizzly bear occurrence. Average RSF values were calculated for the 10 BMUs in the RSA and for each of three seasons. Average ratings were also calculated for: the RSA as a whole; the Project mine permit area; the Project footprint area; and, the existing CVM permit area (Table 5.38-2 (formerly Table 23 in CEAR #42)).

Table 5.38-2 Average Seasonal Resource Selection Function Values by Bear Management Unit and Local Study Area

BMU/LSA/RSA	Spring RSF	Summer RSF	Fall RSF
Beaverdam	7.9	7.6	7.7
Embarras	7.0	6.5	6.5
Erith	4.7	4.7	4.7
Lambert	4.7	4.7	4.8
Lendrum	7.4	6.8	6.9
Lower Pembina	7.9	7.3	7.3
McLeod	8.2	7.5	7.4
McPherson	7.9	7.4	7.4
Raven	5.2	4.9	5.0
Upper Pembina	8.1	7.6	7.6
Entire RSA	6.9	6.5	6.9
Robb Trend LSA	7.2	6.8	6.9
Coal Valley Mine Permit	8.4	8.0	8.0

It is clear from Figure 9, 10 and 11 and verified in Table 5.38-2 that BMUs located in the eastern portion of the RSA (*i.e.,* Erith, Lambert, Raven) support lower average RSF values than other BMUs for all seasons. BMUs located along the higher elevation western border of the RSA (Upper Pembina, Beaverdam, McLeod) had the highest grizzly bear RSF ratings for all three seasons.

4.5.3 Local Study Area Habitat Suitability and Supply

The Project LSA occurs in the Lendrum and Embarras BMUs. These two BMUs support average to low RSF values in a regional context (Table 5.38-2). The Project mine permit area had RSF values that were higher than the regional average for spring and summer and the same for fall. The existing CVM permit area had the highest average RSF values for all seasons notwithstanding active mining taking place during the sampling period.

4.5.4 Grizzly Bear Use of Existing Coal Valley Mine

A total of 16 grizzly bears (8F:8M) were located 962 times within the CVM permit area between 1999 and 2005. Seven (7) of these animals spent time in the permit area for more than one year with one bear spending 4 years, two bears for 3 years and four bears for 2 years. Kansas and Charlebois (2008) reported that of the 16 bears recorded within the CVM permit area from 1999 to 2005, 13 bears spent time (170 locations) within the

boundaries of the CVM mine footprint – most of this in the reclaimed areas. Two bears – one adult male and one adult female-spent three and four years respectively on the CVM mine footprint. The CVM permit area supports one of the highest number of grizzly bear locations (6.2) per km^2 and was utilized by a large number of different bears relative to its small size. Kansas (2005) and Stevens and Duval (2005) reported a similar attraction of grizzly bears to the reclaimed Gregg River/Luscar mine block."

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5.39 Information Request 5.39

Grassy Mountain Coal Project – Updated Environmental Impact Assessment. Consultant Report #9 – Wildlife. (CEAR #42).

Comments from the Coalition of Alberta Wilderness Association and Grassy Mountain Group, and Shirley Kirby. (CEAR #164).

Comments from the Canadian Parks and Wilderness Society - Southern Alberta Chapter. (CEAR #176).

Comments from the Ktunaxa Nation Council. (CEAR #178).

Comments from the Tsuut'ina Nation. (CEAR #192).

Proposed mitigation measures for wildlife are discussed in various sections throughout the updated EIA and referenced within the various addenda. In Consultant Report #9 (CEAR #42), Benga provides a Wildlife Mitigation and Monitoring Section in which Benga proposes mitigation measures and wildlife monitoring programs designed to reduce or minimize the effects of the Project on wildlife and to monitor the effects of the Project to allow for effective adaptive management of mitigation measure over time. Benga states that they will be implementing a number of best management practices, Project design features and other measures to avoid or minimize effects. Throughout the EIA, Benga also refers to, and depends on, the ability to reclaim the landscape at closure as a means to mitigate effects on wildlife.

Several Indigenous communities and stakeholders have expressed concern regarding the efficacy of mitigation measures throughout the life of the Project and the reliance on reclamation at closure to reduce impacts to wildlife (CEAR #164, #176, #178, and #192).

The Panel requires further information to better understand Benga's proposed mitigation measures for wildlife and to assess the effectiveness of these measures. The Panel also requires an understanding of the adaptive management measures that will be adopted if the proposed mitigation measures do not perform as anticipated.

a) Based on the previous information provided by Benga, provide a draft Wildlife Mitigation and Monitoring Plan. Describe the components of the plan including, but not limited to:

   i. a clear statement of the mitigation and monitoring plan objective(s) and scope, spatial and temporal extent at each stage of the life of the Project;

   ii. a list of target species or surrogate species and habitat types to be monitored, including those identified by Indigenous groups;

   iii. an outline of mitigation measures for each species and habitat, including any proposed offsets;

   iv. identification of indicators that will be monitored to determine whether mitigation measures are effective and how identified indicators will be monitored;

v. a description of the strategies and actions that will be implemented, adhering to the mitigation hierarchy of avoid, minimize, restore, and offset, to mitigate project and site- specific effects on wildlife species at risk and of cultural significance throughout the life of the Project that may occur through:
   - direct habitat loss;
   - indirect habitat loss;
   - habitat fragmentation and effects on wildlife movement; and
   - mortality;

vi. identification and discussion of any Project-specific mitigation measures that may have a positive impact on wildlife including any details of proposed conservation offsets.

vii. a description of uncertainties that may necessitate the use of adaptive management;

viii. thresholds that monitoring results will be compared to that will trigger implementation of adaptive management or alternative mitigation measures;

ix. a description of the adaptive management approach that will be used to assess and improve the effectiveness of mitigations; and

x. to the extent possible, a description of how, when and where mitigation measures will be implemented including details on leading methodologies used and their supporting literature or research.

Response:

A draft Wildlife Mitigation and Monitoring Plan has been prepared and is presented as Appendix 5.39-1.

5.40 Information Request 5.40

Comments from the Ktunaxa Nation Council. (CEAR #178).

Ktunaxa Nation Rights and Interests Study in relation to the Grassy Mountain Coal Project. (CEAR #189).

Government of Alberta: Status of the America Bison (*Bison bison)* in Alberta: Update 2017. Alberta Wildlife Status Report No. 38[11].

Ktunaxa Nation Council (CEAR #178, #189) state that the plains bison is of critical cultural and ecological importance to the past and future practice of Ktunaxa Nation rights in the Project area and eastern slopes of the Rockies. While bison are currently extirpated and habitat in the area of the Project is currently vacant, return of plains bison, and Ktunaxa harvest of bison in the Project area is planned and reasonably foreseeable. Indigenous groups have stated that the historical exploitation of the buffalo, relocation by agriculture settlement and other anthropogenic developments have reduced or eliminated the current buffalo populations in some areas. The Ktunaxa Nation, along with the

11 Available online: https://open.alberta.ca/publications/9781460140901

Piikani Nation, and a number of other Indigenous groups are signatories to the Buffalo Treaty: A Treaty for Cooperation, Renewal, and Restoration. Ktunaxa Nation Council indicates that the "plains bison is of critical cultural and ecological importance to the past and future practice of KNC [Ktunaxa Nation Council] rights in the Project area and eastern slopes of the Rockies" and that the "Project is located within an area that is critical to restoration plans and as a signatory to the treaty, the Ktunaxa Nation wishes to ensure the Project provides a reasonable assessment of impacts on bison habitat suitability and capability, that it provides reliable habitat offsetting supportive of bison for the duration of Project impacts, and that end land use goals are clearly supportive of long term future habitat restoration for bison and Ktunaxa harvest in the area" (CEAR #178). The Ktunaxa Nation notes that the assessment currently fails to take into consideration potential effects of the proposed Project on bison habitat and bison recovery, particularly in light of the proximity of reintroduced bison in the National Parks, the potential for range expansion into the Project area, and plans under the modern Buffalo Treaty.

The Government of Alberta states that the future prospects for restoration and recovery of free-ranging plains bison on its original range within southern and central Alberta are limited by the amount of available intact grassland habitats in today's predominantly anthropogenic landscape. A majority of the Plains bison (95%) occur within the Elk Island National Park and recent initiatives have taken place by Parks Canada to reintroduce Plains bison to Banff National Park (2017). To further ecologically restore Plains bison, large native prairies that can support the far-ranging bison are needed. Additionally, recent studies have shown the importance of understanding the mechanistic role of bison foraging behaviour to better predict distribution and habitat use. In general, the most important habitats for plain bison are prairie grasslands and open meadow habitat types. Although potentially successful, the recovery of free- ranging bison will vary with the spatial scale and long-term productivity and availability of reclaimed habitat.

a) Provide an assessment of Project impacts on plains bison habitat suitability and capability within the WLSA.

    i. include an explanation of whether, at present, the LSA presents suitable habitat for the Plains bison and their potential migration.

Response:

As discussed in the response to JRP IR-4.2 b), Bison were reduced from numbering in the millions to some hundreds of individuals by the end of the 1800s and have not been present in the Crowsnest Pass area of the Project in recent memory. In their paper "Reintroduction of Bison into the Rocky Mountain Parks of Canada: Historical and Archaeological Evidence", Kay and White establish that bison were not only present on the plains but also in mountainous areas of the eastern slopes of the Rocky Mountains and quite likely were present at some time in the Crowsnest Pass and the Project area.

Kay and White found, however, that it is unlikely that bison herds in mountainous areas could have survived without a direct connection and constant replenishment from the larger herds found on the prairies. They found that " *... unless constantly replenished with animals from the plains, it is unlikely that bison could have maintained viable populations in the mountains*" and concluded that "*Some bison may have summered in the mountains, but non-migratory animals would have been under intense predation by Native Americans, wolves, and bears."* In other words, the Project site may have been a site where bison could be found but would not be an ideal location to attempt to re-establish the species without a connection to a significant herd on the adjacent plains.

As noted in the response to JRP IR-4.2 b), in 2017, Parks Canada reintroduced a small herd of plains bison to Banff National Park as a pilot project to assess the feasibility of longer-term bison restoration in the area. This five-year project provides a focal point for Parks Canada to work collaboratively with Indigenous people while beginning to restore the roles of bison in the ecosystem. Currently, plains bison occur in only five isolated wild subpopulations and occupy less than 0.5% of their original range in Canada.

According to Alberta Environment and Parks and Alberta Conservation Association (2017):

> "In general, the most important habitats for plains bison are prairie grasslands and open meadow habitat types. If available, forested areas are used to varying degrees for escape and thermal cover, as well as for calving. Prior to European contact, plains bison in the Northern Great Plains portion of present-day southern Alberta occupied the Grasslands Natural Region throughout spring, summer and fall, moving into forested areas of the Central Parkland, Foothills Parkland, and Foothills Fescue natural subregions in winter. The parkland and montane regions of southwestern Alberta were considered to be part of the winter range of plains bison, subject to grazing primarily during the dormant season. Foothills fescue grasslands had likely provided fall forage at a time when summer range was declining in nutritional value. The dormant grasslands would have also provided access to substantial forage in winter and early spring, given occasional chinooks in these areas.
>
> The seasonal movements and migrations of bison were likely localized and flexible, with substantial inter-annual variation as a result of seasonal rainfall patterns, drought, prairie fires, localized overgrazing, blizzards and human hunting pressures. It was also likely that bison occupied higher elevation, mountainous ranges in southwestern Alberta in summer and fall, moving to lower elevation grasslands and floodplains in the Waterton and Crowsnest valleys in winter."

Since bison are ruminant herbivores (*i.e.,* cud-chewers) and are a primary grazer of coarse grasses and sedges, there is some potential for habitats within the WLSA to support bison. As a preferred forage species for bison, foothills rough fescue occupies 218.9 ha (Table 3.3-3, CR#8,

EIA, CEAR #42) or 3.9% of the WLSA based on an assessment of rangeland resources conducted for the Project. On a wildlife habitat basis, however, the WLSA contains slightly more suitable habitat for plains bison (432.7 ha or 7.7%). An additional 39.9% (2,253.8 ha) of the WLSA could provide potentially suitable habitats (Table 5.40-1) for bison based on the presence of other forage species such as hairy wild rye, pine grass and sedges (CR#8, Appendix C, EIA, CEAR #42). While the Project does not occur within the Central Parkland, Foothills Parkland, and Foothills Fescue Natural Subregions where plains bison have historically ranged, it does fall within the Montane Natural Subregion which was considered to be part of the plains bison winter range. Therefore, the WLSA could potentially provide some winter habitat for plains bison if a reintroduction program was successful.

Table 5.40-1 Wildlife Habitat Types and Ecosite Phases Present in the Wildlife Local Study Area

Habitat Type	Ecosite Phase	Natural Subregion	Ecological Site Description	Area	
				Total (ha)	% of Total
Open Pine	*a1*	*MN*	*Limber pine/Juniper* [1]	*57.1*	*1.0*
	a1	SA	Lichen/Lodgepole pine	20.3	0.4
	b1	***MN***	***Bearberry/Lodgepole pine*** [2]	***313.2***	***5.5***
	b1	SA	Bearberry-hairy wild rye/Lodgepole pine	126.0	2.2
Subtotal Open Pine				**516.7**	**9.2**
Open Deciduous	*b2*	*MN*	*Bearberry/Aspen*	*22.5*	*0.4*
	c3	*MN*	*Canada buffaloberry - hairy wild rye/Aspen*	*29.1*	*0.5*
Subtotal Open Deciduous				**51.6**	**0.9**
Open Mixedwood	*b3*	*MN*	*Bearberry/Aspen-white spruce-lodgepole pine*	*34.8*	*0.6*
	c4	*MN*	*Canada buffaloberry-hairy wild rye/Aspen, white spruce, lodgepole pine, Douglas fir*	*256.4*	*4.5*
Subtotal Open Mixedwood				**291.2**	**5.2**
Open Mixed Coniferous	*c1*	*MN*	*Canada buffaloberry-hairy wild rye/Douglas fir*	*228.2*	*4.0*
	c2	*MN*	*Canada buffaloberry-hairy wild rye/Lodgepole pine*	*212.3*	*3.8*
Subtotal Open Mixed Coniferous				**440.5**	**7.8**
Moderate Mixed Coniferous	e1	SA	False azalea-grouseberry/Lodgepole pine	1,127.9	20.0
	e3	SA	False azalea-grouseberry/Engelmann spruce	**220.2**	**3.9**
	e4	SA	False azalea-grouseberry/Subalpine fir	27.7	0.5
Subtotal Moderate Mixed Coniferous				**1,375.8**	**24.4**

Table 5.40-1 Wildlife Habitat Types and Ecosite Phases Present in the Wildlife Local Study Area

Habitat Type	Ecosite Phase	Natural Subregion	Ecological Site Description	Area	
				Total (ha)	% of Total
Closed Deciduous	**f1**	**MN**	**Balsam poplar**	**27.6**	**0.5**
Closed Mixedwood	*d1*	*MN*	*Creeping mahonia-white meadowsweet/ Douglas fir*	*121.0*	*2.1*
	d2	*MN*	*Creeping mahonia-white meadowsweet/Lodgepole pine*	*659.0*	*11.7*
	e2	*MN*	*Thimbleberry-pine grass/Aspen*	*95.2*	*1.7*
	e3	*MN*	*Thimbleberry-pine grass/White spruce*	*115.9*	*2.1*
Subtotal Closed Mixedwood				**991.2**	**17.6**
Closed Spruce	g1	MN	Horsetail/White spruce-balsam poplar	49.4	0.9
	g2	MN	Horsetail/White Spruce	20.6	0.4
	h1	SA	Horsetail/Engelmann spruce	9.3	0.2
Subtotal Closed Spruce				**79.4**	**1.4**
Closed Mixed Coniferous	d3	MN	Creeping mahonia-white meadowsweet/White spruce	11.6	0.2
	e1	*MN*	*Thimbleberry-pine grass/Lodgepole pine*	*319.8*	*5.7*
	f1	SA	Thimbleberry/Lodgepole pine	56.8	1.0
	f2	SA	Thimbleberry/Subalpine fir-Engelmann spruce	31.4	0.6
Subtotal Closed Mixed Coniferous				**419.5**	**7.4**
Grassland	***HG***	***MN***	***Natural grassland[2]***	***119.5***	***2.1***
	HG	SA	Natural grassland	170.8	3.0
Subtotal Grassland				**290.3**	**5.1**
Upland Shrub	**SC**	**MN**	**Closed shrubland**	**0.2**	**0.0**
Shrubby Wetland	FONS	MN	Shrubby fen	17.6	0.3
	SO	MN	Open shrubland	0.3	0.01
Subtotal Shrubby Wetland				**17.9**	**0.3**
Treed Wetland	**STNN**	**MN**	**Wooded swamp**	**4.8**	**0.1**
Rock Barren	**NMR**	**-**	**Talus slope, rock slide**	**48.6**	**0.9**
Waterbody	**NWF, NWL, NWR**	**-**	**Rivers, lakes, and flooded areas**	**63.9**	**1.1**
Anthropogenic Disturbance	AIF	-	Farmstead	2.2	0.0
	AIH	-	Permanent rights-of-way (roads, highways, rail)	124.8	2.2
	AII	-	Industrial (*e.g.,* plant sites)	0.2	0.0
	AIM	-	Historical surface mines	165.2	2.9
	ASC	-	Cities, towns, villages, hamlets	180.4	3.2

Table 5.40-1 Wildlife Habitat Types and Ecosite Phases Present in the Wildlife Local Study Area					
Habitat Type	**Ecosite Phase**	**Natural Subregion**	**Ecological Site Description**	**Area**	
				Total (ha)	**% of Total**
	CC	-	Clearcut	239.7	4.2
	CIP	-	*Pipelines/transmission lines seeded to grass*	*47.9*	*0.8*
	CIW	-	*Geophysical activities/well sites seeded grass*	*17.3*	*0.3*
	CL, CO	-	Clearing	212.4	3.8
	CP	-	*Perennial forage crop (agriculture)*	*37.3*	*0.7*
Subtotal Anthropogenic Disturbance				**1,027.3**	**18.2**
Total				**5,646.4**	**100.0**

[1] Potentially suitable bison habitat in italics. [2] Suitable bison habitat indicated in bold and italics).

Source: Table 2.4-1, CR #8, EIA, CEAR #42

References:

Alberta Environment and Parks and Alberta Conservation Association. 2017. Status of the America Bison (*Bison bison)* in Alberta: Update 2017. Alberta Environment and Parks. Alberta Wildlife Status Report No. 38 (Update 2017). Edmonton, Alberta, Canada.

Kay, Charles E.; Clifford A. White (2001). "Reintroduction of bison into the Rocky Mountain parks of Canada: historical and archaeological evidence" (PDF). Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands. Hancock, Michigan: The George Wright Society, Inc. pp. 143–151. www.georgewright.org/24kay.pdf .

b) Discuss whether or how the Project impact may affect the objectives of the Buffalo Treaty.

Response:

The objectives as described in the Buffalo Treaty include:

- the desire to have plains bison live as a free-ranging animal amongst the people of the signed nations once again;
- the commitment of the signed nations to everything within their means to ensure the return of plains bison;
- to provide a safe space and environment for the plains bison to exist across the nations homelands (in both Canada and the Unites States);
- to preserve the cultural heritage of the plains bison and their relationship with the signed nations; and

- to ensure the continuation of co-existence with plains bison for future generations.

As discussed in JRP IR-4.2 b), Benga has committed to work with Ktunaxa and other Indigenous groups to ensure that Indigenous goals are effectively incorporated in the reclamation planning process and would consider inclusion of measures specific to a possible re-establishment of bison to the area. This could include, for example, an Indigenous-led assessment of the potential carrying capacity of the land to support quality bison habitat essential for successful future reintroduction of the species. The Project is not expected to adversely affect the objectives established for the Buffalo Treaty.

c) Describe the potential of the Project area to support plains bison habitat and habitat connectivity.

Response:

As outlined in the updated conceptual Conservation and Reclamation Plan (Appendix 2.6-1, JRP IR-2.6), the Project will be undergoing progressive reclamation throughout the life of the mine. This progressive reclamation will include a re-vegetation program that will aim to establish a diverse range of plant species at the start of reclamation to increase the potential of achieving a biodiversity level equivalent to pre-development conditions. Vegetation communities are expected to evolve into a biologically diverse forest suitable for commercial forest harvesting, traditional land uses, wildlife and recreational uses. Natural processes and succession will augment the vegetation program and will provide the framework for the revegetated areas to evolve into ecosystems similar to those naturally present in the region.

A comparison of pre-disturbance and post-reclamation ecological units (EU) cover across the Project footprint was provided in Table F.4.3-1 of the C&R Plan (Appendix 2.6-1, JRP IR-2.6). This table shows that post-reclamation area for the Grassland Open Forest EU will increase from 160 ha to 276.7 ha, and the % relative cover will increase from 10.5% to 18.2%. As plains bison rely primarily on grasslands and open meadows habitat types, the potential for the Project area to support bison habitat will be similar once reclamation and closure for the Project have been completed.

d) Summarize the outcomes of any discussions Benga has had with Indigenous groups or relevant government agencies regarding future prospects for restoration and recovery of free-ranging plains bison in the project area.

Response:

Please see response to JRP IR-5.40 b).

LAND USE AND EA METHODOLOGY

5.41 Information Request 5.41

Eighth Addendum to the Environmental Impact Assessment. Appendix A-1, Table 2-1 and Figure 2-2. (CEAR #89).

In Appendix A-1 in Addendum 8 (CEAR #89) Benga provided Figure 2-2 to illustrate "Existing and Planned Projects within the Vicinity of the Proposed Project". No such figure was provided to illustrate the past activities listed in Table 2-1.

A visual representation of past projects in the Grizzly Bear Regional Study Area would be helpful to the Panel and participants in their review of the environmental assessment.

Provide a figure similar to Figure 2-2 in Appendix A-1 in Addendum 8 (CEAR #89) to illustrate the extent of past projects and activities considered in the cumulative environmental assessment for the Project.

Response:

Many of the past and existing activities considered in the cumulative effects assessment (as listed in Table 2-1 of the Cumulative Effects Assessment, Appendix A-1, Addendum 8, CEAR #89) were already on the Figure 2-2 (Appendix A-1, Addendum 8, CEAR #89), however the labelling did not allow for easy identification.

The following clarifications or additions have been made to Figure 2-2, presented here as Figure 5.41-1.

- Historic mining was already included and labeled on the Figure 2-2;
- Teck Coal Mountain was included on the Figure 2-2 as an existing disturbance, shaded in grey. It has now been highlighted and labeled on Figure 5.41-1;
- Teck Elkview and Baldy Ridge Expansion were already on Figure 2-2. The Baldy Ridge Expansion took place on the same footprint as Teck Elkview. This label has been clarified on Figure 5.41-1;
- Existing Crown timber operations were on Figure 2-2 labeled in grey as an existing disturbance. The methodology for how these disturbed areas were calculated and categorized was described in CR#8, Section 2.2.1 (EIA, CEAR #42);
- Past or existing wells or compressor stations were on Figure 2-2. They have now been labeled on Figure 5.41-1 to enable individual identification;
- Roads and trails were already on Figure 2-2, labeled in grey as an existing disturbance.
- The communities listed in the MDs of Crowsnest Pass, Ranchlands, and Pincher Creek were already on Figure 2-2;
- The Alberta Transportation roadways and CP rail lines were already on Figure 2-2. The rail line has been added to the legend on Figure 5.41-1;

- The recreation sites of Lost Lemon Campground, Pass Powderkeg Ski Resort, and Crowsnest Community Trails have been added to Figure 5.41-1;
- The existing and proposed sites of the Crowsnest Golf and Country Club have been added to Figure 5.41-1; and
- The existing water supply dam on Gold Creek has been added to Figure 5.41-1.

5.42 Information Request 5.42

Final Environmental Impact Statement Guidelines. Sections 1.4, 3.1, 4.3, 6.5, 6.6.3, 8.1. (CEAR #11).

Eighth Addendum to the Environmental Impact Assessment. Section E - Environmental Assessment. (CEAR #89).

Eighth Addendum to the Environmental Impact Assessment. EIA Section F - Conservation and Reclamation Plan. (CEAR #89).

Eighth Addendum to the Environmental Impact Assessment. Appendix A-1. (CEAR #89).

Comments from the Coalition of Alberta Wilderness Association and Grassy Mountain Group, and Shirley Kirby ("the Coalition"). (CEAR #164).

Comments from the Canadian Parks and Wilderness Society – Southern Alberta Chapter. (CEAR #176).

Comments from JFK Law Corporation on behalf of Káinai First Nation. (CEAR #184).

In the EIA and addenda, Benga mentions the South Saskatchewan Regional Plan and integrated resources plans that were considered in the assessment of effects, under Sections E.10 and F.1.6 in the EIA (CEAR #42), Sections 4.2 and 5.3 of Consultant Report #10 (CEAR #42), and section 8.1 in Addendum 8 (CEAR #89). The information contained in these sections discusses the relevant objectives and principles from these plans that were taken into consideration in the closure and reclamation plan for the land use and resources, the land and resource use assessment, and the alignment of the proposed Project with the development objectives for the region.

The Káinai First Nation (CEAR #184), the Coalition (CEAR #164), and the Canadian Parks and Wilderness Society's Southern Alberta Chapter (CEAR #176), questioned how applicable regional land use plans were taken into account in the assessment of effects on valued components, beyond what is discussed by Benga in the EIA and its addenda.

For example, the Káinai First Nation requested further information on how existing land use plans, guidelines or policies were integrated into the assessment of effects of changes to the environment on Indigenous peoples, impacts to Aboriginal and Treaty rights, and mitigation measures committed to by Benga (CEAR #184). Also, the Coalition (CEAR #164) commented on the Livingstone – Porcupine Hills Land Footprint Management Plan and asked how the cumulative effects assessment considered the proposed establishment of management thresholds and performance metrics under this plan.

Although Benga identified that land use plans were considered in the environmental assessment for the purpose of closure and reclamation as well as effects on land use and resources, the EIA does not explicitly discuss whether the plans contributed:

- provide benchmarks and thresholds for criteria used to characterize residual Project effects, cumulative effects, and determine significance for valued components, including effects on Aboriginal and Treaty Rights;
- identify technically and economically feasible mitigation measures that may apply to residual Project effects and cumulative effects, regardless of significance; and,
- inform the development of follow-up programs required to verify the accuracy of the environmental assessment, and to determine the effectiveness of mitigation measures.

a) Provide a summary of the information within applicable regional land use and resource plans that is relevant to the effects assessment of each valued component, and to the identification of potential impacts on asserted and established Aboriginal and Treaty rights. This information may include, but is not limited to:

i. objectives and outcomes that can serve as benchmarks or thresholds to inform the characterization of Project effects and cumulative effects, and

ii. strategies and actions proposed under the regional land use and resource plans that are relevant to mitigation measures and follow-up programs proposed for the Project.

Response:

Tables 5.42-1 and 5.42-2 demonstrate how the Project' mitigation is aligned with the Livingstone-Porcupine Hills Land Footprint Management Plan (LFMP) and the South Saskatchewan Regional Plan (SSRP), respectively. These tables outlined the thresholds, where available, under the regional Plans and how the Project has used those thresholds in characterizing Project effects. The tables detail which Project VCs are related to each Objective and Outcome and the relevant Project mitigation measures.

LFMP

Numerous mitigation strategies for the Project align with the objectives of the LFMP, as outlined in Table 5.42-1. Of note, one of the key objectives in the LFMP is the reduction in road density. It targets a restricted motorized access disturbance limit of 0.6 km/km^2. As noted in Section 5.3.8.3 of CR #9 (EIA, CEAR #42), through progressive reclamation and appropriate end-of-mine land use planning, road densities in the WLSA can be maintained at levels approximating 0.6 km/km^2. Benga plans to implement vegetated buffers around waterbodies, which supports the near-stream motorized access disturbance limits. Reclamation of historic mine disturbances is aligned with the LFMP goal of reduced human footprint, although regulators have not yet set thresholds.

SSRP

Numerous mitigation strategies for the Project align with the objectives of the SSRP, as outlined in Table 5.42-2. One of the outcomes of the SSRP is that Aboriginal peoples are included in the land-use planning. Benga has and will continue to consult and involve nearby Indigenous groups in the ongoing development of C&R plans and C&R related monitoring. The intent is to ensure that habitat and vegetation selections align with traditional land use interests.

Table 5.42-1 Summary of Grassy Mountain Coal Project Alignment with Relevant Objectives and Strategies of the Livingstone-Porcupine Hills Land Footprint Management Plan

Outcome	Objective(s)	Relevant Strategies/ Actions[1]	Thresholds	Performance Metric	Project-Related VCs	Relevant Project-related Mitigation[2]
Human footprint and disturbance are effectively minimized so as to sustain biodiversity and watershed values and provide a range of benefits to communities and all Albertans	1.1 Motorized access is managed to sustain biodiversity and watershed integrity	Establish an Open Motorized Access disturbance limit of 0.4 km/km^2 in Zone 2	Open Motorized Access disturbance limit of 0.4 km/km in Zone 2	Open Motorized Access: Livingstone: <386.2 km	• Vegetation VCs • Wildlife VCs • Aquatic Resources (WSCT) • Surface Water VCs	• The project will have a positive contribution by reducing fragmentation and establishing larger patches of forest with respect to vegetation communities. The Project will reduce the amount of historical fragmentation present from existing disturbances (primarily previous mining operations), as well, through tree planting programs on previously disturbed areas • Over the life of the Project, road densities in the WLSA are estimated to decline from Baseline conditions (0.88 km/km^2) to 0.69 km/km^2 at Year 14 and 0.61 km/km^2 at Year 27). Through progressive reclamation and appropriate end-of-mine land use planning, road densities in the WLSA can be maintained at levels approximating 0.6 km/km^2 which should maintain habitat security and population viability • Where appropriate, vegetated buffer zones (100 m or minimum of 30 m, pending topography constraints) will be maintained between Project infrastructure and wetlands, creeks, and streams to the best extent possible. • Progressive reclamation to reduce the amount of disturbed area at any given time. During reclamation, permanent plant cover and revegetation will be established. Soil erosion will be reduced by minimizing the time that reclaimed surfaces are left bare. • Maintain a 100 m minimum **setback** from the main stems of Blairmore Creek and Gold Creek, and a 30 m setback from associated headwater tributaries.
		Establish a Restricted Motorized Access disturbance limit of 0.6 km/km^2 in both Zone 2	Restricted Motorized Access disturbance limit of 0.6 km/km^2 in both Zone 2 and Zone 3	Restricted Motorized Access: Livingstone: <832.3 km		
		Establish a Near-stream Motorized Access disturbance limit (within 100 m of a stream on erodible soils) of 0.04 km/km^2 in each analysis unit	Near-stream motorized access disturbance limit of 0.04 km/km^2	Near-stream Motorized Access: Livingstone: <55.4 km		
	1.2 Important ecosystems and habitat are managed to sustain biodiversity and watershed integrity	Within 1 year of the effective date of this Plan, management thresholds to guide spatial human footprint until 2045, will be developed	Human footprint targets have not been set	None		
Operational planning and management are aligned so as to minimize the extent, duration and rate of footprint development	2.3 Planning and development of energy (including renewables) and mining incorporate human footprint requirements for biodiversity and watersheds, and integrate forestry, recreation, tourism, grazing, wildfire and other resource uses.	Coordinated access planning (and subsequent approval) of energy and mining activity will meet thresholds established in this Plan (Objectives 1.1 and 1.2)	See Objectives 1.1 and 1.2	See Objectives 1.1 and 1.2	• Vegetation VCs • Surface Water VCs • Wildlife VCs • Aquatic Resources (WSCT)	• Whenever possible, construction activities in close proximity to watercourses will be carried out during periods of lowest potential impact, typically during the winter months. A 100 m undisturbed buffer zone, maintaining existing vegetation, strip will be left between development activities and Blairmore Creek to the west and Gold Creek to the east. • Size of the Project's physical footprint has been minimized through proactive mine design. • Slope grading and stabilization techniques will be adopted. Slopes will be contoured to produce moderate slope angles to reduce erosion risk. Other stabilization techniques used to control erosion include: ditching above the cutslope to channel surface runoff away from the cutslope, leaving buffer (vegetation) strips between the construction site and a watercourse, and placing large rock rip rap to stabilize slopes. • The design and construction of all stream crossings will be done in compliance with the Alberta Code of Practice for Watercourse Crossings and associated guidelines. This means that all stream crossings constructed by the Project will meet regulatory requirements for protection of fish resources and aquatic habitat, which also will effectively mitigate against effects on surface water quality.
	2.7 Restoration is planned to sustain biodiversity and watershed integrity	Work with stakeholders and adjacent land managers to ensure wildlife connectivity corridors are enhanced throughout the Livingstone, Porcupine Hills and adjacent landscapes.	None	TBD, ongoing	• Wildlife VCs • Aquatic Resources (WSCT)	• Preserve remnant forest patches within the development areas where feasible to provide habitat, habitat connectivity and hide cover for wildlife species. • A minimum of six wildlife crossings (underpasses and overpasses) will be incorporated into the design of the coal conveyor, which will be strategically placed in locations that will maximize wildlife use (*e.g.,* presence of well used trails, suitable habitats, and terrain features such as valleys and depressions that act as natural crossings). • Incorporate the existing legacy mining disturbances into the development and reclamation plans for the project, and other proposed land use activities to the best extent possible so that habitat loss, habitat fragmentation, linear disturbance features, and cumulative habitat loss are minimized.
		Rare, significant or sensitive ecosystems and habits are maintained or enhanced through existing species at risk recovery planning initiatives, best practices, or through measures described in the Plan to manage new footprint disturbance	None	TBD, ongoing	• Wildlife VCs • Aquatic Resources (WSCT) • Vegetation VCs	• Implementation of a C&R Plan that aims to establish communities that are locally and regionally limited in distribution where conditions allow. • Effects on westslope cutthroat trout habitat loss will be mitigated through offsetting measures to counterbalance any permanent loss of fish habitat where serious harm to fish and fish (critical) habitat cannot be avoided. • As part of the C&R Plan (JRP IR-2.6, Appendix 2.6-1, Updated C&R Plan), Benga has developed a Rare Plant Propagule or Relocation Mitigation Plan, Rare Plant General Mitigation Plan, Whitebark Pine and Limber Pine Mitigation Plans, and a Fescue Grassland Community Mitigation Plan. • To prevent or minimize Project effects on federally-listed (SARA) species at risk, Benga will work in consultation with Environment Canada to develop species-specific mitigation and monitoring plans for species at risk known to occur in the WLSA.
		Develop a strategy to restore linear features in the area to support the above threshold, to reduce landscape fragmentation, and to integrate used of public land.	See Objective 1.1	TBD: Restoration Strategy completed within timeframe with sites and areas identified and prioritized for restoration and reclamation	• Wildlife VCs • Vegetation VCs	• Preservation of adjacent vegetation communities by minimizing the area required for construction and operation of the Project. • The project will have a positive contribution by reducing fragmentation and establishing larger patches of forest with respect to vegetation communities. The Project will reduce the amount of historical fragmentation present from existing disturbances (primarily previous mining operations), as well, through tree planting programs on previously disturbed areas • Progressive reclamation to reduce the amount of disturbed area at any given time. During reclamation, permanent plant cover and revegetation will be established. Soil erosion will be reduced by minimizing the time that reclaimed surfaces are left bare.

Table 5.42-1 Summary of Grassy Mountain Coal Project Alignment with Relevant Objectives and Strategies of the Livingstone-Porcupine Hills Land Footprint Management Plan

Outcome	Objective(s)	Relevant Strategies/ Actions[1]	Thresholds	Performance Metric	Project-Related VCs	Relevant Project-related Mitigation[2]
		Where possible, plant or re-plant native vegetation using seeds sourced within the respective area; where not possible, use best certified native see sources or best available alternative sources	None	TBD: Restoration Strategy identifies this directive for restoration and reclamation	• Vegetation VCs	• The implementation of a re-vegetation program that utilizes native vegetation species and does not include agronomic invasive species; • Where practicable, utilize locally collected seed to preserve the legacy of species and of place. • Implementation of a re-vegetation program that aims to establish diverse native vegetation communities (closed conifer forests, moderate mixed forests, natural upland herbaceous grasslands, and treed wetlands) with equivalent pre-disturbance capability. • Use direct placement of soil for provision of propagules to enhance opportunity for re-establishment of native species composition and enhanced species richness. • Implement seed collection, propagation, and/or relocation plan for rare species.

Note:

[1] Only strategies relevant to the Project have been included in the summary table.

[2] This table does not provide a comprehensive list of all Project-related mitigation measures but provides a subset to show how the Project aligns with the objectives of the LFMP.

Table 5.42-2 Summary of Grassy Mountain Coal Project Alignment with Relevant Objectives and Strategies of the South Saskatchewan Regional Plan

Outcome	Strategic Direction	Objective(s)	Relevant Strategies[1]	Indicators	Limits	Triggers	Project-Related VCs	Relevant Project-related Mitigation[2]

The region's economy is growing and diversified	Sustainable development wherein economic development takes into account environmental sustainability and social outcomes	Opportunities for the responsible exploration, development and extraction of energy resources are maintained	1.7. Ensure rules regarding access to energy and processing and transportation of energy resources are clear and ensure economic development opportunities are appropriately considered against other land uses and values.
			1.8. Maintain physical access to freehold (that is, privately owned) petroleum and natural gas, coal and minerals.
				• Gross domestic product
				• Business establishments
				• Inventory of major projects
				• Building permits
				• Employment
				• Average total income
					None	None	• Land and Resource Use VCs
							• Socio-Economic VCs
								• Continuing to consult with local stakeholders, through the life of the Project, in order to identify concerns and proactively address issues when they arise.
								• Undertaking progressive reclamation, and reclaiming the area to a landscape that includes provisions for a variety of land uses, including forestry, wildlife habitat, grazing, recreational use, *etc.*
								• Project contribution is positive during both construction and operation as the Project will:
								  • contribute to increased incomes to individuals, households, and businesses in the region; and
								  • create employment opportunities at both the regional and provincial level.
								In order to ensure the local economy and people benefit from the Project, Benga will:
								• Cooperate with service providers (*e.g.,* health, social, education), government, and other industrial operators in the region to assist in addressing effects of its project and resource development.
								• Work with the municipalities in the region to keep them informed of its development plans and their timing so that the affected municipalities have sufficient time to plan for changes in the demand for services.

Air quality is managed to support healthy ecosystems and human needs through shared stewardship	Managing air quality through continued collaboration	Releases from various point and non-point sources are managed so they do not collectively result in unacceptable air quality	2.1. Implement the South Saskatchewan Region Air Quality Management Framework. 2.3. Encourage municipalities, industry and the public to be proactive in addressing air quality issues through voluntary programs and initiatives to address emissions sources such as transportation.	• Fine particulate matter ($PM_{2.5}$) • Ground-level ozone (O_3) • Nitrogen dioxide (NO_2)	Based on existing Canadian Ambient Air Quality Standards for $PM_{2.5}$ and O_3 and Alberta Ambient Air Quality Objectives for NO_2.	Based on existing Canadian Ambient Air Quality Standards for $PM_{2.5}$ and O_3 and Alberta Ambient Air Quality Objectives for NO_2.	• Air Quality (analysis conducted and compared to both Provincial and Federal limits)	• Mined areas are reclaimed promptly and backfilled with overburden and soil from pre-strip areas and then covered by vegetation, which reduces windblown fugitive dust emissions from the barren land. • Trees and bushes will be preserved around mines and plant, effectively trapping dust emissions from mining activities and reducing dust concentrations further from mining activities. • The coal processing plant will be contained within an enclosed area and all coal material handling will be *via* covered conveyors. • Dust generation from transferring coal from the conveyor to the stock pile will be minimized by the use of luffing stackers (those that can lower and raise their boom) which will minimize the drop height and drop time of the coal. • Fugitive dust generation will be minimized at the rail load-out, with full cladding on the sides of the load-out structure to create a wind shelter, and with the movable discharge chute of the bin located as close as practical to the coal within the rail cars. • Benga proposes to establish an ambient air quality monitoring program designed to document the potential, localized, fugitive dust impacts due to Project operation. The measurement program is designed to measure dustfall. Details of the required monitoring are a function of the operational configuration at any time. As such, the monitoring program will need to be developed when the mine plan is established and operations begin, and then modified as mining progresses.

Table 5.42-2 Summary of Grassy Mountain Coal Project Alignment with Relevant Objectives and Strategies of the South Saskatchewan Regional Plan

Outcome	Strategic Direction	Objective(s)	Relevant Strategies[1]	Indicators	Limits	Triggers	Project-Related VCs	Relevant Project-related Mitigation[2]
Biodiversity and ecosystem function are sustained through shared stewardship	Conserving and maintaining the benefits of biodiversity	**Regional:** • Terrestrial and aquatic biodiversity are maintained. • Long-term ecosystem health and resiliency is maintained. • Species at risk are recovered and no new species at risk are designated. • Intact grasslands habitat is sustained. • Biodiversity and healthy, functioning ecosystems continue to provide a range of benefits to communities in the region and all Albertans and there is sustainable use of Alberta's biodiversity resources.	3.4. Review Integrated Resource Plans in the region for their relevance and incorporate as appropriate under this regional plan by the end of 2015. 3.10. Continue to work with other government agencies, other levels of government, landholders, non-government organizations, industry, the research community and other partners within and outside the province to manage risk associated with invasive species.	• Amount of land in conservation easements • Amount of intact native grasslands • Area of conserved land	None	None	• Hydrology VCs • Aquatic Resources: WSCT • Vegetation and Wetland VCs • Wildlife VCs	• Maintain a 100 m minimum setback from the main stems of Blairmore Creek and Gold Creek, and a 30 m setback from associated headwater tributaries. • Offsetting measures will be implemented to counterbalance any permanent loss of fish habitat where serious harm to fish and fish (critical) habitat cannot be avoided (Detailed Fisheries Offsetting Plan, Appendix B1, Addendum 8, CEAR #89). • Implementation of a re-vegetation program that aims to establish diverse native vegetation communities (closed conifer forests, moderate mixed forests, natural upland herbaceous grasslands, and treed wetlands) with equivalent pre-disturbance capability. • Implementation of a C&R Plan that aims to establish communities that are locally and regionally limited in distribution where conditions allow. • Preservation of adjacent vegetation communities by minimizing the area required for construction and operation of the Project. • Use direct placement of soil for provision of propagules to enhance opportunity for re-establishment of native species composition and enhanced species richness. • Planting of multiple layers of native vegetation (*e.g.,* trees, shrubs and graminoids) to provide initial structure for wildlife habitat and to enhance biodiversity. • Implement seed collection, propagation, and/or relocation plan for rare species. • As part of the C&R Plan (JRP IR-2.6, Appendix 2.6-1, Updated C&R Plan), Benga has developed a Rare Plant Propagule or Relocation Mitigation Plan, Rare Plant General Mitigation Plan, Whitebark Pine and Limber Pine Mitigation Plans, and a Fescue Grassland Community Mitigation Plan. • Preserve remnant forest patches within the development areas where feasible to provide habitat, habitat connectivity and hide cover for wildlife species. • In areas of suitable wildlife habitat (on the edge of the Project footprint boundary) appropriate setback distances (or buffer zones) will be considered. • Incorporate the existing legacy mining disturbances into the development and reclamation plans for the project, and other proposed land use activities to the best extent possible so that habitat loss, habitat fragmentation, linear disturbance features, and cumulative habitat loss are minimized. • Benga will engage regulators (both provincial and federal), First Nations, and traditional land users in discussion regarding approaches to further minimize effects on species of special interest. Such approaches might include continued monitoring, habitat management, and participation in regional initiatives (*e.g.,* the ABMI program to assist with monitoring regional cumulative effects on biological resources).

Table 5.42-2 Summary of Grassy Mountain Coal Project Alignment with Relevant Objectives and Strategies of the South Saskatchewan Regional Plan

Outcome	Strategic Direction	Objective(s)	Relevant Strategies[1]	Indicators	Limits	Triggers	Project-Related VCs	Relevant Project-related Mitigation[2]
Watersheds are managed to support healthy ecosystems and human needs through shared stewardship	Advancing watershed management	Surface water quality in the Bow, Oldman, South Saskatchewan and Milk rivers is managed so current and future water uses are protected	4.1. Implement the South Saskatchewan Region Surface Water Quality Management Framework.	General water quality indicators: • Total ammonia • Chloride • Nitrate • Total nitrogen • Total dissolved phosphorus • Total phosphorus • Sulphate • Sodium adsorption ratio • Specific conductivity • Total dissolved solids • Total organic carbon • Total suspended solids • Turbidity • pH • E. coli. Two metals and four pesticides have been selected as secondary indicators to be monitored, but triggers and limits are not yet established due to insufficient data.	Established from existing provincially accepted water quality guidelines where applicable; further risk-based limits are to be developed.	Based on statistical deviation from historical ambient concentrations.	• Hydrology VCs • Surface Water Quality VCs (analyzed and compared to Provincial guidelines)	• Implementation of a water management plan to address selenium management and augmentation of potentially impacted tributaries for the Project. • Ensure the CHPP facilities will be aligned in such a way to minimize drainage diversions and runoff interception (*e.g.,* maintain natural vegetated buffers between active mine areas and undisturbed streams). • Maintain a 100 m minimum setback from the main stems of Blairmore Creek and Gold Creek, and a 30 m setback from associated headwater tributaries. • A series of collection ditches, sumps, pumps and settling ponds will be established to manage all surface water on the mine site. A total of five settling ponds are proposed to treat total suspended solids and associated constituents in the water before release of water to the environment. Surface water runoff from mining areas, haul roads, overburden disposal areas and any other disturbed areas as well as groundwater runoff from the pit will be collected and directed to settling ponds for treatment and or will be pumped to the raw water pond for storage and use in the coal cleaning process. Once suspended solids are settled, water will be released to Blairmore Creek and Gold Creek. • Slope grading and stabilization techniques will be adopted. Slopes will be contoured to produce moderate slope angles to reduce erosion risk. Other stabilization techniques used to control erosion include: ditching above the cutslope to channel surface runoff away from the cutslope, leaving buffer (vegetation) strips between the construction site and a watercourse, and placing large rock rip rap to stabilize slopes. • Temporary measures to control erosion before a vegetation cover is re-established, including: diversion ditches, drainage control, check dams, sediment ponds, sumps, and mulches. • Progressive reclamation to reduce the amount of disturbed area at any given time. During reclamation, permanent plant cover and revegetation will be established. Soil erosion will be reduced by minimizing the time that reclaimed surfaces are left bare. • Water quality compliance monitoring will be an integral component of the Project operations, and Benga expects certain ambient aquatic monitoring conditions to be contained in the EPEA Approval with respect to water quality sampling. Settling/release ponds will be tested before release to the surrounding environment to verify acceptability of release waters for variables to be defined under the approval(s) for the Project. A water quality monitoring program will be implemented in natural watercourses both upstream and downstream of the Project.
Watersheds are managed to support healthy ecosystems and human needs through shared stewardship (*cont'd*)	Advancing watershed management (*cont'd*)	Regional approaches and tools support integrated management of water and aquatic ecosystems	4.3 Stakeholders are encouraged to support the work of the Watershed Planning and Advisory Councils including development and implementation of watershed management plans. 4.5 Continue to increase knowledge and improve management of riparian lands within the region. 4.6 Encourage the use of best management practices for land disturbances to minimize sedimentation of water bodies and encourage municipalities to work with land developers to develop and implement best management practices appropriate for the site and establish policies and guidelines for erosion and sediment control in locations with high development pressures.	None	None	None	• Aquatic Resources (WSCT) • Surface Water Quality VCs • Hydrology VCs	• Same as above

Table 5.42-2 Summary of Grassy Mountain Coal Project Alignment with Relevant Objectives and Strategies of the South Saskatchewan Regional Plan

Outcome	Strategic Direction	Objective(s)	Relevant Strategies[1]	Indicators	Limits	Triggers	Project-Related VCs	Relevant Project-related Mitigation[2]
Watersheds are managed to support healthy ecosystems and human needs through shared stewardship (*cont'd*)	Advancing watershed management (*cont'd*)	Headwaters in the region are managed to maintain recharge capabilities and support critical water quality, quantity and aquatic ecosystem requirements	4.15 Review existing water conservation objectives for headwaters tributaries in support of the Approved Water Management Plan for the South Saskatchewan River Basin.	• Annual reported water use volumes by major licence holders • Water conservation holdback volumes through licence transfers for the Bow, Oldman and South Saskatchewan rivers • Annual water supply volumes for the Bow, Milk, Oldman and South Saskatchewan rivers • Percentage of time the water conservation objective targets are achieved annually for key reaches of the Bow, Oldman and South Saskatchewan rivers	None	None	• Surface Water Quality VCs • Hydrology VCs • Hydrogeology VCs	• Implementation of a water management plan to address selenium management and augmentation of potentially impacted tributaries for the Project. • Maintain a 100 m minimum setback from the main stems of Blairmore Creek and Gold Creek, and a 30 m setback from associated headwater tributaries. • Conduct continuous monitoring of flow on Blairmore Creek, Gold Creek, and all potentially impacted tributaries. • Mitigation measures for minimizing or preventing adverse impacts on shallow groundwater quality include industry-standard operating practices, preparedness for upset conditions and the appropriate management of upset conditions. • Monitoring of water levels in bedrock aquifers near the open pit and up-gradient of any receptors will be undertaken as part of the monitoring program. Monitoring will provide verification of the magnitude and extent of predicted impacts to hydraulic head. • Progressive reclamation to reduce the amount of disturbed area at any given time. During reclamation, permanent plant cover and revegetation will be established. Soil erosion will be reduced by minimizing the time that reclaimed surfaces are left bare. • Whenever possible, construction activities near watercourses will be carried out during periods of lowest potential impact, typically during the winter months. A 100 m undisturbed buffer zone, maintaining existing vegetation, strip will be left between development activities and Blairmore Creek to the west and Gold Creek to the east. • Construction techniques will be employed that protect the integrity of the streams as well as the quality of water. • The Project will incorporate design features, management practices and mitigation plans to minimize the potential for spills that might adversely affect surface water quality. Appropriate design features (*e.g.,* berms and containment areas around potential sources), best management practices and emergency spill response plan will be followed.
Land is used efficiently to reduce the amount of area that is taken up by permanent or long-term developments associated with the built environment	Promoting efficient use of land	The amount of land that is required for development of the built environment is minimized over time	5.2 Build awareness and understanding of the efficient use of land principles and the application of land-use planning tools that reduce the footprint of the built environment, how they might be applied and how their effectiveness would be measured over time with municipalities, land-use decision-makers and land users, on both public and private lands.	• Over time standard measures and indicators for determining how efficiently land is used will be developed to evaluate the effectiveness of efficient use of land principles, best practices and tools.	None	None	• Land and Resource Use VCs	• Implement progressive reclamation to reduce the amount of disturbed area at any given time. During reclamation, permanent plant cover and revegetation will be established. Soil erosion will be reduced by minimizing the time that reclaimed surfaces are left bare. • Undertake progressive reclamation, giving consideration to traditional land use, where possible. • Incorporate the existing legacy mining disturbances into the development and reclamation plans for the Project, and other proposed land use activities to the best extent possible so that habitat loss, habitat fragmentation, linear disturbance features, and cumulative habitat loss are minimized.
The quality of life of residents is enhanced through increased opportunities for outdoor recreation and the preservation and promotion of the region's unique cultural and natural heritage	Providing outdoor recreation and nature-based tourism opportunities and preserving and promoting the region's unique cultural and natural heritage	The artifacts, fossils, historic places and Aboriginal heritage sites that define the region's distinctive character are identified and effectively managed	6.8 In concert with developers, ensure that land-based development activities are assessed to identify and protect historic resources.	• Number of historic resources studies conducted • Number of new and previously identified historic resources protected and managed • Parks per capita • Recreation infrastructure • Historic resources	None	Historic resources will be managed to minimize the impacts of development on their integrity. Promoting the preservation of historic places and structures will ensure that tangible examples of the past continue to be accessible.	• Historical Resources	• Disturbance of any further remains located within the proposed rail load out footprint, will be mitigated with controlled excavations to remove the remains. • A mitigation excavation of approximately 80 m^2 will occur in the CHPP footprint in advance of Project development to remove all remaining historical resources or representative samples. • Historic mine remains will be completely documented and recorded. • Historic mining camp remains will be documented in a 20 m^2 excavation. • Additional field surveys and documentation, where required. • Site-specific mitigations for historical resources identified in the Historical Resources Impact Assessment. • Implementation of a Cultural Site Discovery Contingency Plan. • Ongoing Indigenous consultation.

Table 5.42-2 Summary of Grassy Mountain Coal Project Alignment with Relevant Objectives and Strategies of the South Saskatchewan Regional Plan

Outcome	Strategic Direction	Objective(s)	Relevant Strategies[1]	Indicators	Limits	Triggers	Project-Related VCs	Relevant Project-related Mitigation[2]

Aboriginal peoples are included in land-use planning	Inclusion of Aboriginal peoples in land-use planning	To encourage Aboriginal peoples' participation in land-use planning and input to decision-making in recognition of the cultural and economic importance of land use to those Aboriginal communities with constitutionally protected rights.	7.1. In accordance with applicable government policy as it may be from time to time, the GoA will continue to consult with aboriginal peoples in a meaningful way when government decisions may adversely affect the continued exercise of their constitutionally protected rights and the input from such consultations continues to be considered prior to the decision.
			7.2. Explore and present potential new approaches to draw on the rich cultural, ecological and traditional land-use knowledge and stewardship practices of aboriginal communities.
			7.6. Promoting the economic, social and cultural well-being of aboriginal communities.
				• Participation of First Nations in the Treaty 7 – Tourism Development Engagement Group Initiative
				• Aboriginal peoples continue to be consulted when GoA decisions may adversely affect their continued exercise of their constitutionally protected rights and the input from such consultation continues to be reviewed prior to the decision
					None	None	• Land and Resource Use VCs
							• Indigenous VCs
							• TEK Vegetation Resources VC
								• Undertake progressive reclamation, giving consideration to traditional land use, where possible.
								• Provide access to traditional users across the lease.
								• Compensate trappers directly affected by the Project, according to industry standards.
								• Promote cultural diversity awareness to Benga's employees and contractors regarding respect for traditional resource users.
								• Support specific community projects, such as elder and youth programs, where appropriate.
								• Continue working with Indigenous communities in the region to ensure that their concerns with respect to traditional land use and culture are continually considered during Project planning and operation.
								• Develop an Access Management Plan for construction, operation, and reclamation phases of the Project that includes notification of access to the Project site by authorized users.
								• Information gained during the environmental assessment process, subsequent consultations, and TEK reports has been used to identify issues relating to development and reclamation of the Project.
								• Traditional Ecological Knowledge (TEK) and Traditional Land Use reports were completed as part of the Project by Indigenous groups identified as potentially affected by the Project and are provided in Appendix 4.1-1: Updated Assessment on the Potential Effects of the Grassy Mountain Project on Indigenous Peoples (JRP IR-4.1)
								Benga has and will continue to incorporate TEK into C&R planning and implementation. Supplementary mitigation measures for TEK vegetation impacts include the following:
								  • consult with and involve Indigenous groups in designing mitigation measures for sustainable management of TEK vegetation;
								  • implement a re-vegetation program that aims to re-establish vegetation communities, such as those previously mentioned (closed conifer forests, mature mixed forests, native upland herbaceous grasslands and treed swamps) that are common to the pre-disturbed landscape and that will support TEK vegetation for gathering and hunting purposes; and
								  • where practicable, utilize locally collected seed to preserve the legacy of species and of place.
								Benga has committed to consulting and involving nearby Indigenous groups in the ongoing development of C&R plans and C&R related monitoring as the Project advances through the construction, operations, and progressive reclamation phases. The intent is to ensure that habitat and vegetation selections align with traditional land use interests.

Note:

[1] Only strategies relevant to the Project have been included in the summary table.

[2] This table does not provide a comprehensive list of all Project-related mitigation measures but provides a subset to show how the Project aligns with the objectives of the South Saskatchewan Regional Plan. Mitigation measures are described in more detail in the EIA (CEAR#42).

FIGURES

R4 W5M

T8

BC-07

BL-02

BC-03

Pit Area

CRDA

SRDA

Caudron Creek

Morin Creek

Southwest Surge Pond Year 1

Southeast Surge Pond Year 0

Dewatering Well

Phase 2 Dike (1450m) Year 4

Phase 1 Dike (1440m) Year 3

Plant Site Sedimentation Pond Year 0

Raw Water Pond Year 0

Metals Treatment Plant

Clean Water Polishing Pond

SBZ Polishing (Test) Pond

Option A

Option B

LEGEND

- Dewatering Well
- Injection Well
- Model Node
- Release Point
- Treated Water
- Contact Water
- SBZ Treated Water
- Subsurface Flow
- Existing Powerline
- CHPP Facilities
- Access Road
- Topographic Contour (20m interval)
- Polishing Pond
- Dike
- Saturated Fill Zone
- Release Pond
- Dam
- Surge Pond (No Release)
- Metals Treatment Plant
- Proposed Mine Permit Boundary
- Project Footprint
- Future Pond

Coleman

Blairmore

RIVERSDALE RESOURCES

GRASSY MOUNTAION COAL PROJECT

WATER MANAGEMENT - SBZ POLISHING POND

AltaLIS, 2019; Deswik, 2016; Golder 2016; MEMS, 2019; NRCAN, 2015; Riversdale, 2019

Coordinate System: NAD 1983 UTM Zone 11N

0 200 400 Metres

MILLENNIUM EMS Solutions Ltd.

PROJECT: 14-00201

DRAWN BY: JLAMBERTS

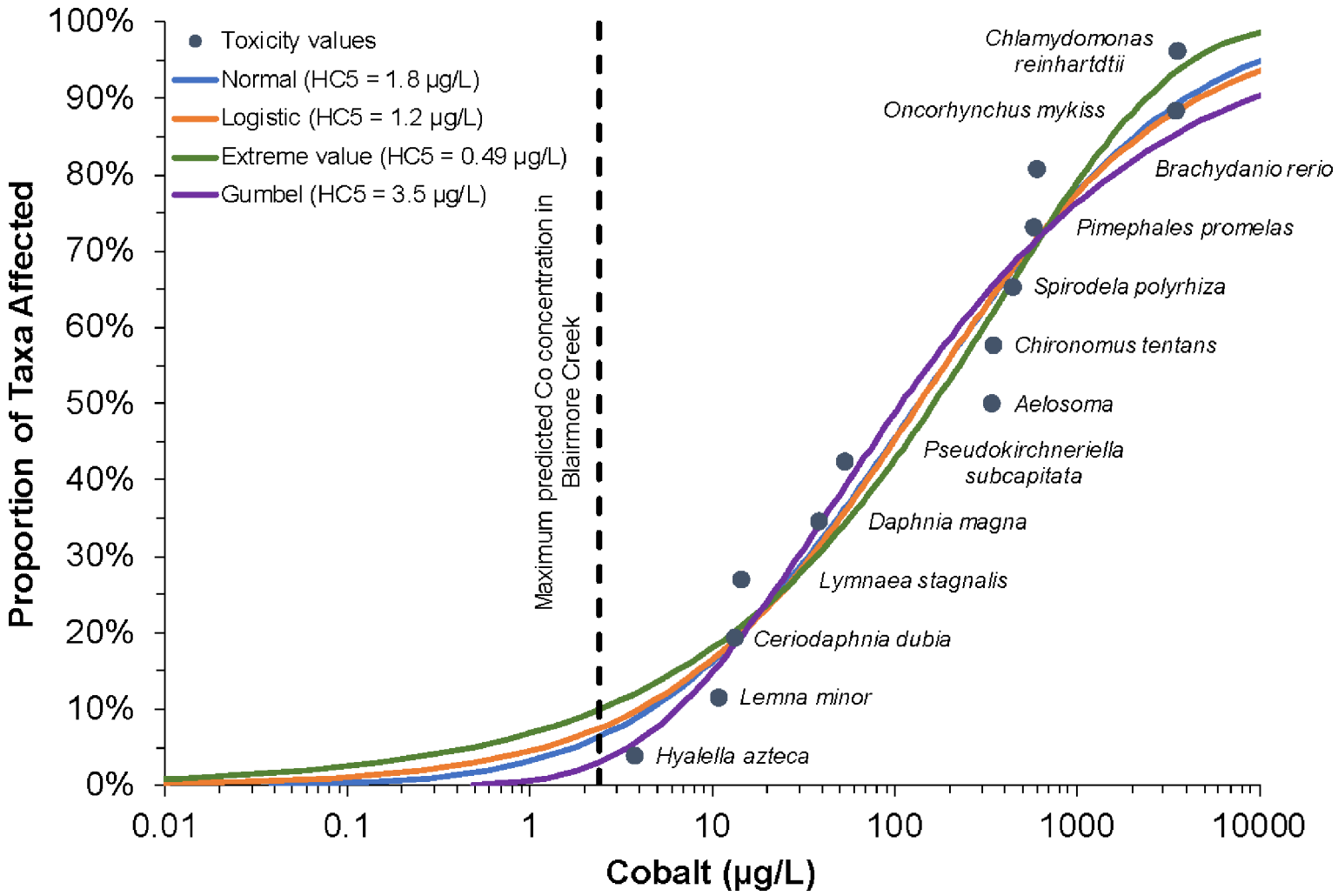
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DATE: JUNE 25, 2019

FIGURE 5.2-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-2-1 Polishing Pond 14-00201.mxd

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RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

CHRONIC COBALT SPECIES SENSITIVITY DISTRIBUTION (SSD) NORMALIZED TO THE PREDICTED HARDNESS OF BLAIRMORE CREEK (372 MG/L)

MEMS, 2019

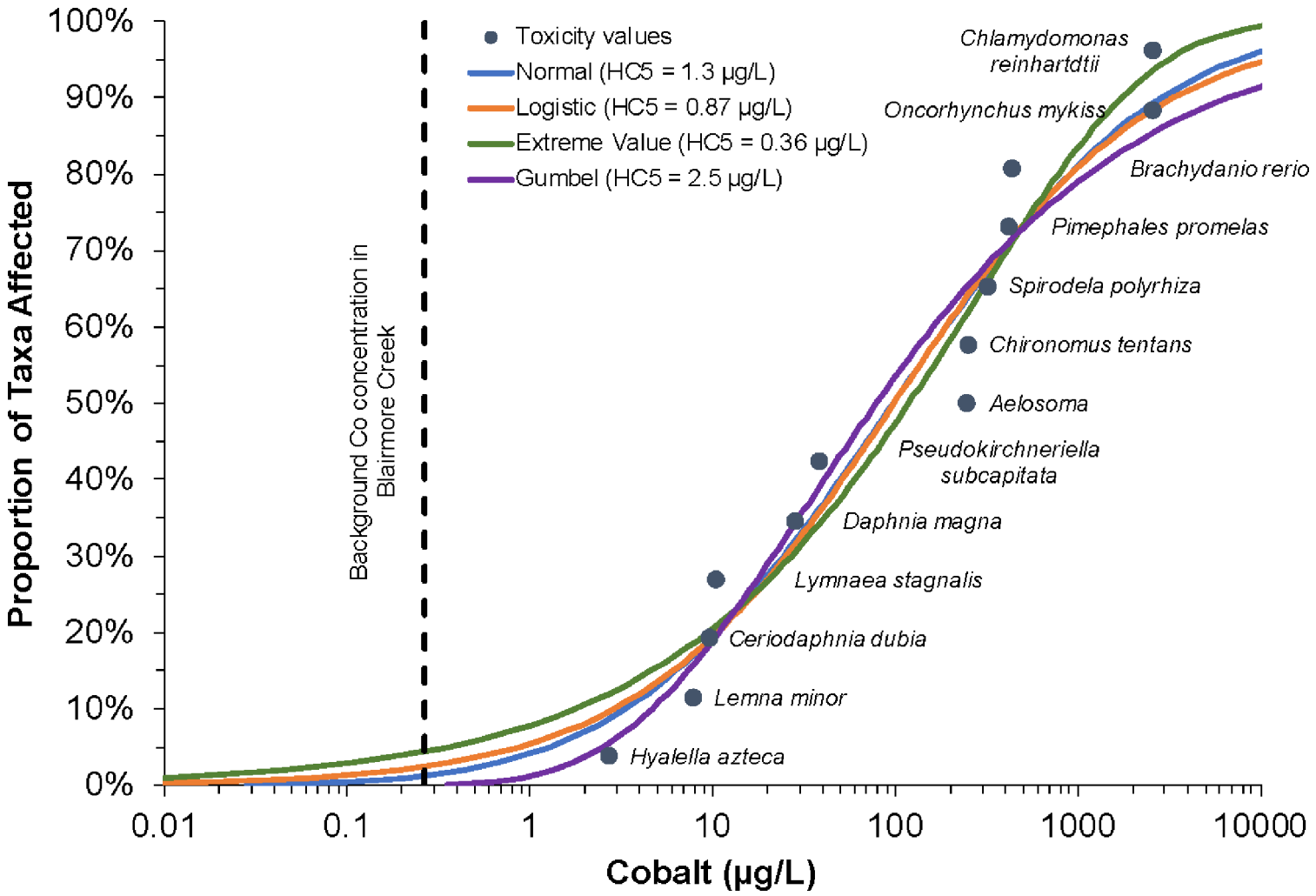
Toxicity data and hardness slope of 0.414 from ECCC (2017). SSD models from SSD Master (Version 3.0)

PROJECT: 14-00201
DRAWN BY: JLAMBERTS
CHECKED BY: MB
DATE: JULY 7, 2019

FIGURE
5.11-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-11-1 Chronic Cobalt 372 mgl 14-00201.mxd

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RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

CHRONIC COBALT SPECIES SENSITIVITY DISTRIBUTION (SSD) NORMALIZED TO THE BASELINE HARDNESS OF BLAIRMORE CREEK (170 MG/L)

PROJECT:	14-00201
DRAWN BY:	JLAMBERTS
CHECKED BY:	MB
DATE:	JULY 7, 2019
FIGURE	5.11-2

MEMS, 2019

Toxicity data and hardness slope of 0.414 from ECCC (2017). SSD models from SSD Master (Version 3.0)

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-11-2 Chronic Cobalt 170 mgl 14-00201.mxd

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Rg 4 Rg 3 W5M

Tp 9

Tp 8

Forestry Trunk Road

Blairmore Creek

Gold Creek

Green Creek

Photo 1

Photo 2

Photo 3



Photo 1: View of the legacy coal pile deposition along Gold Creek resulting from Legacy mining activity (July 2014).



Photo 2: Coal fine deposits acting as streambanks on the mainstem of Gold Creek.



Photo 3: Coal fine deposits and legacy infrastructure along the mainstem of Gold Creek.

Coleman

Blairmore

Frank

Crowsnest River

Yoyk Creek

Lyons Creek

Nez Perce Creek

Pelletier Creek

40

3

LEGEND

- Photo Location
- Surface Water Drainage
- Primary Highway
- Secondary Highway
- Road Access
- Existing Trails
- Existing Railway
- Proposed Mine Permit Boundary
- Proposed Mine Permit Boundary Addition
- Project Footprint
- Undisturbed Area
- Legacy Mine Disturbance

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

EXISTING LEGACY COAL NEAR GOLD CREEK

NOTES

AltaLIS, 2016; Geobase, 2016; MEMS, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

PROJECT:	14-00201-01
DRAWN BY:	JL
CHECKED BY:	MB
DATE:	JUNE 26, 2019

0 1 2 4
Kilometres

FIGURE

IR-5.12-1

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MIA

EMERGENCY TAILING POND

BN-701

CV-702

CV-201

POTABLE WATER PLANT

1120tph CPP

FIRE WATER TANKS & PUMPS

CHPP OFFICE & CONTROL ROOM

WAREHOUSE & WORKSHOP & LAB

BN-102

CHPP OFFICE

CATIONIC LIQUID TANK

FLOC ANIONIC POWDER SILO

MAG PIT

REAGENTS STORAGE

PROPANE TANK

Methanol Storage Tank

1535

0 5 15 25m

SCALE 1:500 AT ORIGINAL SIZE

DRA WNG NO	TITLE
REFERENCE DRAWINGS	

REV	DESCRIPTION	BY	DRG CHK	ENG CHK	DATE	APPROVED
A	PRELIMINARY ISSUE	MDC			07.04.16	

DRAWING REVISIONS

CLIENT RIVERSDALE RESOURCES

RIVERSDALE RESOURCES

DRAWN	MDC	07.04.16
CHECKED		
DESIGNED		
LEAD ENG		
APPROVED		
SCALE	1:500	OR AS SHOWN
	DO NOT SCALE	A1

SEDGMAN

PRELIMINARY NOT FOR CONSTRUCTION

PROJECT GRASSY MOUNTAIN PROJECT

TITLE
COAL HANDLING AND PREPARATION PLANT
SITE LAYOUT
CPP PAD

PROJECT NO	DRAWING NO	REVISION
A258-D02	A258-P-1-2715	A

PLOTDATE:7/04/2016 11:24:43 AM File:P:\A258 - Grassy Mountain\20 CAD_Preliminary\P1\A258-P-1-2710.dwg - ByMitch Carter

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Figure 5.13-1

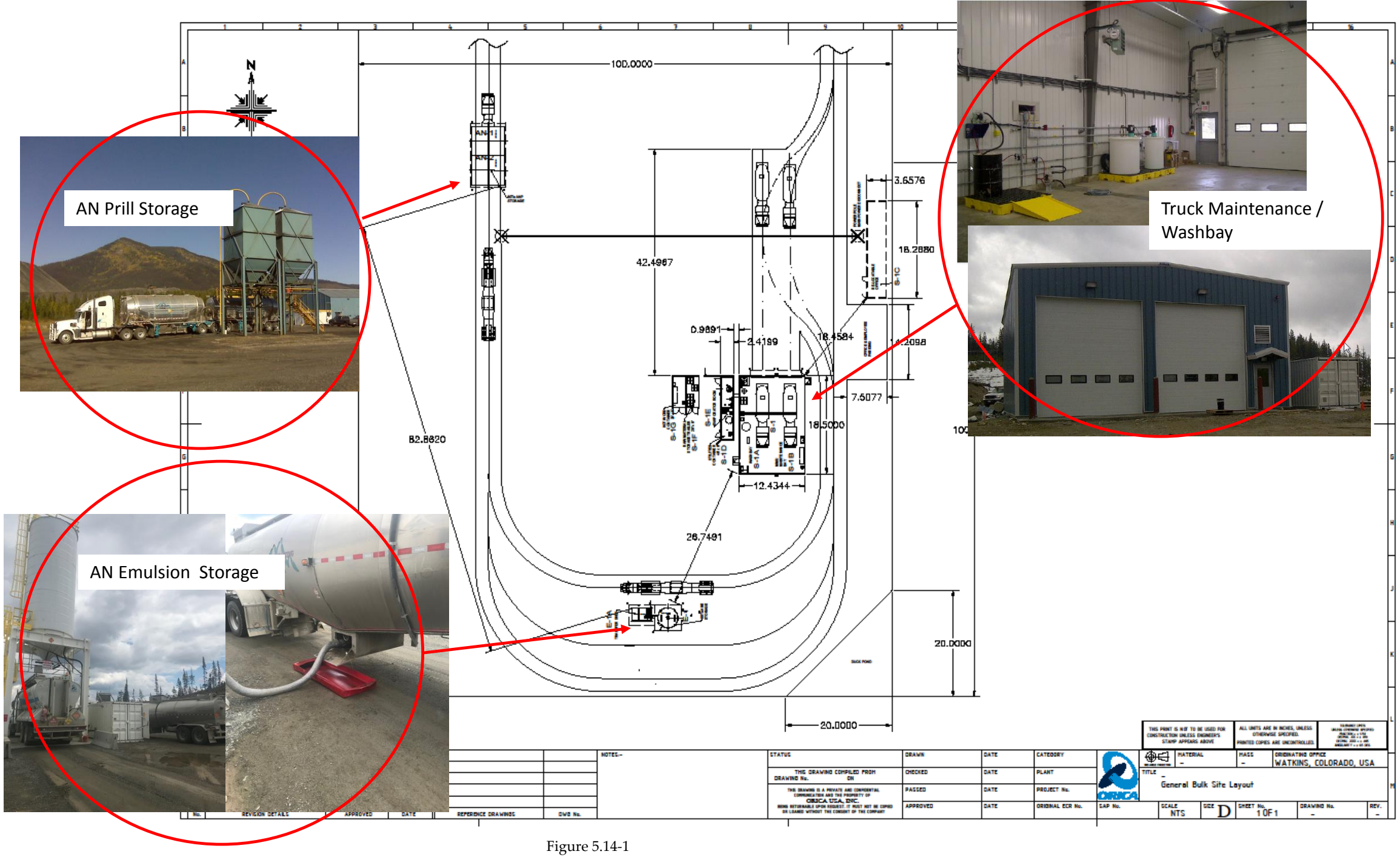
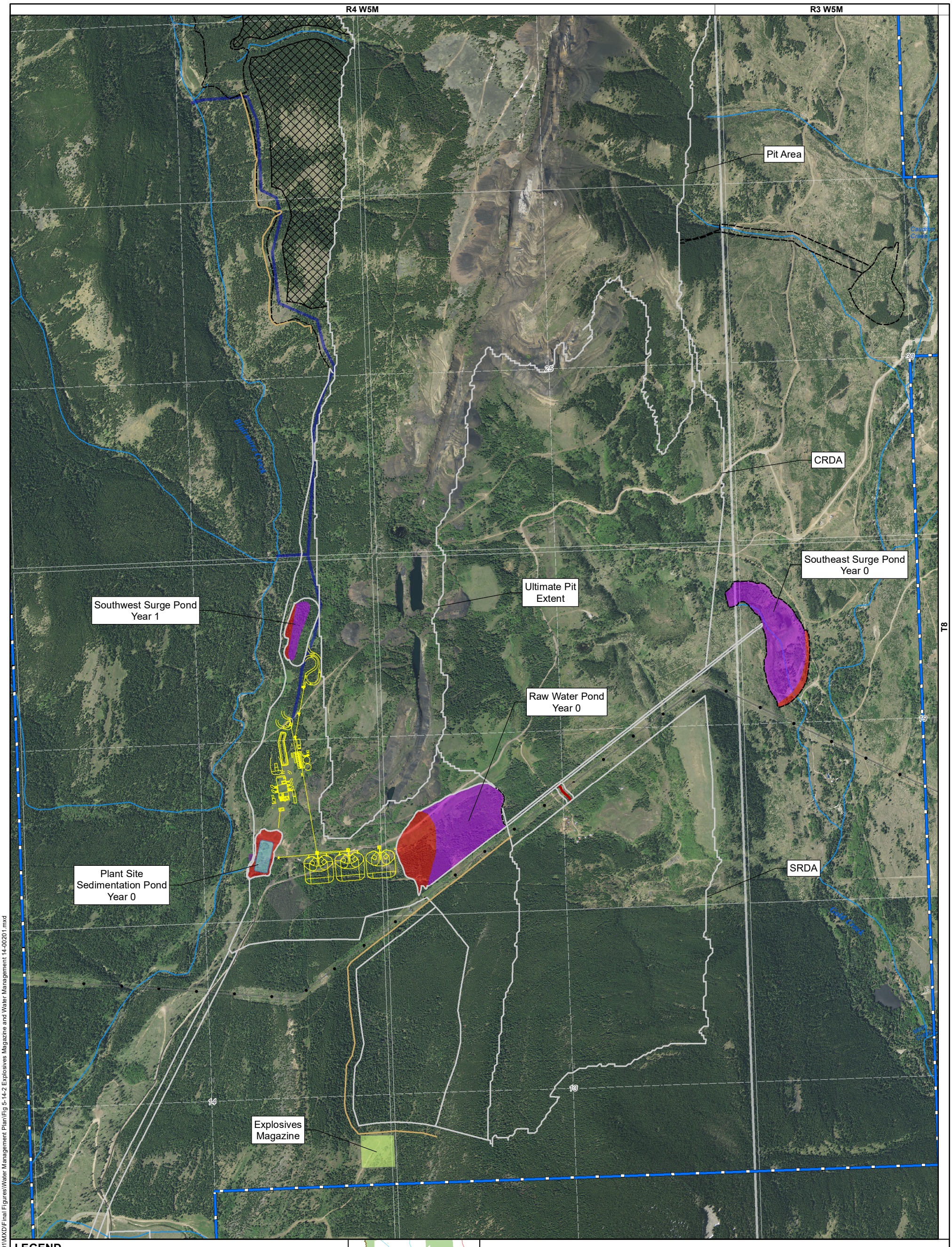

AN Prill Storage
Truck Maintenance / Washbay
AN Emulsion Storage
100.0000
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0.9891
2.4189
18.4584
14.2098
7.5077
18.5000
12.4344
82.8620
26.7491
20.0000
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N
ORICA
WATKINS, COLORADO, USA
General Bulk Site Layout
NTS
D
1 OF 1

Figure 5.14-1



LEGEND

- Release Point
- Drainage Ditch to Raw Water Pond
- Proposed Water Pipeline
- Existing Powerline
- CHPP Facilities
- Surface Water Drainage
- Proposed Mine Permit Boundary
- Project Footprint
- Future Pond
- Undisturbed Area
- Release Pond
- Dam
- Surge Pond (No Release)
- Explosives Magazine

RIVERSDALE RESOURCES

GRASSY MOUNTAION COAL PROJECT

EXPLOSIVES MAGAZINE AND WATER MANAGEMENT

AltaLIS, 2018; Deswik, 2016; Golder 2016; MEMS, 2018; NRCAN, 2015; Riversdale, 2018

Datum/Projection: UTM Zone 11 Nad 83

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Kilometres

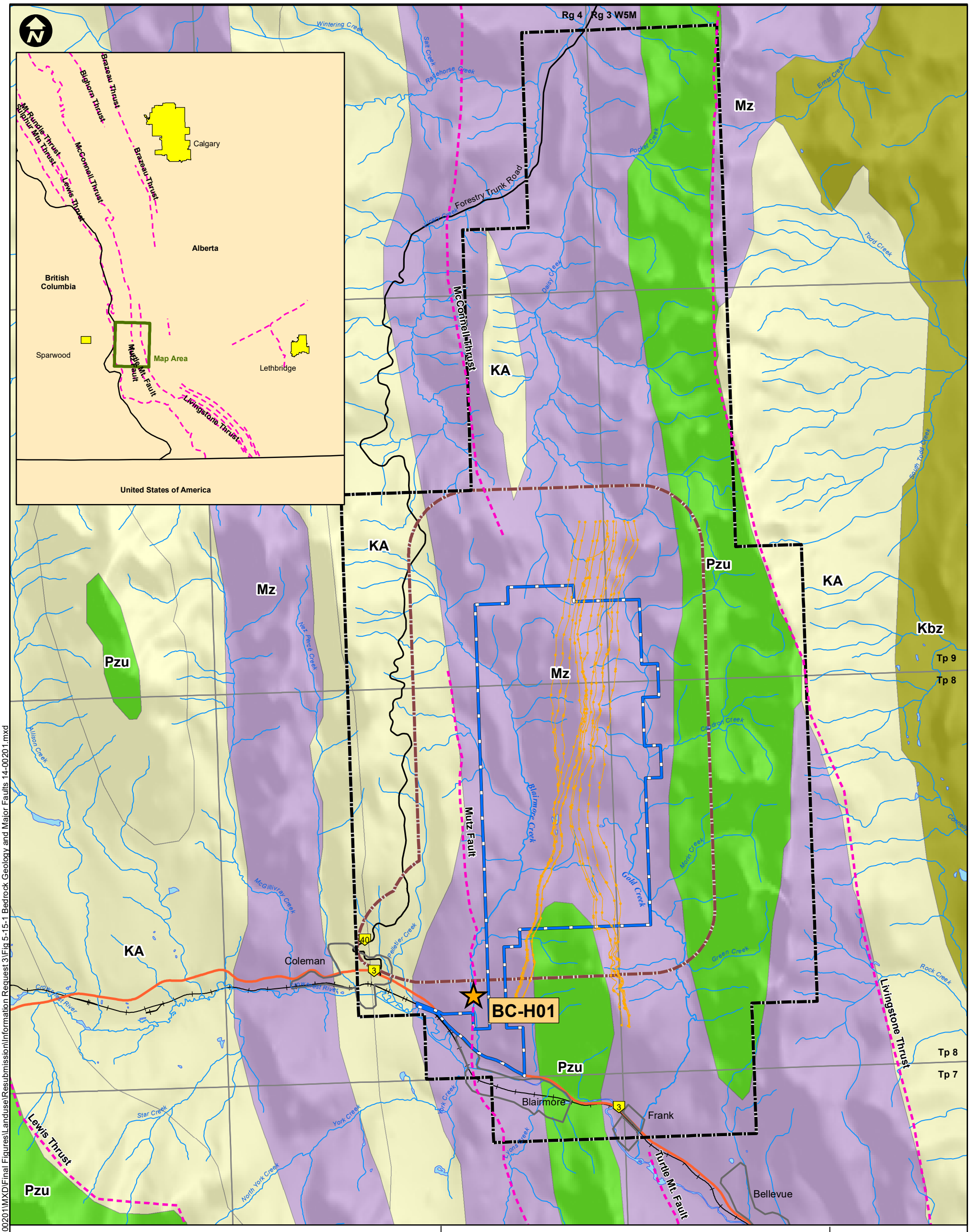
MILLENNIUM EMS Solutions Ltd.

PROJECT: 14-00201
DRAWN BY: JL
CHECKED BY: MB
DATE: SEPTEMBER 18, 2018

FIGURE
5.14-2

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Water Management Plan\Fig 5-14-2 Explosives Magazine and Water Management 14-00201.mxd

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LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Thrust Fault
- Major Fault
- Surface Water Drainage
- LSA
- RSA
- Proposed Mine Permit Boundary

Geological Formation

- Brazeau Formation (Kbz)
- Alberta Group (KA)
- Lower Mesozoic-Lower Cretaceous (Mz)*
- Upper Paleozoic (Pzu)

* Include Blairmore, Kootenay, Fernie, Spray River groups

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

BEDROCK GEOLOGY AND MAJOR FAULTS

NOTES

AGS, 2015 (modified); AltaLIS, 2016; GeoBase, 2011; Golder, 2015; NRCAN, 2015; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

PROJECT:	14-00201-01
DRAWN BY:	JDC/SL
CHECKED BY:	MB
DATE:	JULY 4, 2019

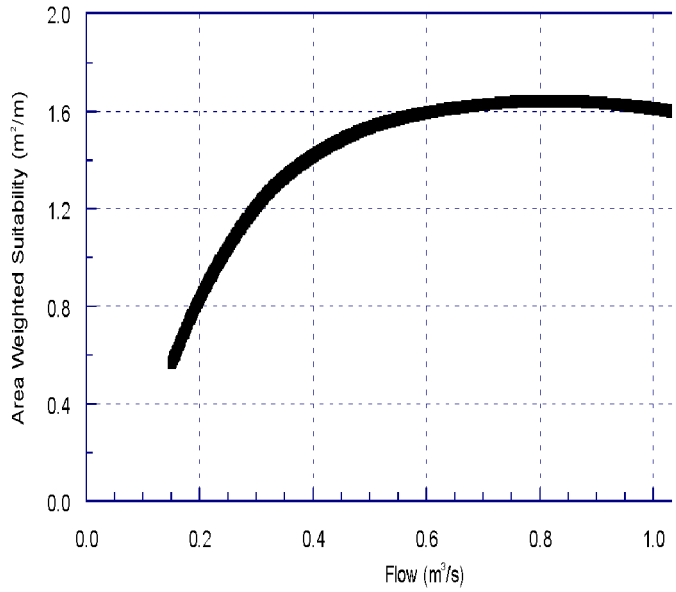
0 1.5 3 6
Kilometres

FIGURE

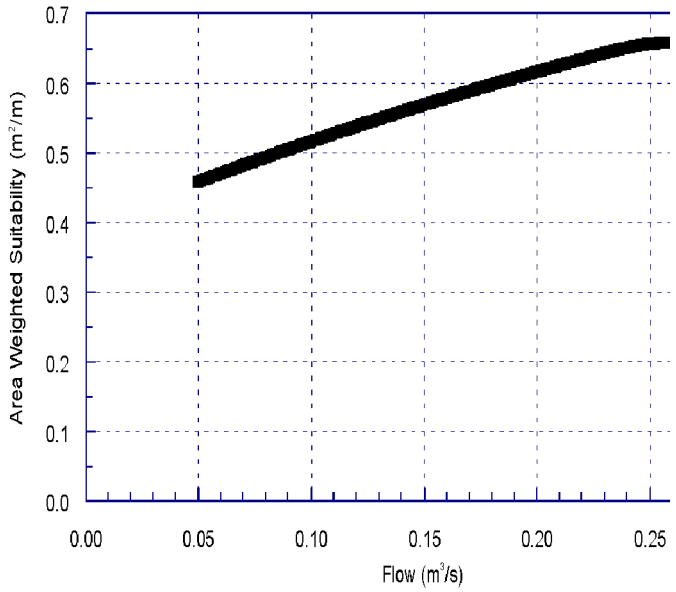
5.15-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-15-1 Bedrock Geology and Major Faults 14-00201.mxd

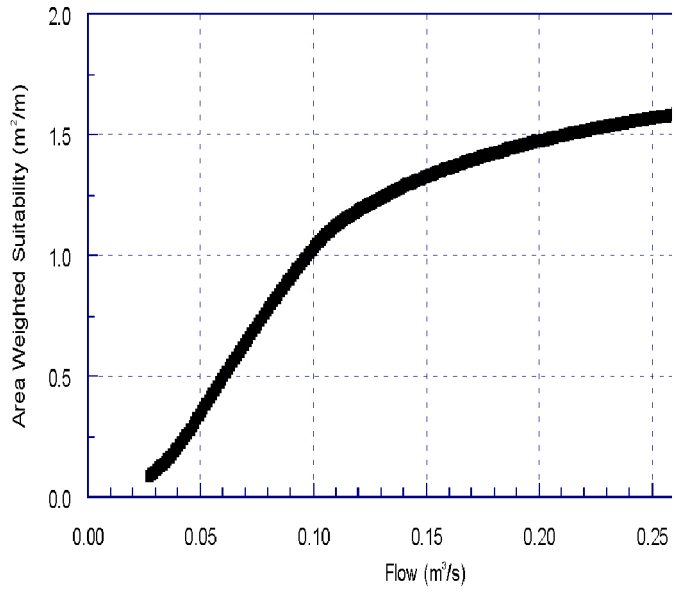
Reach 7-GC-10-spawning



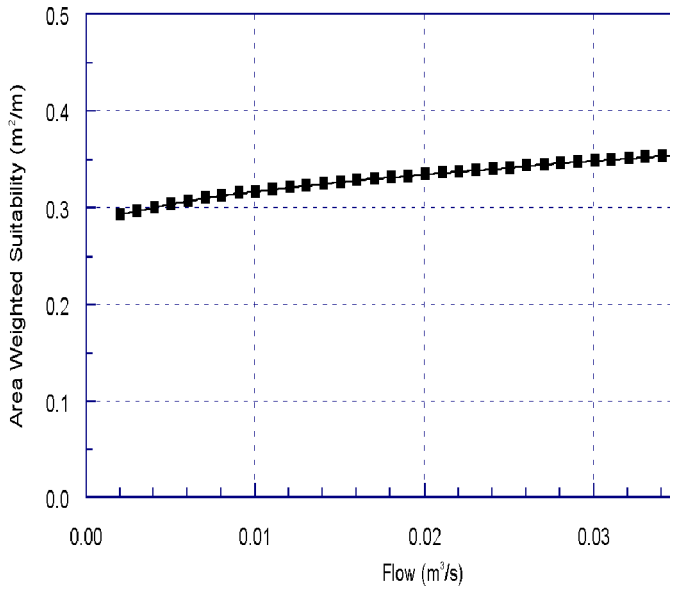
Reach 7-GC-13-overwintering



Reach 8-GC-13-spawning



Reach 8-GC-17-overwintering



RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

FLOW-AWS RELATIONSHIPS AT OVERWINTERING AND SPAWNING TRANSECTS ON REACHES 7-8

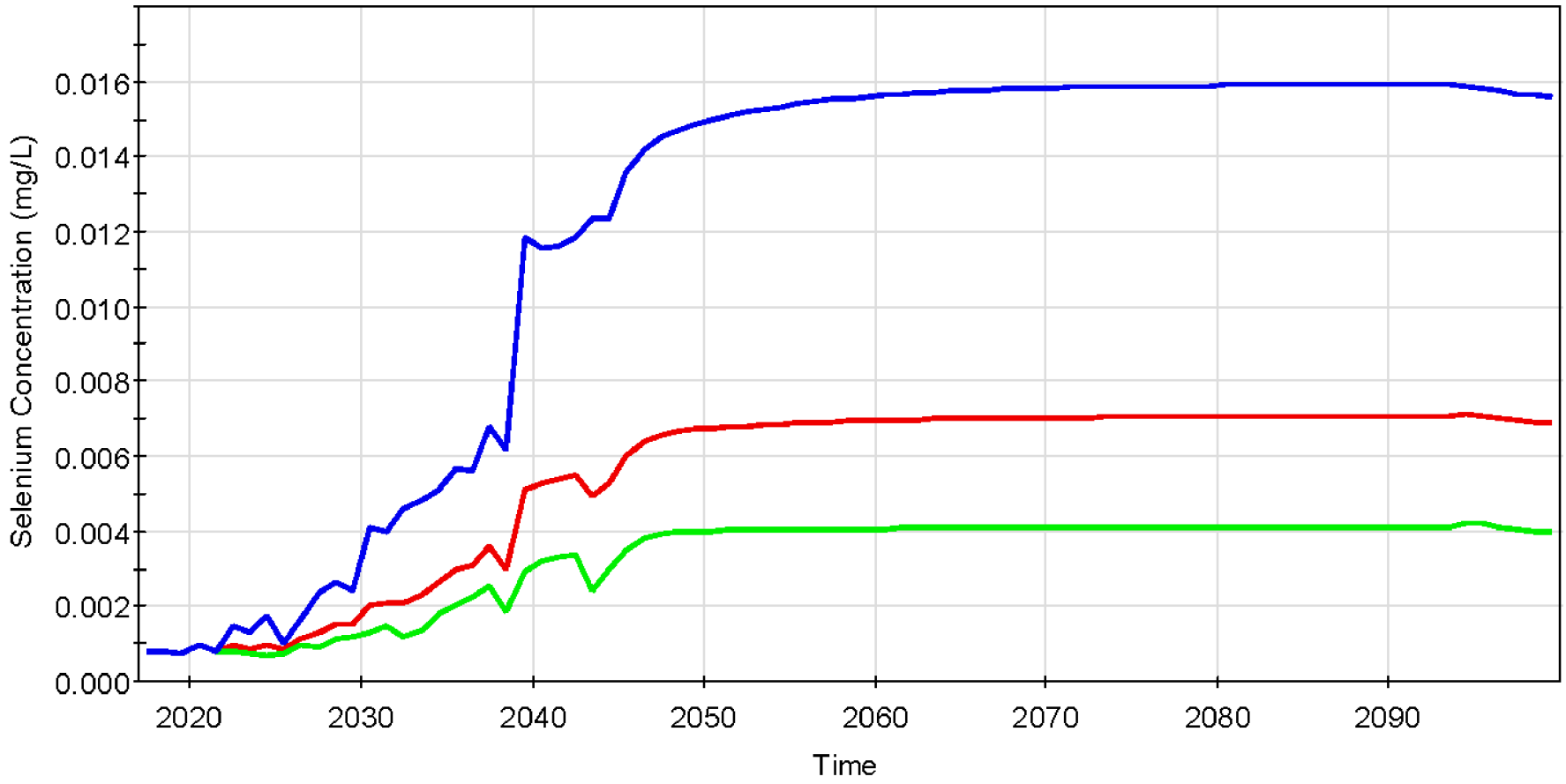
MEMS, 2019

MILLENNIUM EMS Solutions Ltd.

PROJECT:	14-00201
DRAWN BY:	JLAMBERTS
CHECKED BY:	MB
DATE:	JULY 5, 2019
FIGURE	5.15-2

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-15-2 Flow-AWS Relationships 7-8 14-00201.mxd

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L_BC03

1A Capture Efficiency = 95%

1B Capture Efficiency = 100%

1C Capture Efficiency = 80%

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

SENSITIVITY OF THE CONTACT WATER CAPTURE EFFICIENCY WITH NATURAL RUNOFF COEFFICIENT OF 0.41

MEMS, 2019

PROJECT: 14-00201

DRAWN BY: JLAMBERTS

CHECKED BY: MB

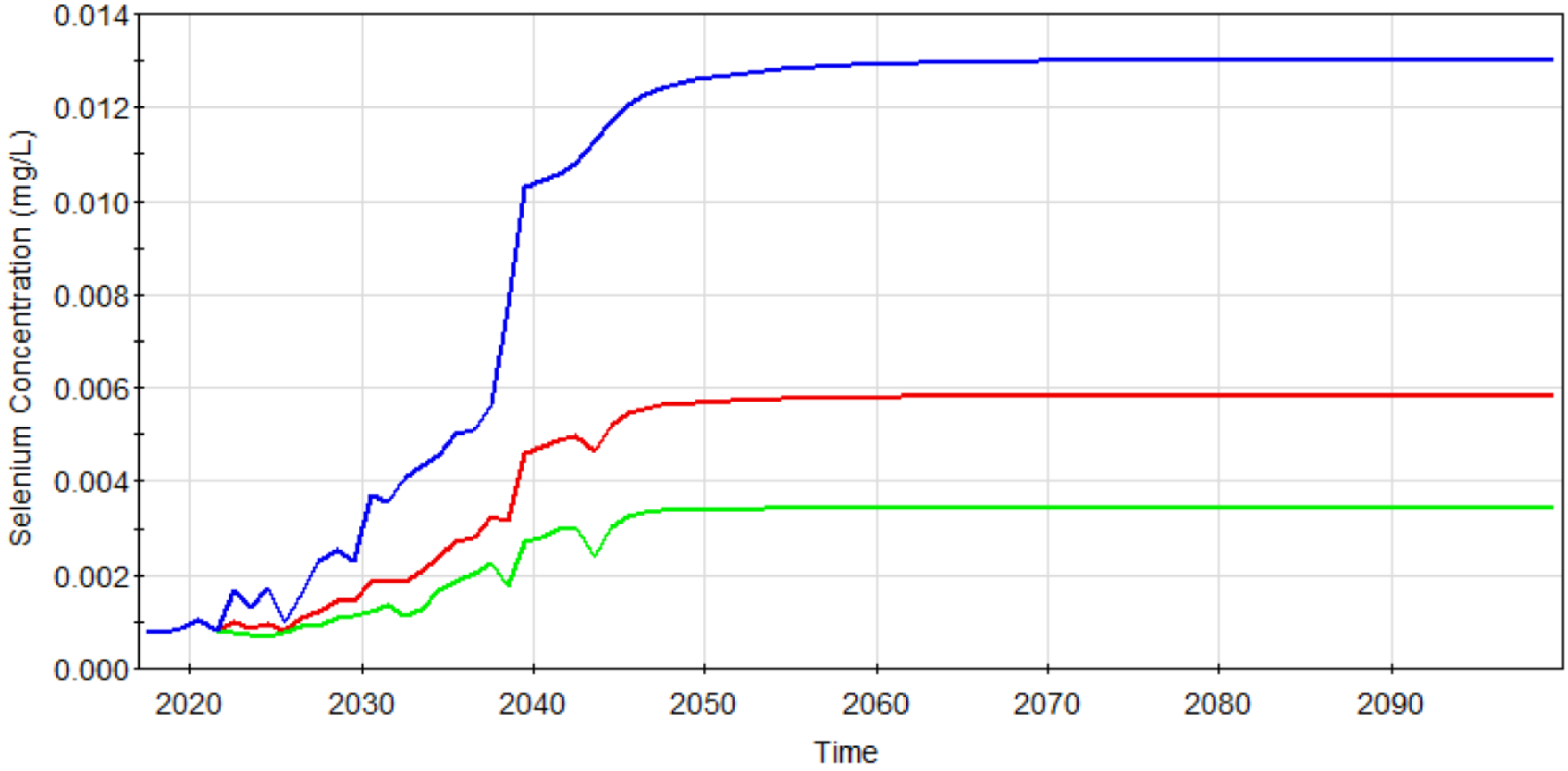
DATE: JULY 5, 2019

FIGURE

5.15-3

Document Path: K:\Active Projects 2019\AP 19-00001 to 19-00050\19-00033\Figures\Groundwater\Fig 5-15-3 Sensitivity of the Contact Water 14-00201.mxd

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RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

SENSITIVITY OF THE CONTACT WATER CAPTURE EFFICIENCY WITH NATURAL RUNOFF COEFFICIENT OF 0.51

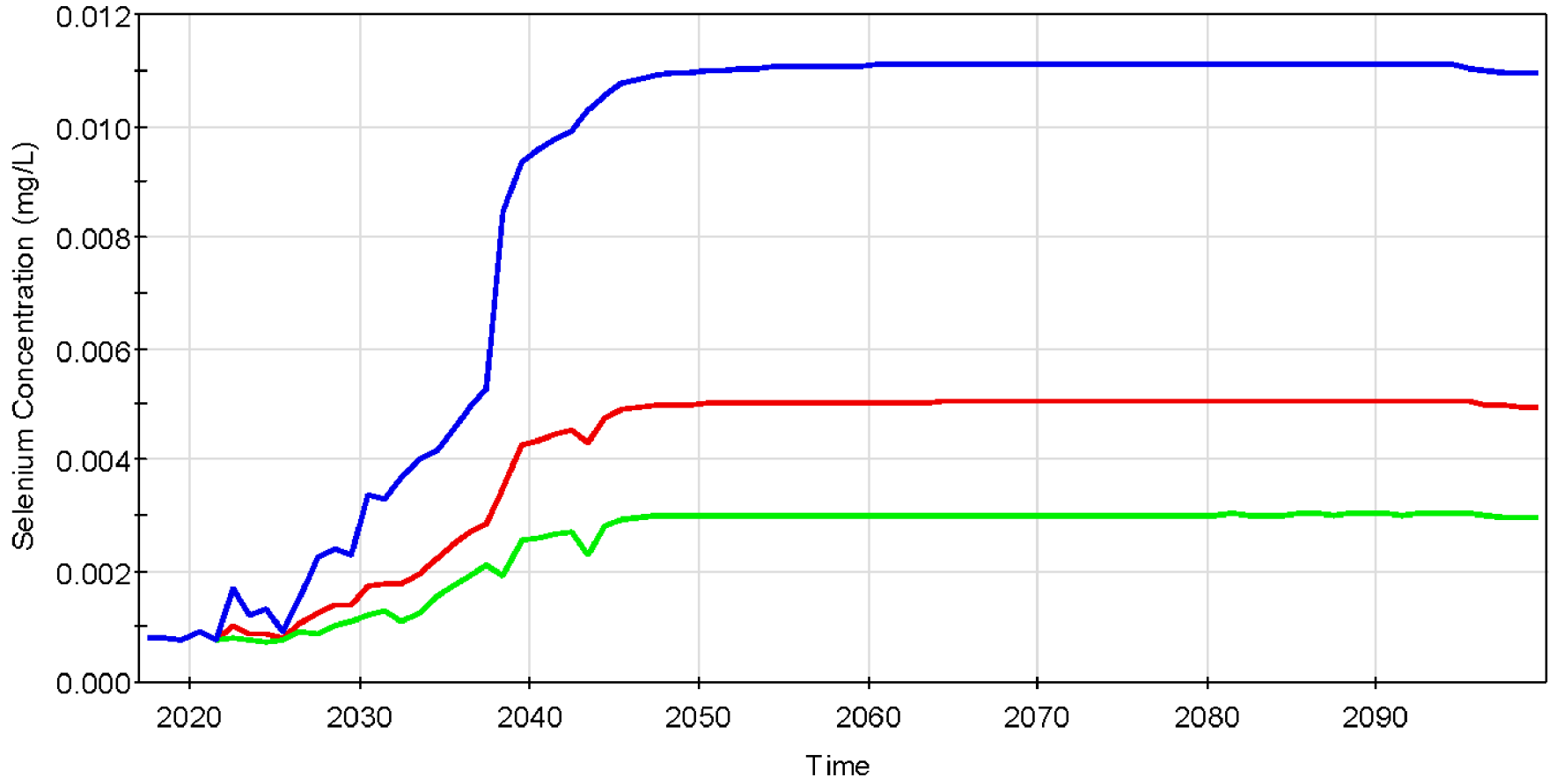
MEMS, 2019

PROJECT: 14-00201
DRAWN BY: JLAMBERTS
CHECKED BY: MB
DATE: JULY 5, 2019

FIGURE
5.15-4

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L_BC03

1A Capture Efficiency = 95%

1B Capture Efficiency = 100%

1C Capture Efficiency = 80%

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

SENSITIVITY OF THE CONTACT WATER CAPTURE EFFICIENCY WITH NATURAL RUNOFF COEFFICIENT OF 0.61

MEMS, 2019

PROJECT: 14-00201

DRAWN BY: JLAMBERTS

CHECKED BY: MB

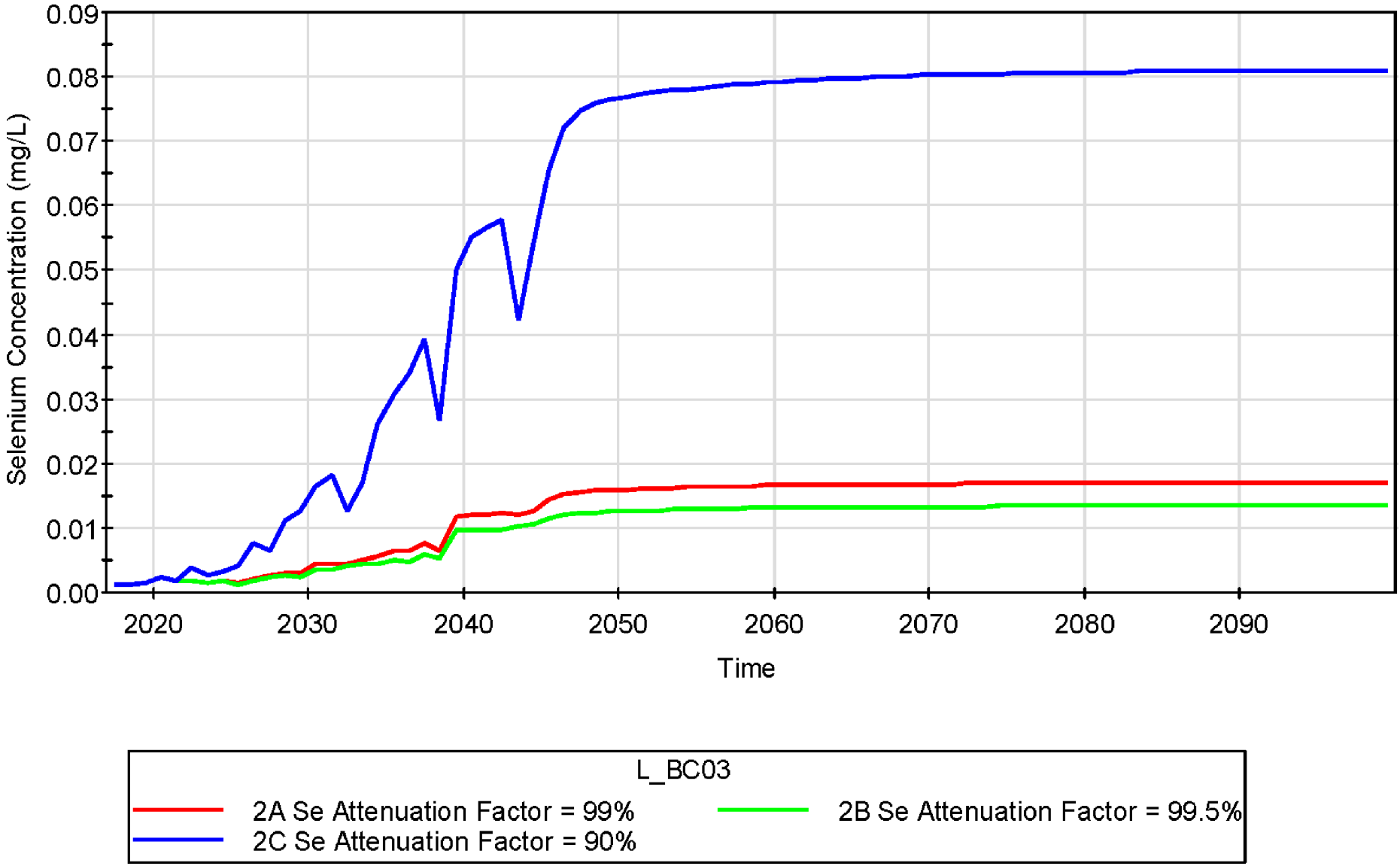
DATE: JULY 5, 2019

FIGURE

5.15-5

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RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

ATTENUATION FACTOR SENSITIVITY WITH RUNOFF COEFFICIENT OF 0.41

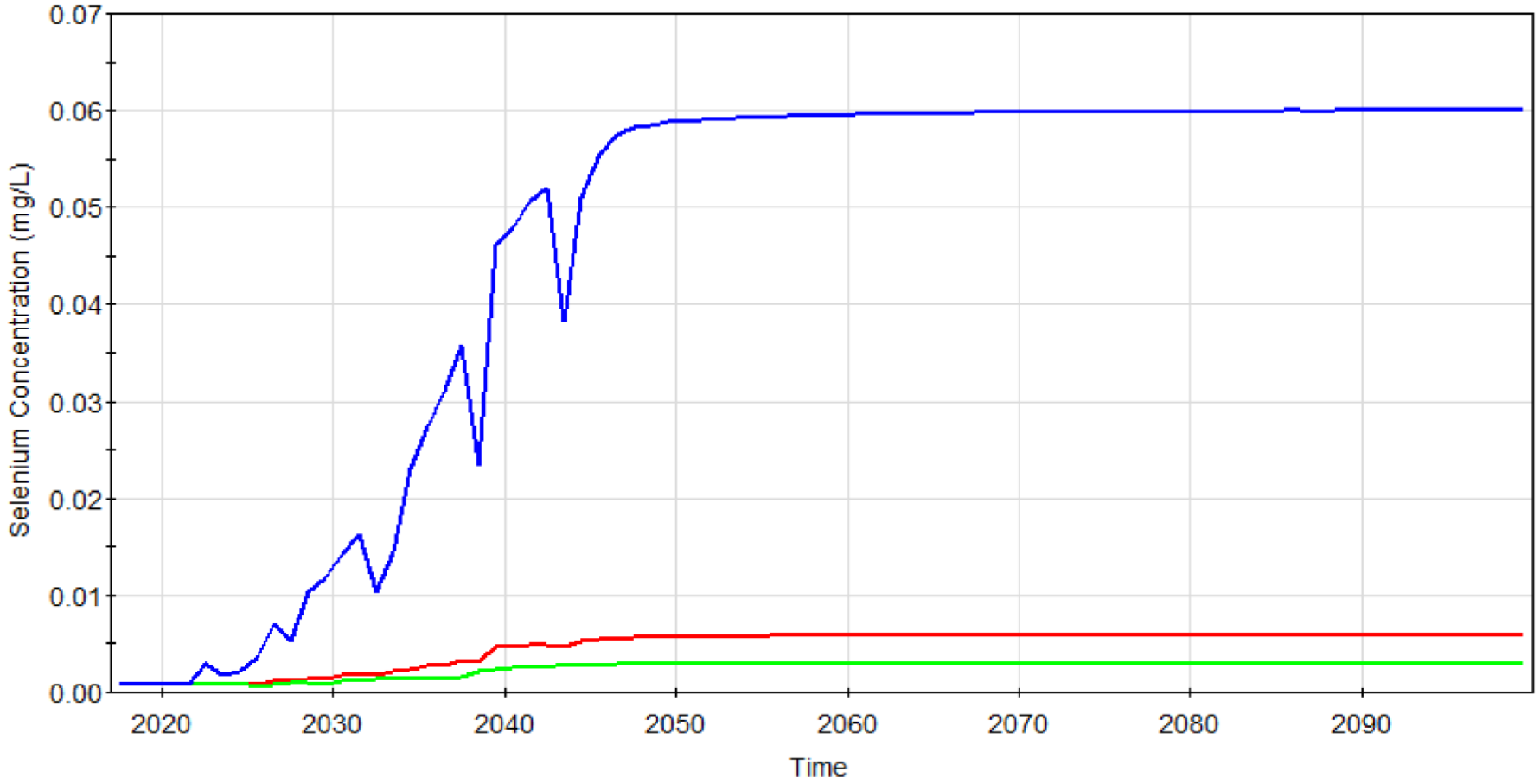
MEMS, 2019

PROJECT: 14-00201
DRAWN BY: JLAMBERTS
CHECKED BY: MB
DATE: JULY 5, 2019

FIGURE
5.15-6

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-15-6 Attenuation Factor Sensitivity 0-41 14-00201.mxd

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RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

ATTENUATION FACTOR SENSITIVITY WITH RUNOFF COEFFICIENT OF 0.51

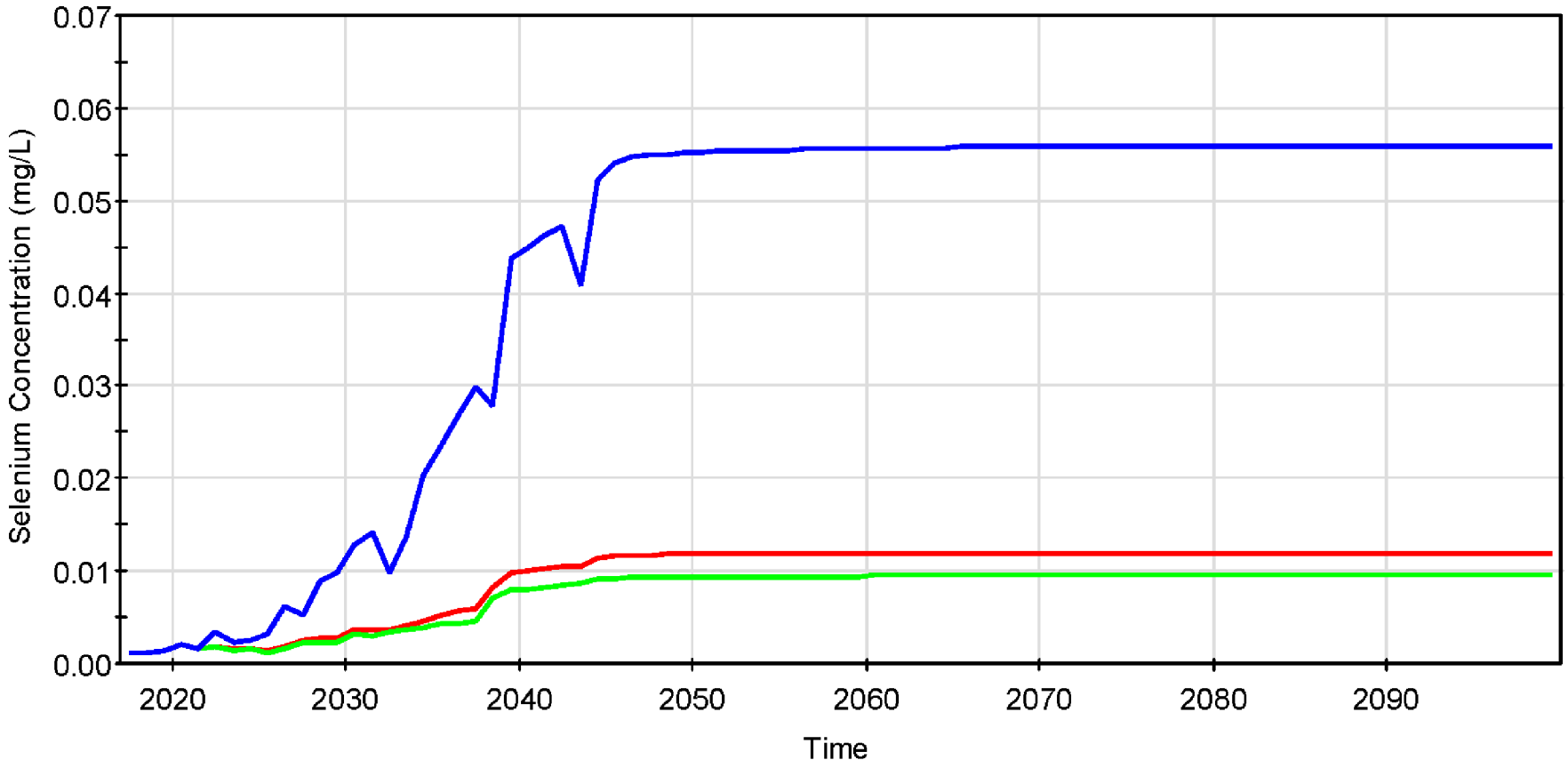
MEMS, 2019

PROJECT: 14-00201
DRAWN BY: JLAMBERTS
CHECKED BY: MB
DATE: JULY 5, 2019

FIGURE
5.15-7

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-15-7 Attenuation Factor Sensitivity 0-51 14-00201.mxd

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L_BC03

2A Se Attenuation Factor = 99%

2B Se Attenuation Factor = 99.5%

2C Se Attenuation Factor = 90%

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

ATTENUATION FACTOR SENSITIVITY WITH RUNOFF COEFFICIENT OF 0.61

MEMS, 2019

PROJECT: 14-00201

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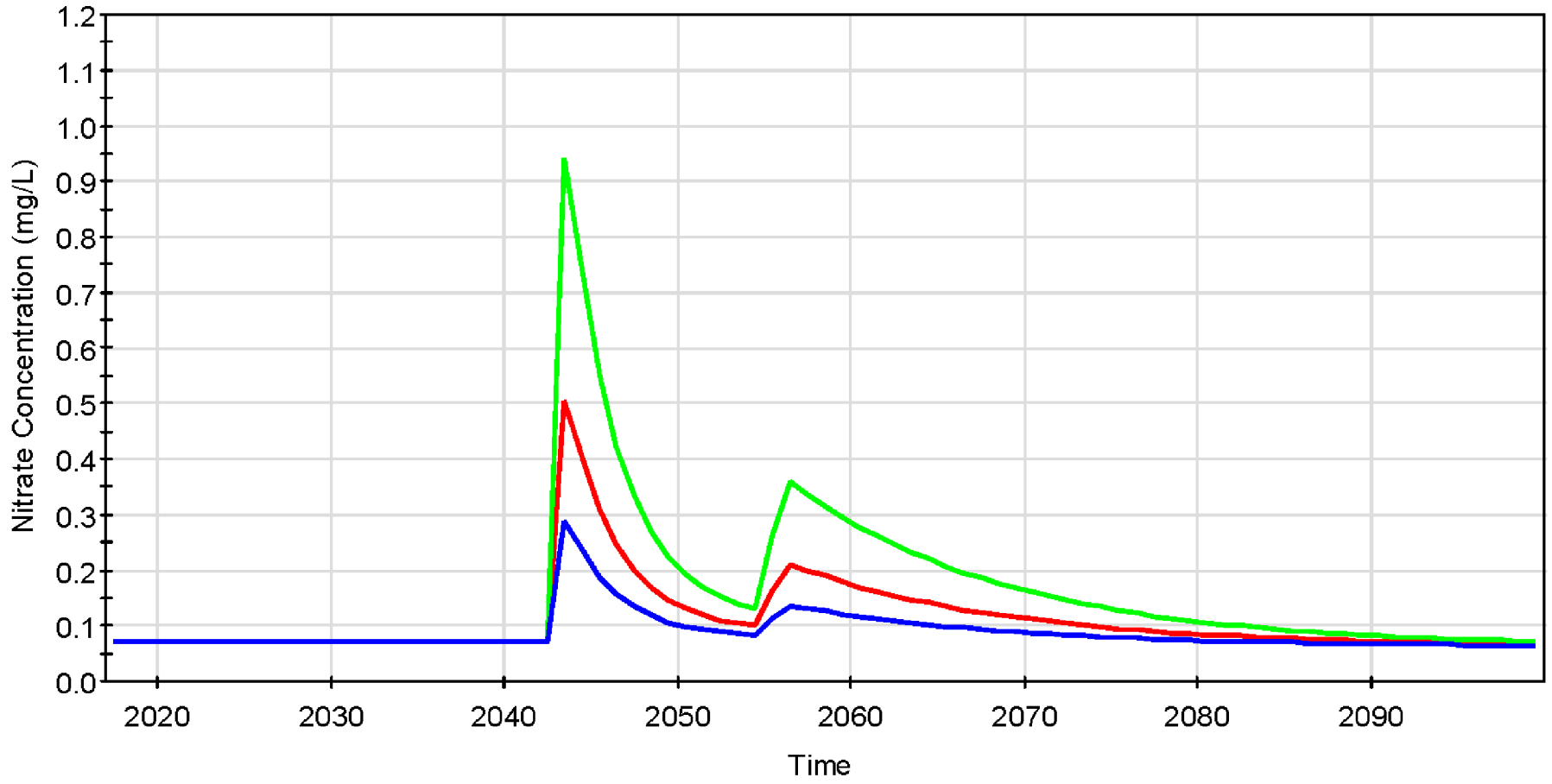
DATE: JULY 5, 2019

FIGURE

5.15-8

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L_GC10

3A Pit Wall Thickness = 1m

3B Pit Wall Thickness = 2 m

3C Pit Wall Thickness = 0.5m

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

PIT WALL THICKNESS SENSITIVITY TEST WITH RUNOFF COEFFICIENT OF 0.41

MEMS, 2019

PROJECT: 14-00201

DRAWN BY: JLAMBERTS

CHECKED BY: MB

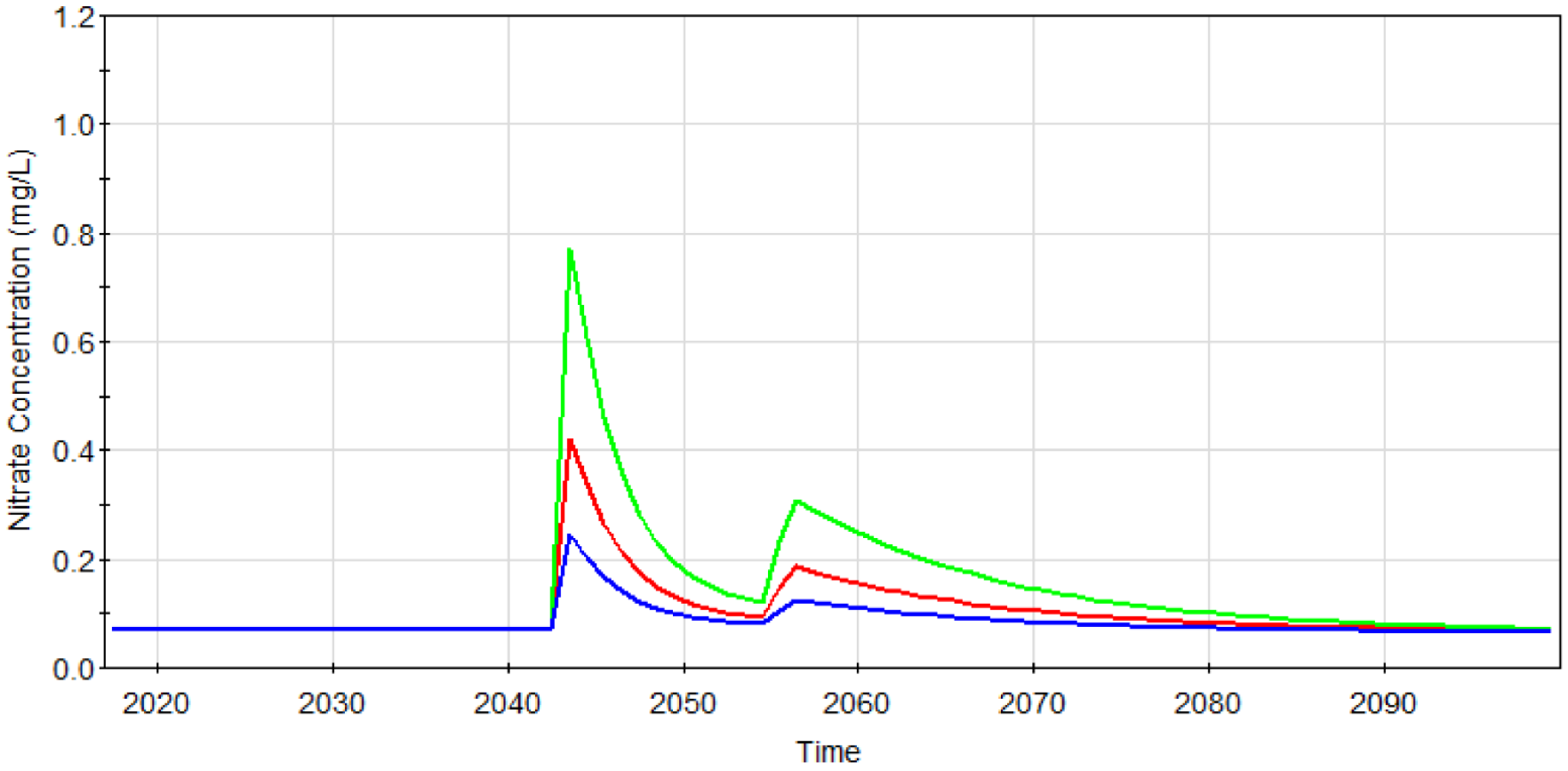
DATE: JULY 5, 2019

FIGURE

5.15-9

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RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

PIT WALL THICKNESS SENSITIVITY TEST WITH RUNOFF COEFFICIENT OF 0.51

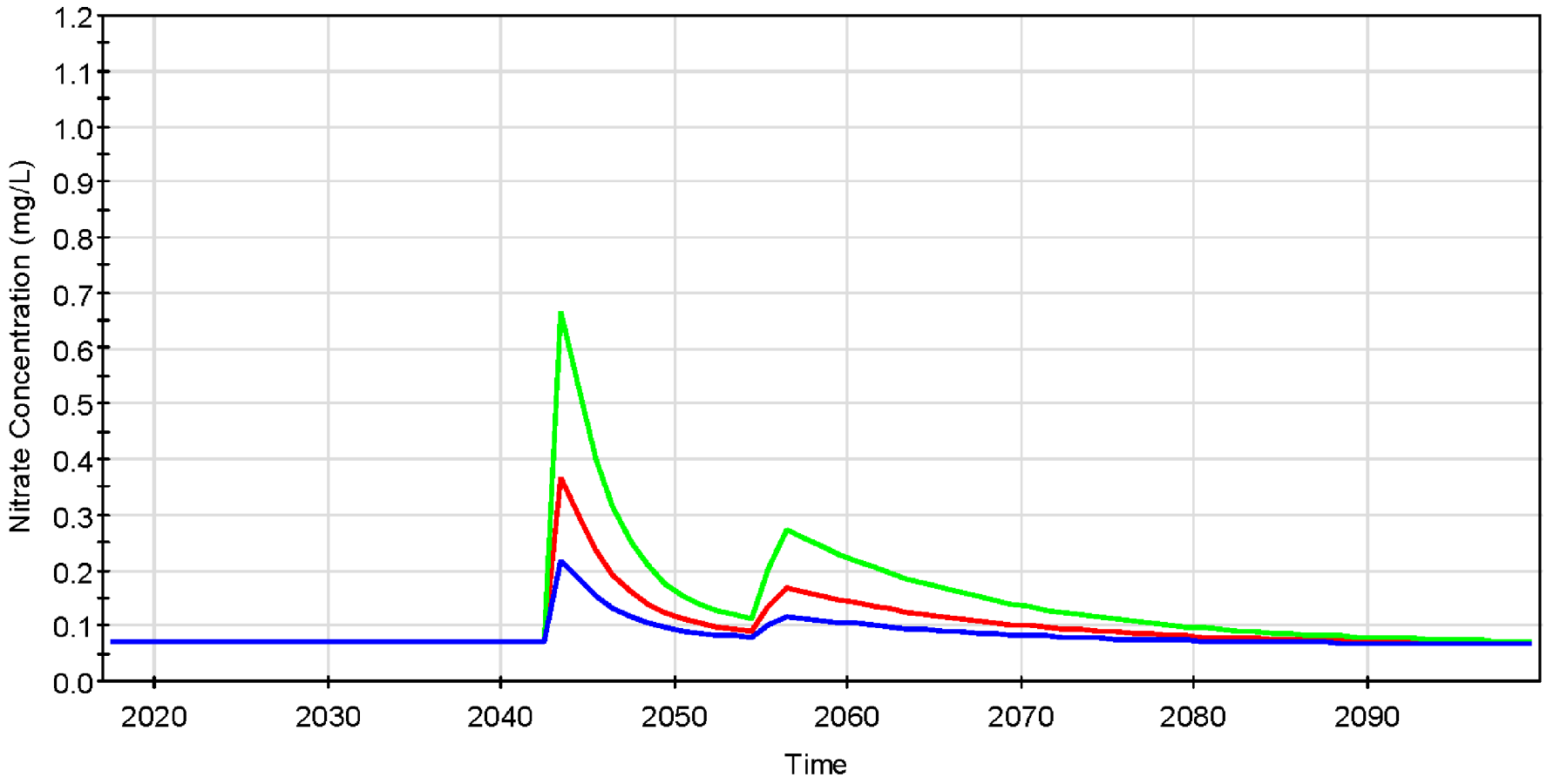
MEMS, 2019

PROJECT: 14-00201
DRAWN BY: JLAMBERTS
CHECKED BY: MB
DATE: JULY 5, 2019

FIGURE
5.15-10

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-15-10 Pit Wall Thickness Sensitivity Test 0-51 14-00201.mxd

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L_GC10

3A Pit Wall Thickness = 1 m

3B Pit Wall Thickness = 2 m

3C Pit Wall Thickness = 0.5 m

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

PIT WALL THICKNESS SENSITIVITY TEST WITH RUNOFF COEFFICIENT OF 0.61

MEMS, 2019

PROJECT: 14-00201

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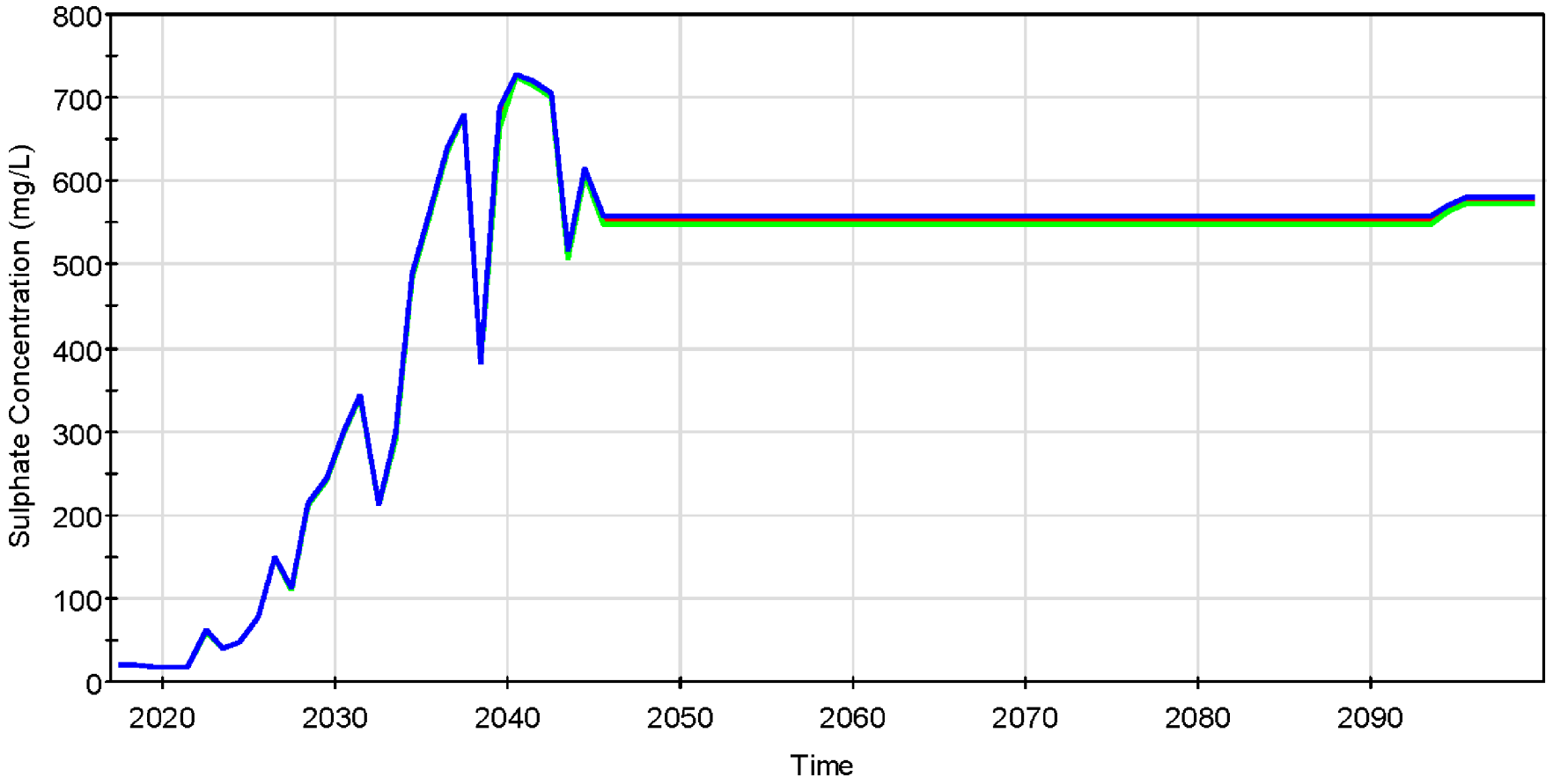
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FIGURE

5.15-11

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L_BC03

4A SZ Leakage Rate Base Case

4B SZ Leakage Rate +25%

4C SZ Leakage Rate -25%

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

SZ LEAKAGE RATE SENSITIVITY TEST WITH RUNOFF COEFFICIENT OF 0.41

MEMS, 2019

PROJECT: 14-00201

DRAWN BY: JLAMBERTS

CHECKED BY: MB

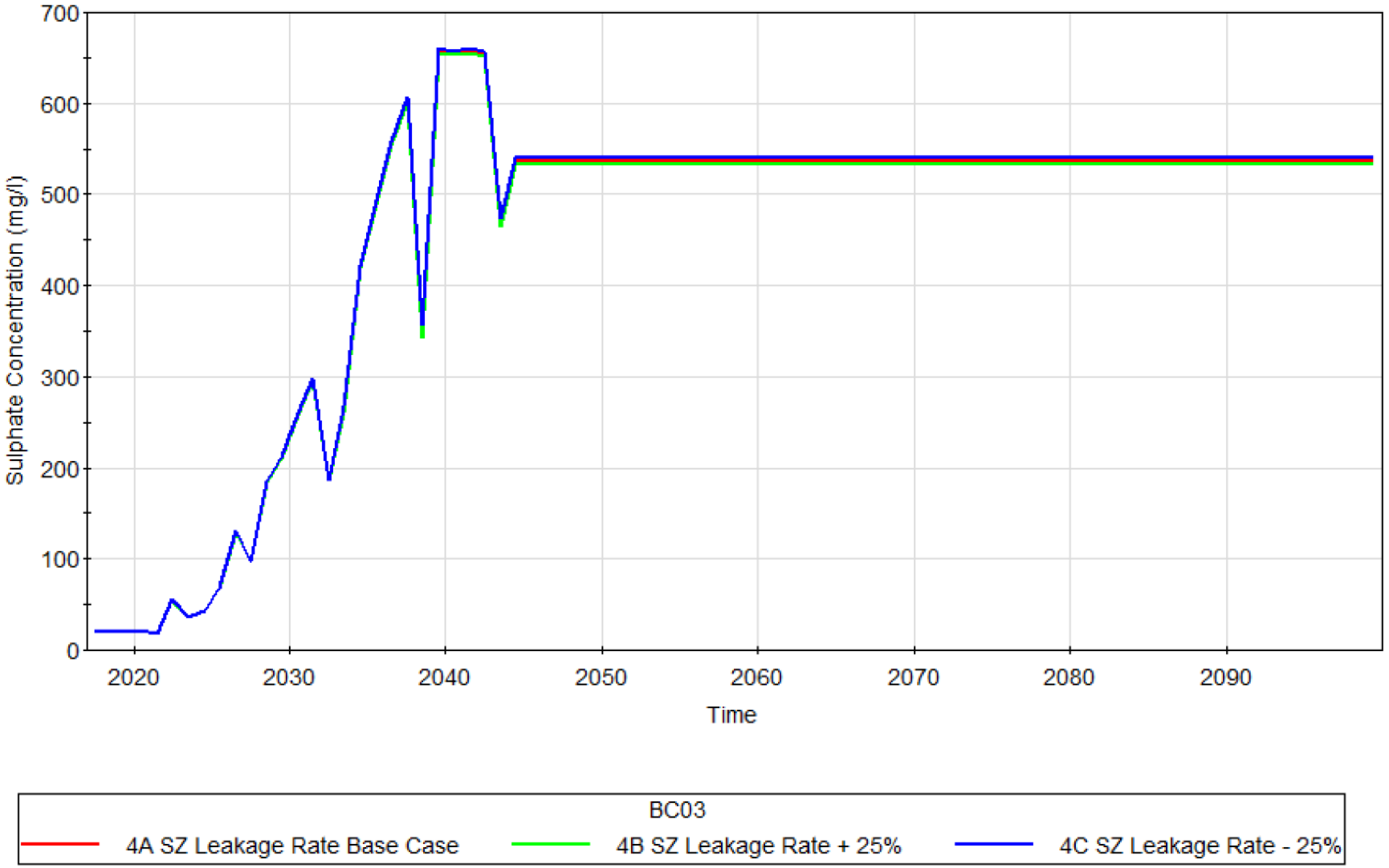
DATE: JULY 7, 2019

FIGURE

5.15-12

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RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

SZ LEAKAGE RATE SENSITIVITY TEST WITH RUNOFF COEFFICIENT OF 0.51

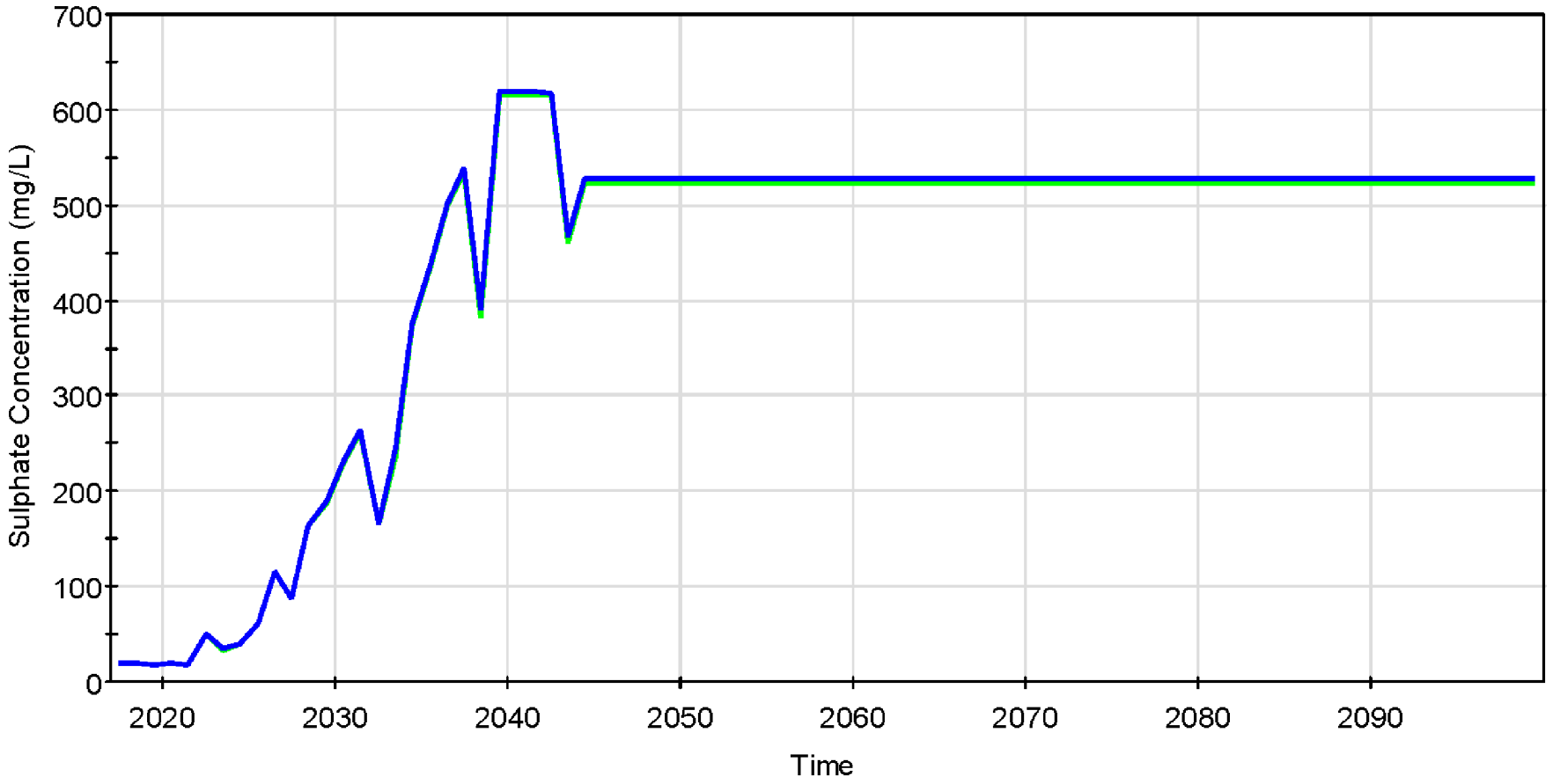
MEMS, 2019

PROJECT: 14-00201
DRAWN BY: JLAMBERTS
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DATE: JULY 7, 2019

FIGURE
5.15-13

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L_BC03

4A SZ Leakage Rate Base Case

4B SZ Leakage Rate +25%

4C SZ Leakage Rate -25%

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

SZ LEAKAGE RATE SENSITIVITY TEST WITH RUNOFF COEFFICIENT OF 0.61

MEMS, 2019

PROJECT: 14-00201

DRAWN BY: JLAMBERTS

CHECKED BY: MB

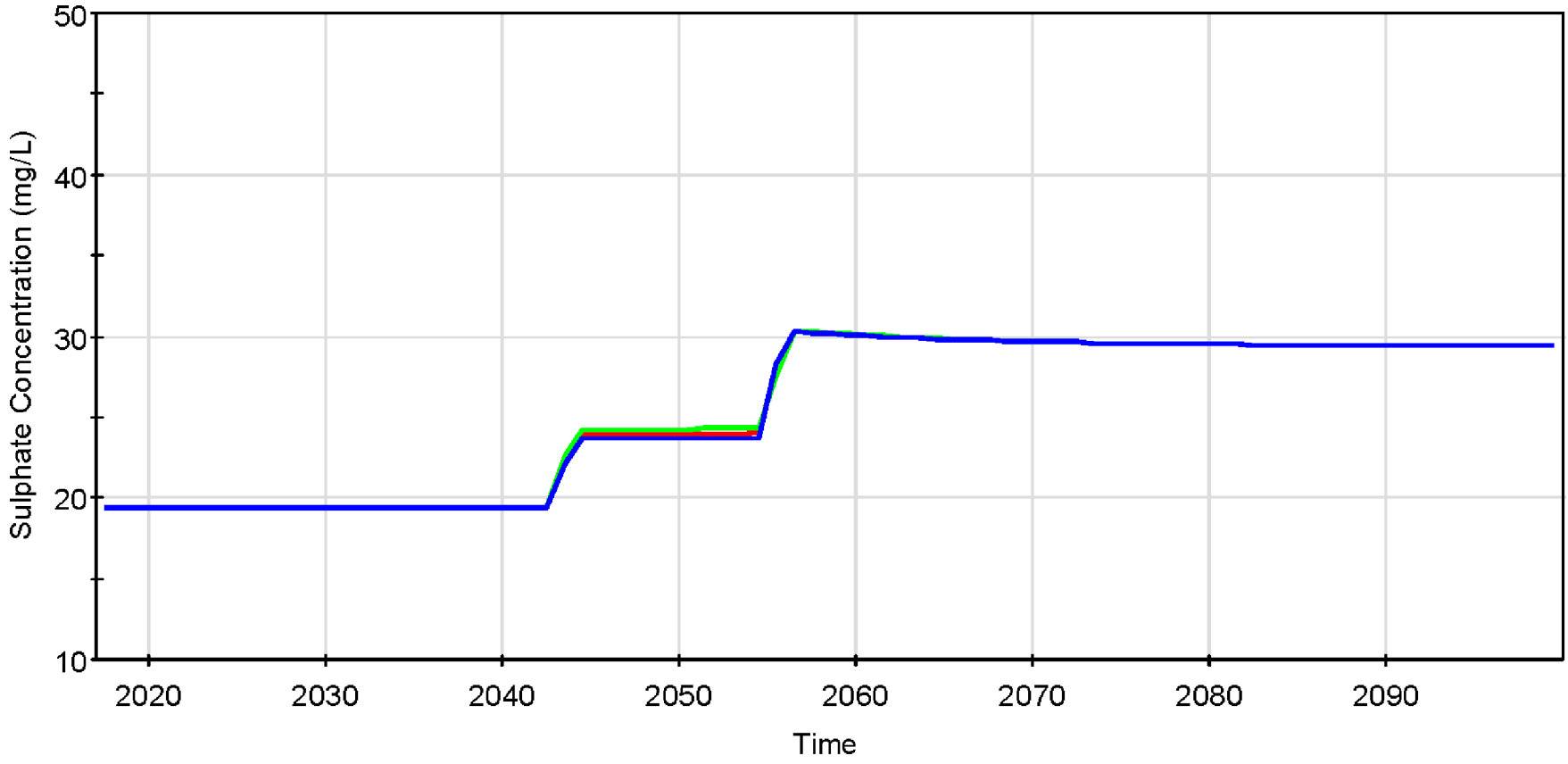
DATE: JULY 7, 2019

FIGURE

5.15-14

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RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

LEAKAGE RATE FROM PIT SENSITIVITY TEST WITH RUNOFF COEFFICIENT OF 0.41

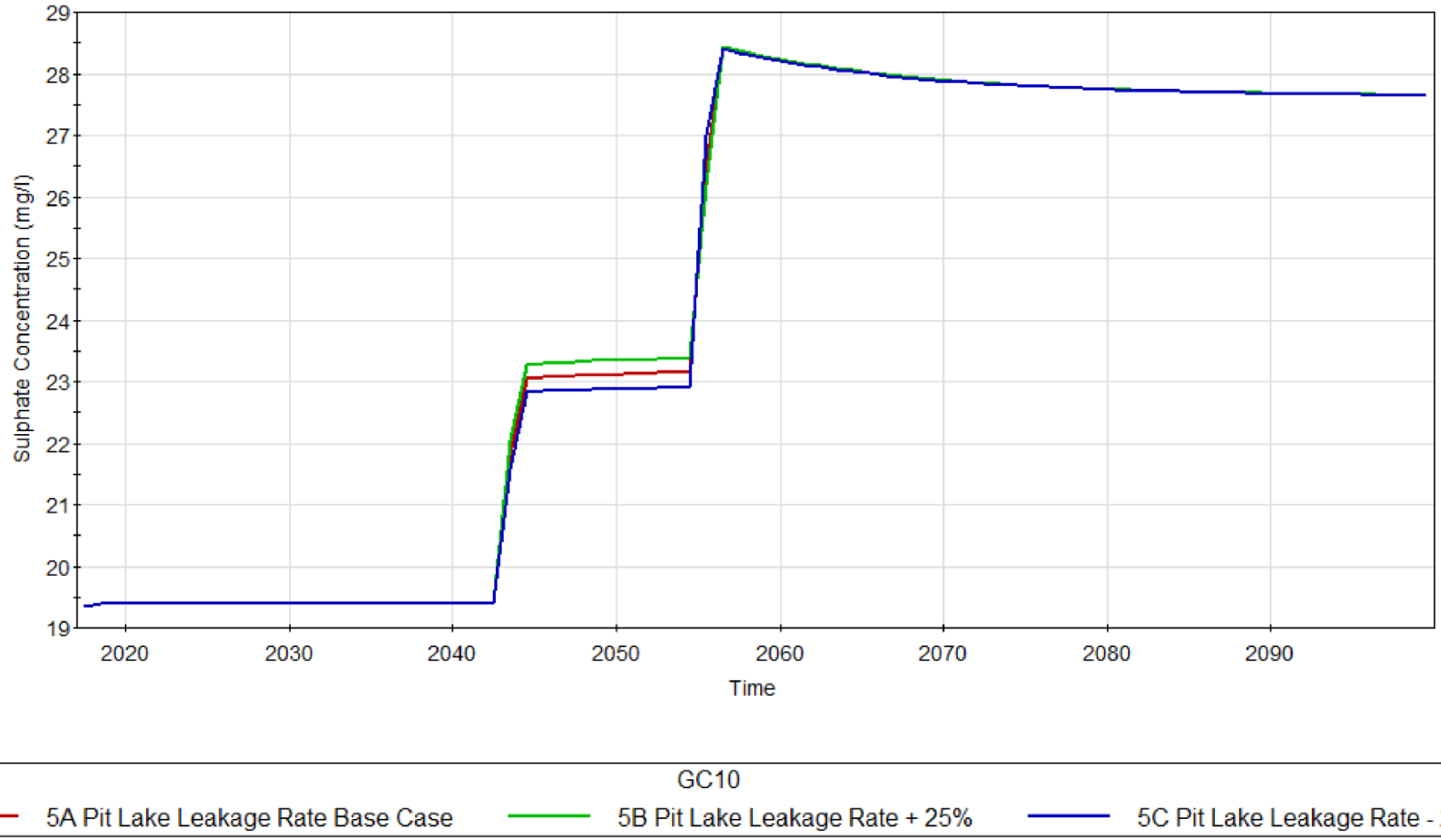
MEMS, 2019

PROJECT: 14-00201
DRAWN BY: JLAMBERTS
CHECKED BY: MB
DATE: JULY 7, 2019

FIGURE
5.15-15

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-15-15 Leakage Rate From Pit Sensitivity 0-41 14-00201.mxd

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RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

LEAKAGE RATE FROM PIT SENSITIVITY TEST WITH RUNOFF COEFFICIENT OF 0.51

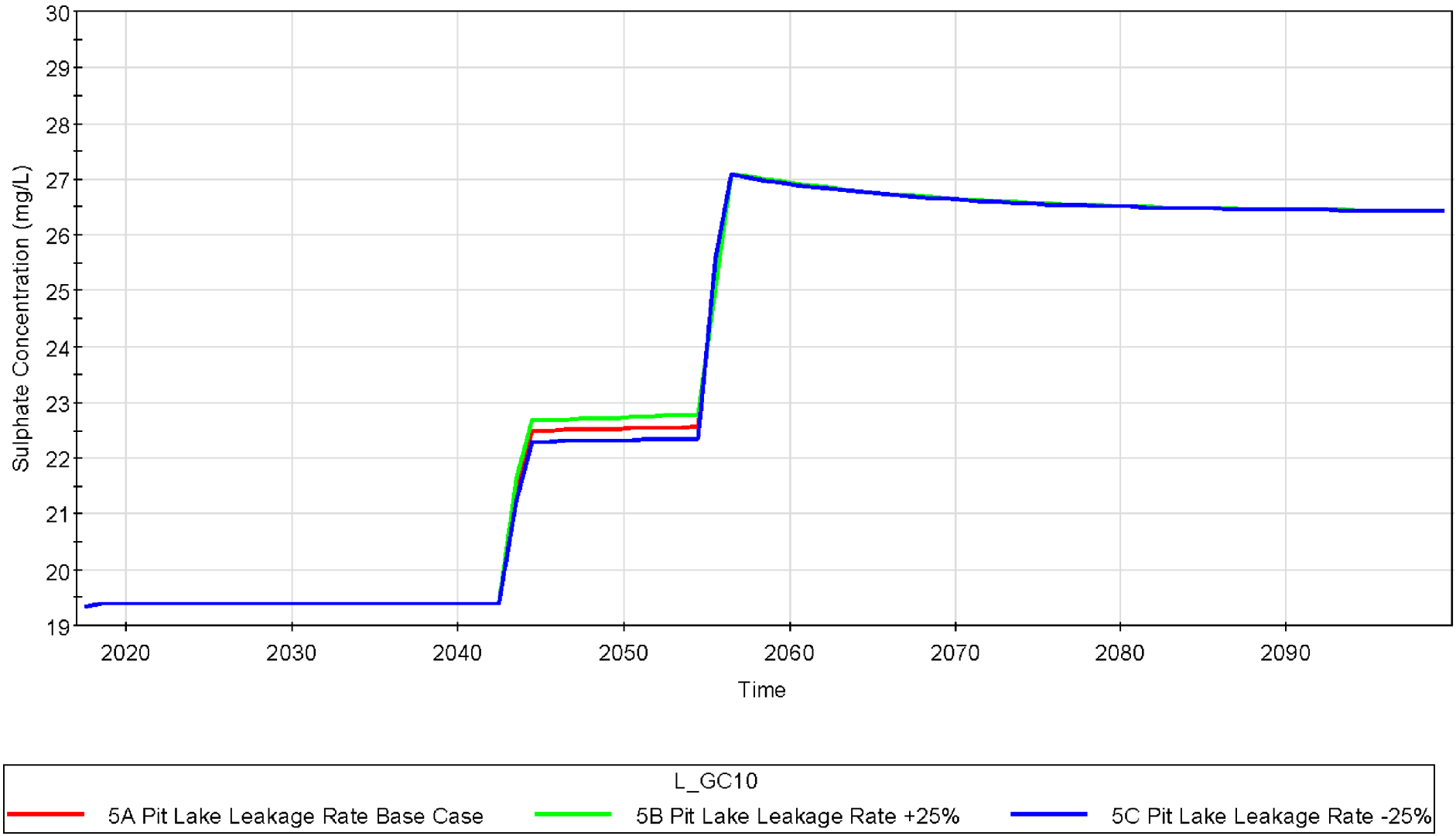
MEMS, 2019

PROJECT: 14-00201
DRAWN BY: JLAMBERTS
CHECKED BY: MB
DATE: JULY 7, 2019

FIGURE
5.15-16

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-15-16 Leakage Rate From Pit Sensitivity 0-51 14-00201.mxd

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RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

LEAKAGE RATE FROM PIT SENSITIVITY TEST WITH RUNOFF COEFFICIENT OF 0.61

MEMS, 2019

PROJECT: 14-00201
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CHECKED BY: MB
DATE: JULY 7, 2019

FIGURE
5.15-17

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-15-17 Leakage Rate From Pit Sensitivity 0-61 14-00201.mxd

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R5 W5M | R4 W5M | R3 W5M | R2 W5M

T9 | T8 | T7

MUNICIPAL DISTRICT OF RANCHLAND NO. 66

MUNICIPALITY OF CROWSNEST PASS

MUNICIPAL DISTRICT OF PINCHER CREEK NO. 9

MUNICIPAL DISTRICT OF PINCHER CREEK NO. 9

Northeast Sedimentation Pond Measurement and Release Point

West Sedimentation Pond Measurement and Release Point

Saturated Backfill Measurement and Release Point

East Sedimentation Pond Measurement and Release Point

Plant Site Sedimentation Pond Measurement and Release Point

Fence-line WA Boundary

Site BC-01 Measurement Point

Site GC-01 Measurement Point

35850

39493

44947

45622

212433

35136

31356

156043

29743

29005

26653

34586

Coleman

Blairmore

	Catchment (km^2)	Mean Annual Flow (m^3/year)	% of Total from Project Area
Project Area to Blairmore Creek	21.87	7,064,010	0.63
Project Area to Gold Creek	12.80	4,134,400	0.37

Total Flow to 1	88.24	28,501,520
Total Flow to 2	283.73	91,644,790
Total Flow to 3	423.45	136,774,350

River Length between 1 and 2	11 km
River Length between 2 and 3	5.5 km
River Length between 2 and 4	1.9 km

Mean Annual Runoff	323 mm, as per hydrology baseline assessment

LEGEND

- Flow/Distance Marker
- Riparian Water Users

Surface Water Licence

- Individual
- Devon Canada Corporation
- Dunn Creek Resources Ltd.
- Lethbridge Area Office
- Municipality of Crowsnest Pass
- Existing Access Road
- Existing Powerline
- CHPP Facilities
- Proposed Water Pipeline/ Service Road
- Railway Loop
- Proposed Helipad Access
- Access Road
- Rail Loadout
- Proposed Haul Road
- Blairmore_Catchment
- Gold_Catchment
- Primary Highway
- Secondary Highway
- Powerline
- Railway
- Watercourse (Definite)
- Watercourse (Indefinite)
- Waterbody (Definite)
- Waterbody (Indefinite)
- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Coal Handling Processing Plant and Infrastructure
- Covered Conveyor, Access Road and Powerline ROW
- Proposed Golf Course Area
- Undisturbed Area
- Legacy Mine Disturbance
- Municipal Boundary

Elkford, Sparwood, Coleman, Blairmore, Cowley, Pincher Creek, British Columbia, Alberta

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

SURFACE WATER LICENSE TRANSFERS AND IMPACTS TO FLOWS

AltaLIS, 2019; MEMS, 2019

Coordinate System: NAD 1983 UTM Zone 11N

0 2 4 Kilometres

MILLENNIUM EMS Solutions Ltd.

PROJECT: 14-00201
DRAWN BY: JLAMBERTS
CHECKED BY: DM
DATE: JULY 9, 2019

FIGURE 5.16-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-16-1 Surface Water Licences 14-00201.mxd

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R4 W5M

R3 W5M

T8

T7

Blairmore Creek

Gold Creek

Crowsnest River

LEGEND

Year

- 2018
- 2019

Proposed Mine Infrastructure

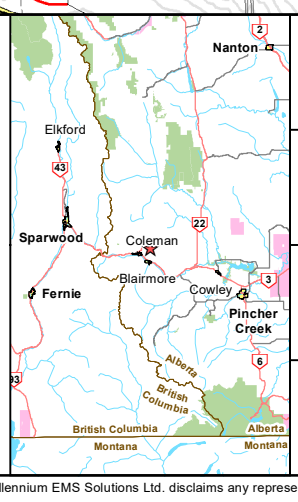
Proposed Pit

Proposed Sedimentation Ponds

Proposed Topsoil Storage

Proposed South Dump

Topographic Contours (20m)



RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

2017 TO 2019 GEOTECHNICAL BOREHOLES

MILLENNIUM EMS Solutions Ltd.

AltaLIS, 2019; MEMS, 2019;
Valtus, 2019 (Image Date: 2009/2010)

Coordinate System: NAD 1983 UTM Zone 11N

0 1 2
Kilometres

PROJECT: 14-00201

DRAWN BY: JLAMBERTS

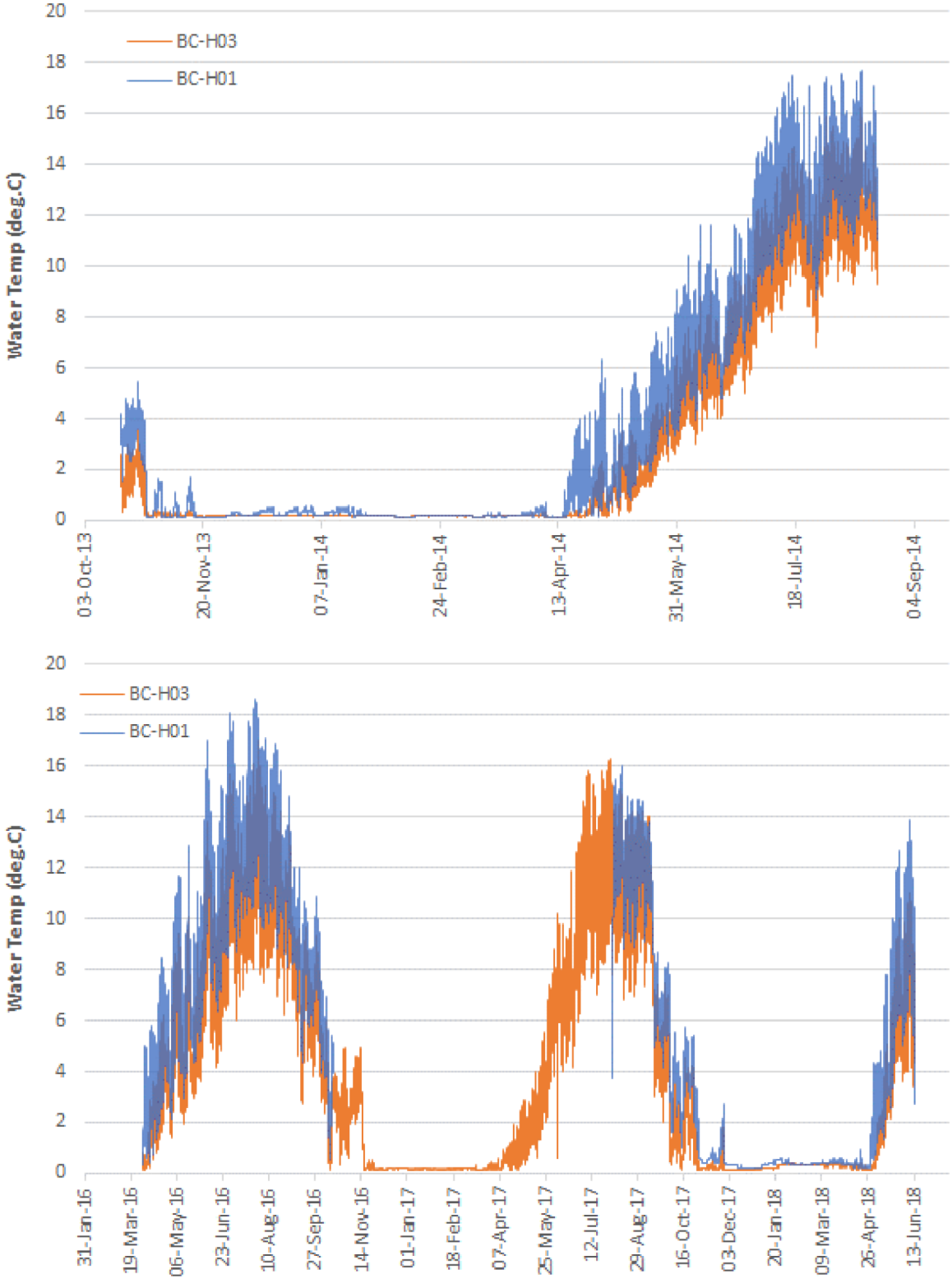
CHECKED BY: MB

DATE: JULY 10, 2019

FIGURE
5-18.1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-18-1 2017 to 2019 Geotechnical Boreholes 14-00201.mxd

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RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

BLAIRMORE AVAILABLE CONTINUOUS WATER TEMPERATURE DATA

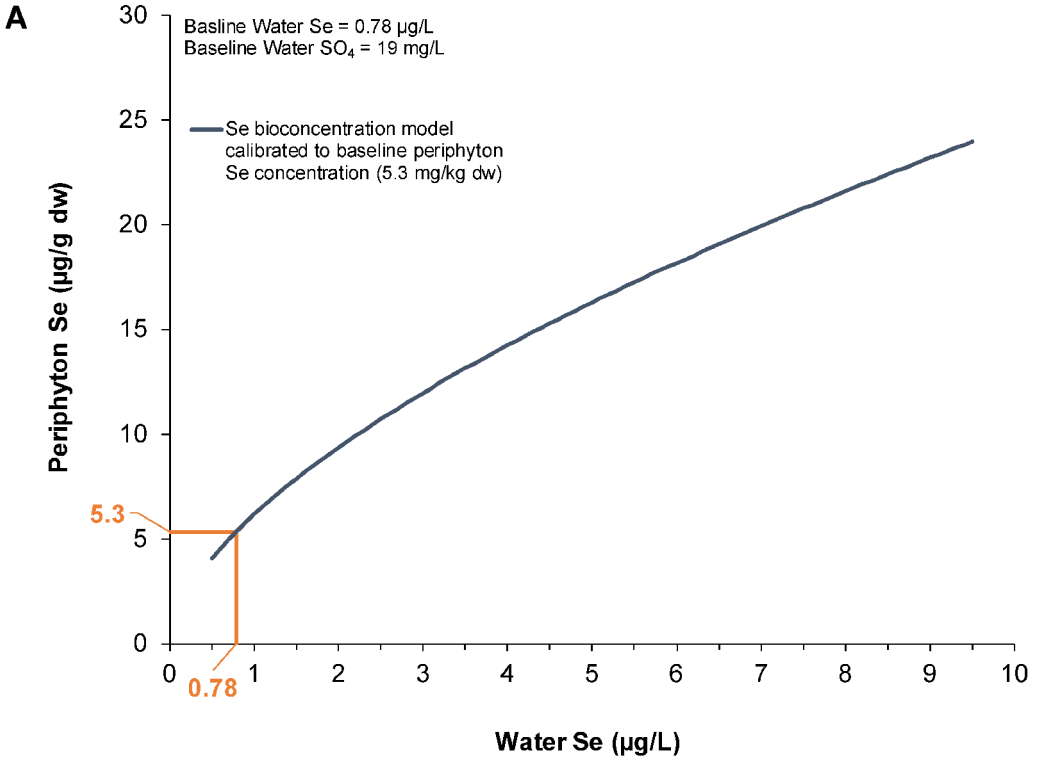
MEMS, 2019

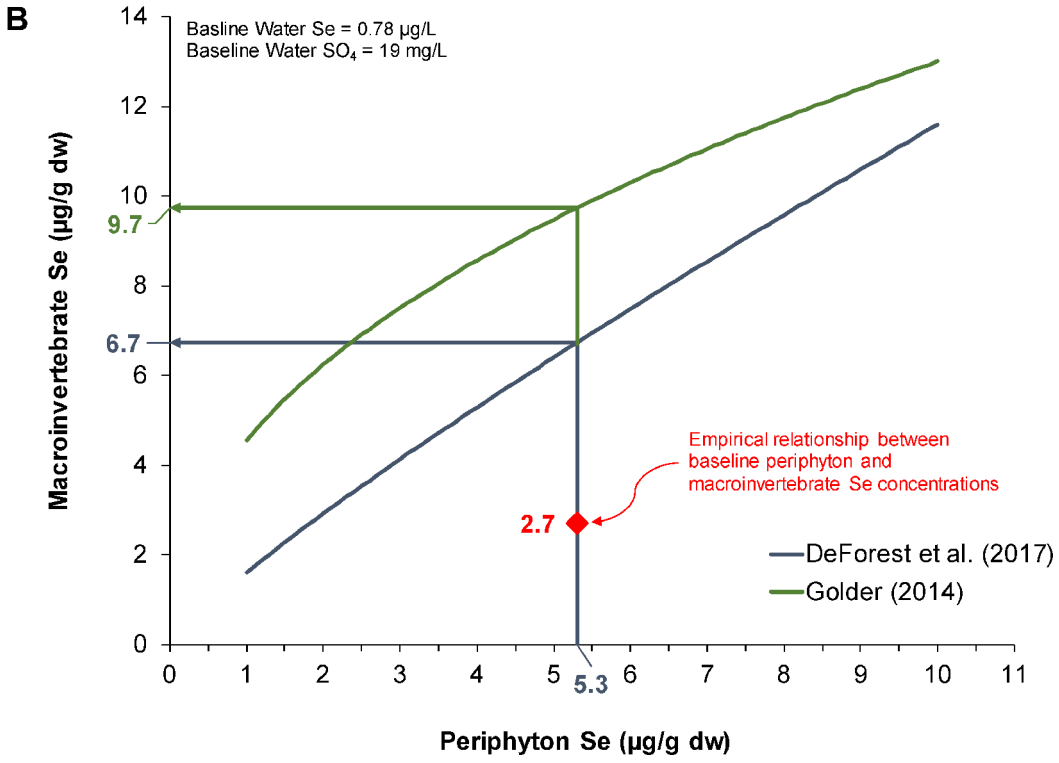
MILLENNIUM EMS Solutions Ltd.

PROJECT:	14-00201
DRAWN BY:	JLAMBERTS
CHECKED BY:	MB
DATE:	JULY 9, 2019
FIGURE	5.20-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-20-1 Blairmore Available Continuous Water Temperature 14-00201.mxd

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RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

SULPHATE-DEPENDENT WATER-TO-PERIPHYTON SELENIUM MODEL CALIBRATED TO BASELINE WATER SE (0.78 µG/L) AND PERIPHYTON SE (5.3 MG/KG DW); AND (B) COMPARISON OF PREDICTED AND OBSERVED BASELINE MACROINVERTEBRATE SE CONCENTRATIONS

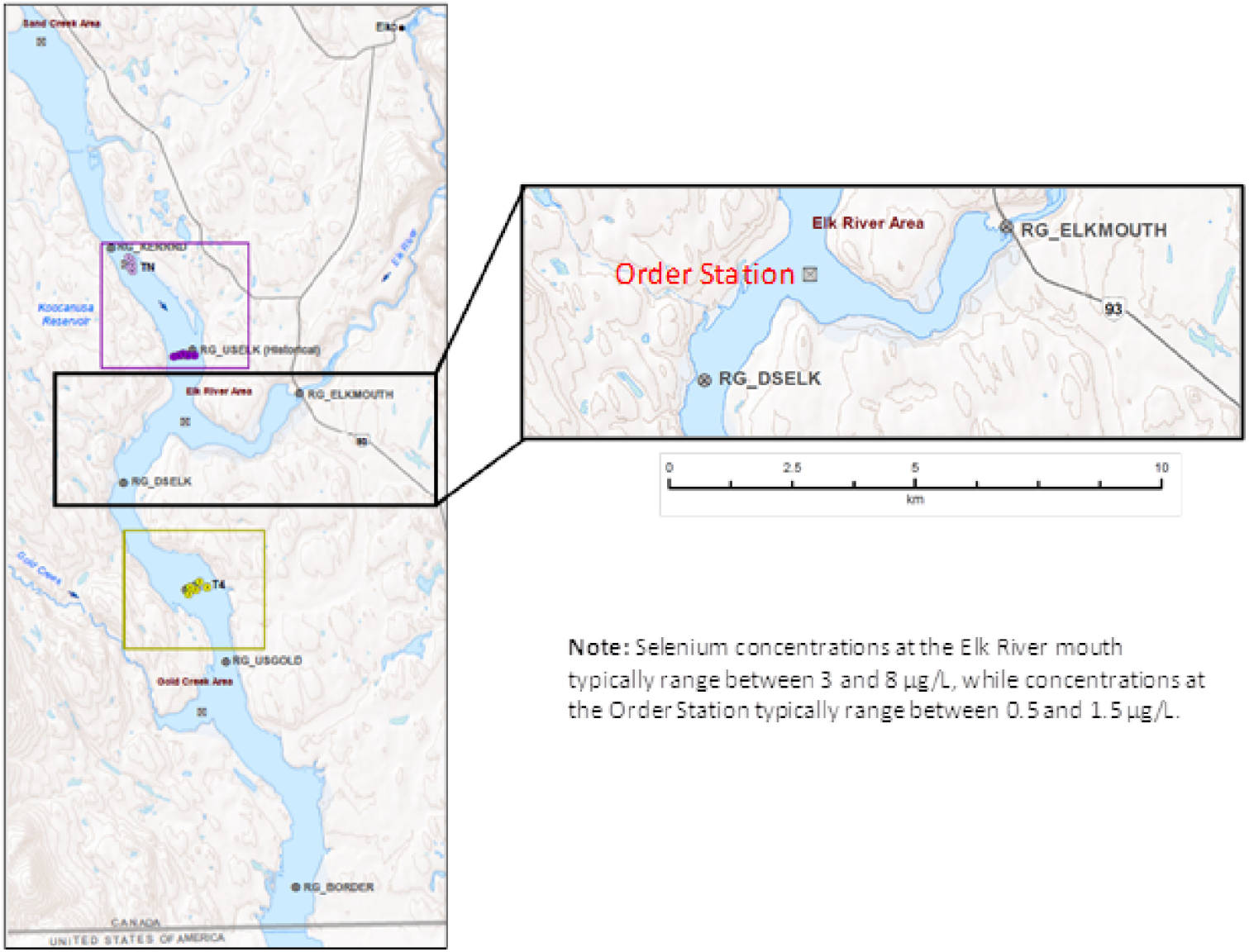
MEMS, 2019

MILLENNIUM EMS Solutions Ltd.

PROJECT:	14-00201
DRAWN BY:	JLAMBERTS
CHECKED BY:	MB
DATE:	JUNE 20, 2019
FIGURE	**5.23-1**

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-23-1 Selenium Model and Se Concentrations 14-00201.mxd

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Note: Selenium concentrations at the Elk River mouth typically range between 3 and 8 µg/L, while concentrations at the Order Station typically range between 0.5 and 1.5 µg/L.

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

MAP OF LAKE KOOCANUSA WITH INSET SHOWING THE SURFACE WATER MONITORING STATION AT THE MOUTH OF THE ELK RIVER (RG_ELKMOUTH) AND THE ORDER STATION

PROJECT:	14-00201
DRAWN BY:	JLAMBERTS
CHECKED BY:	MB
DATE:	JULY 7, 2019

MEMS, 2019

Map adapted from Figure 2.1 in Minnow Environmental (2018)

FIGURE

5.29-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\LanduseResubmission\Information Request 3\Fig 5-9-1 Lake Koocanusa 14-00201.mxd

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R5 W5M | R4 W5M | R3 W5M | R2 W5M | R1 W5M

T9

Line Creek

TECK Elkview and Baldy Ridge Extension Project

Sparwood Ridge

Alexander Creek

Michel Creek Coking Coal Project

Marten Wheeler

Teck Coal Mountain

British Columbia

Alberta

Forestry Trunk Road

Coleman

Blairmore

Frank

Bellevue

Hillcrest

Maycroft

Burmis

Cowley

Beaver Mines

3

22

40

LEGEND

- Gas Plant or Compressor
- Town
- AltaLink Castle Rock Ridge to Chapel Rock Proposed Transmission Line
- Alberta Transportation Highway 3 Realignment
- Primary Highway
- Secondary Highway
- Trail
- Primary Highway
- Railway
- Surface Water Drainage
- Proposed Mine Permit Boundary
- Historic Surface Mine
- Historic Underground Mine
- Michel Creek Coking Coal Project
- Existing TECK Coal Mine Permit and Baldy Ridge Extension
- TECK Conservation Land
- Existing Development/Disturbance
- Forestry Management Unit - C5
- Vegetation and Grizzly RSA
- Aquatic RSA
- Wildlife RSA
- Hydrology RSA
- Forestry - Operations to 2032
- Forestry - Operations to 2045
- BC Private Managed Forest Lands

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

C5 FOREST MANAGEMENT UNIT IN THE REGIONAL STUDY AREAS

AER, 2016; AltaLIS, 2019; MEMS, 2019; NRCAN, 2016; Riversdale, 2016

Coordinate System: NAD 1983 UTM Zone 11N

0 4 8 Kilometres

MILLENNIUM EMS Solutions Ltd.

PROJECT: 14-00201

DRAWN BY: JLAMBERTS

CHECKED BY: TB

DATE: JUNE 18, 2019

FIGURE 5.30-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-30-1 Planned Projects 14-00201.mxd

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R4 W5M

R3 W5M

T9

T8

T7

Gold Creek

Blairmore Creek

Caudron Creek

Morin Creek

Pellet Creek

Green Creek

Coleman

Blairmore

Crowsnest River

York Creek

Lyons Creek

Blairmore Creek

Gold Creek

Blairmore Creek

Crowsnest River

Status End of Year 15	AREA (ha)
Unreclaimed or Disturbed	681.4
Levelled	147.9
Soil Placement	61.3
Revegetation	148.6
Reforestation	329.4
Decommission	64.8
Conveyor and Access Road	15.2
Water Management	40.9
Selenium Management	31.3
Total	**1520.7**

LEGEND

- Powerline
- Railway
- Secondary Road
- Gravel Road
- Trail/Winter/Unimproved Road
- Watercourse (Definite)
- Watercourse (Indefinite)
- Waterbody (Definite)
- Waterbody (Indefinite)
- Proposed Mine Permit Boundary
- Undisturbed Area

Reclamation Progression

- Conveyor and Access Road
- Decommission and Plant Site
- Levelled
- Unreclaimed or Disturbed
- Reforestation
- Revegetation
- Selenium Management
- Soil Placement
- Water Management

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MINE FINANCE SECURITY PROGRAM YEAR 15 EVALUATION

MILLENNIUM EMS Solutions Ltd.

AltaLIS, 2019; MEMS, 2019

Coordinate System: NAD 1983 UTM Zone 11N

PROJECT:	14-00201
DRAWN BY:	JLAMBERTS
CHECKED BY:	DM
DATE:	MAY 31, 2019

0 1 2 Kilometres

FIGURE 5.33-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig X Security Year 15 Evaluation 14-00201.mxd

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R4 W5M

R3 W5M

T9

T8

T7

Gold Creek

Blairmore Creek

Pellatier Creek

Morin Creek

Caudron Creek

Green Creek

Crowsnest River

York Creek

Lyons Creek

Nez Perce Creek

Project Area (ha)	Slope Categories (degrees)				
	0 – 5°	5 – 23°	23 - 27°	Highwalls	Total (ha)
Unreclaimed or Disturbed	281.6	346.9	23.0	29.8	**681.3**
Decommission	23.3	41.5	0.0	0.0	**64.8**
Conveyor and Access Road	5.7	9.5	0.0	0.0	**15.2**
Water Management	17.2	23.5	0.2	0.0	**40.8**
Selenium Management	23.0	8.3	0.1	0.0	**31.3**
Total (ha)	**350.7**	**429.7**	**23.2**	**29.8**	**833.4**

LEGEND

- Reclaimed Topographic Contour (20m interval)
- Powerline
- Railway
- Secondary Road
- Gravel Road
- Trail/Winter/Unimproved Road
- Watercourse (Definite)
- Watercourse (Indefinite)
- Waterbody (Definite)
- Waterbody (Indefinite)
- Proposed Mine Permit Boundary
- Undisturbed Area
- End-Pit Lake
- Previously Levelled

Slope Degrees

- 0 - 5
- 5 - 23
- 23 - 27
- Highwall

Reclamation Progression

- Conveyor and Access Road
- Decommission and Plant Site
- Levelled
- Unreclaimed or Disturbed
- Selenium Management
- Water Management

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

SLOPE CATEGORIES

MILLENNIUM EMS Solutions Ltd.

AltaLIS, 2019; MEMS, 2019

Coordinate System: NAD 1983 UTM Zone 11N

PROJECT: 14-00201

DRAWN BY: JLAMBERTS

CHECKED BY: DM

DATE: JUNE 7, 2019

FIGURE

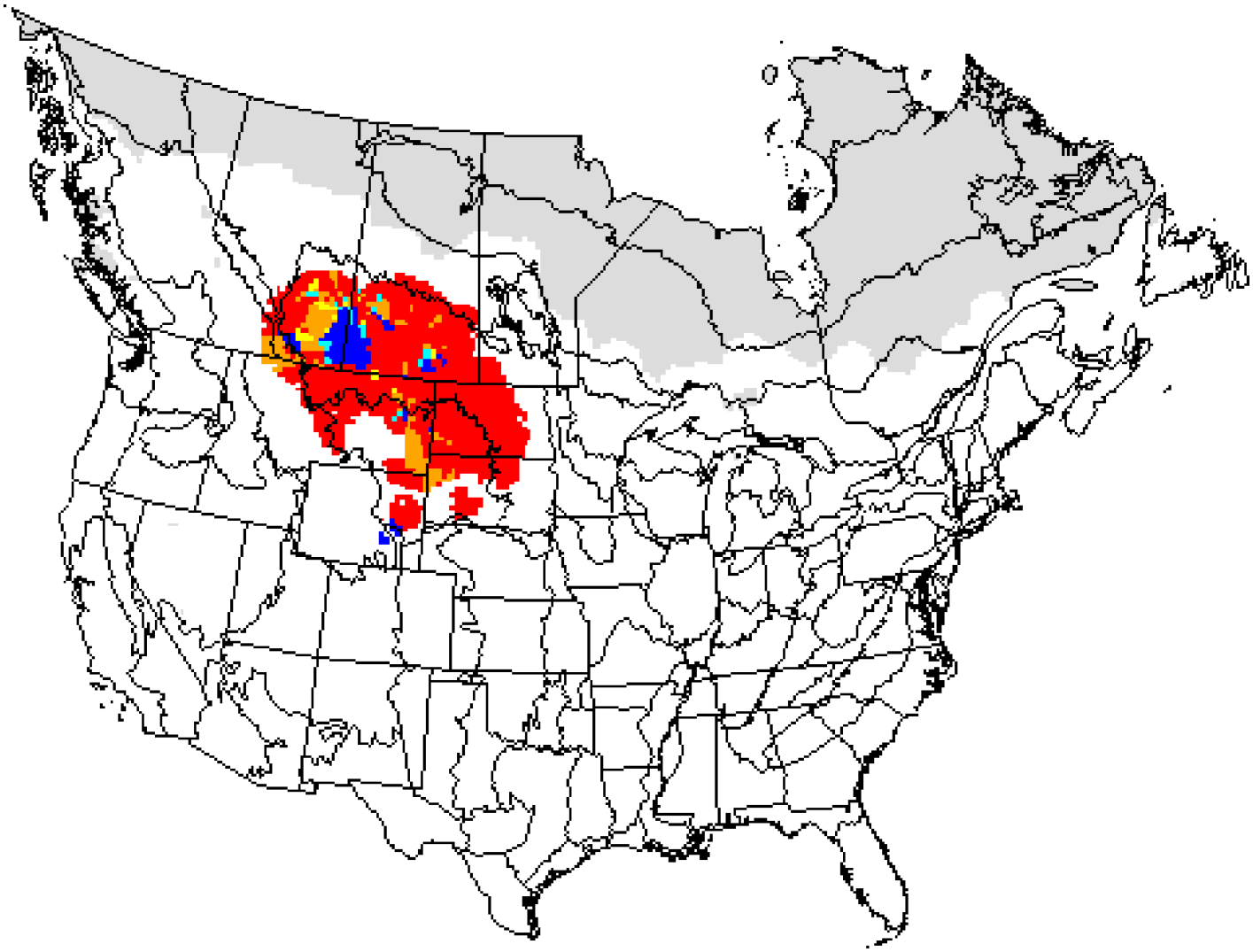
5.33-2

0 1 2

Kilometres

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig X Security Year 15 Slope Categories 14-00201.mxd

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LEGEND

Percent Change per Year

- Less than -1.5
- -1.5 to -0.25
- > -0.25 to 0.25
- > 0.25 to +1.5
- Greater than +1.5

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

NORTH AMERICAN BREEDING BIRD SURVEY TREND MAP FOR THE BAIRD'S SPARROW, 1966-2015

Patuxent Wildlife Research Center, 2019

MILLENNIUM EMS Solutions Ltd.

PROJECT: 14-00201

DRAWN BY: JLAMBERTS

CHECKED BY: TB

DATE: JUNE 25, 2019

FIGURE

5.34-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-34-1 Bairds Sparrow Breeding Survey 14-00201.mxd

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LEGEND

- Breeding Range
- Wintering Range

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

THE BREEDING AND WINTER WINTERING RANGES OF BAIRD'S SPARROW

MILLENNIUM EMS Solutions Ltd.

COSEWIC, 2012

PROJECT: 14-00201

DRAWN BY: JLAMBERTS

CHECKED BY: TB

DATE: JUNE 25, 2019

FIGURE

5.34-2

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-34-2 Bairds Sparrow Breeding and Wintering 14-00201.mxd

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R6 W5M | R5 W5M | R4 W5M | R3 W5M | R2 W5M | R1 W5M | R30 W4M | R29 W4M | R28 W4M

T10 | T9 | T7 | T6 | T5 | T4 | T3

Don Getty Wildland
Mt. Livingstone
Willow Creek
Livingstone Falls
Beehive
Honeymoon Creek
Bob Creek Wildland
British Columbia
Alberta
Oldman River North
Black Creek
Dutch Creek
Racehorse
Maycroft
22
PEIGAN TIMBER LIMIT 147B
Chinook
Crowsnest Pass
40
Island Lake
Coleman
Blairmore
3A
Lundbreck Falls
Cowley
Oldman Dam
3
PIKANI RESERVE NO. 147
Pincher Creek
Lynx Creek
Castle Falls
1635
Castle River Bridge
Beauvais Lake
Syncline
Beaver Mines Lake
West Castle Wetlands
British Columbia
Alberta

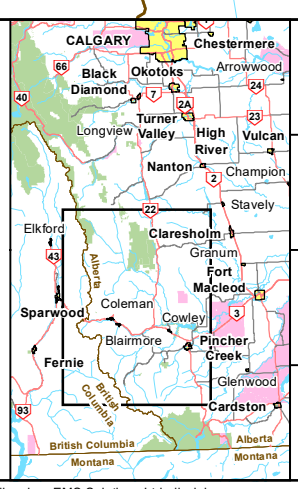
LEGEND

- ABMI Sample Site Location
- Primary Highway
- Secondary Highway
- Watercourse

Breeding Bird Survey Route

- 04-205 Coleman
- 04-304 Summerview
- 04-404 Trout Creek

- Waterbody
- Populated Place
- Indian Reserve/Metis Settlement
- Park/Protected Area
- Grizzly Bear Regional Study Area
- Project Location
- Wildlife Regional Study Area
- Wildlife Local Study Area
- Provincial Boundary



RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

BREEDING BIRD SURVEY ROUTES AND ABMI SAMPLE SITES IN THE VICINITY OF THE PROJECT

ABMI, 2019; AltaLIS, 2019; MEMS, 2019

Projection/Datum: UTM Zone 11 Nad 83

0 10 20
Kilometres

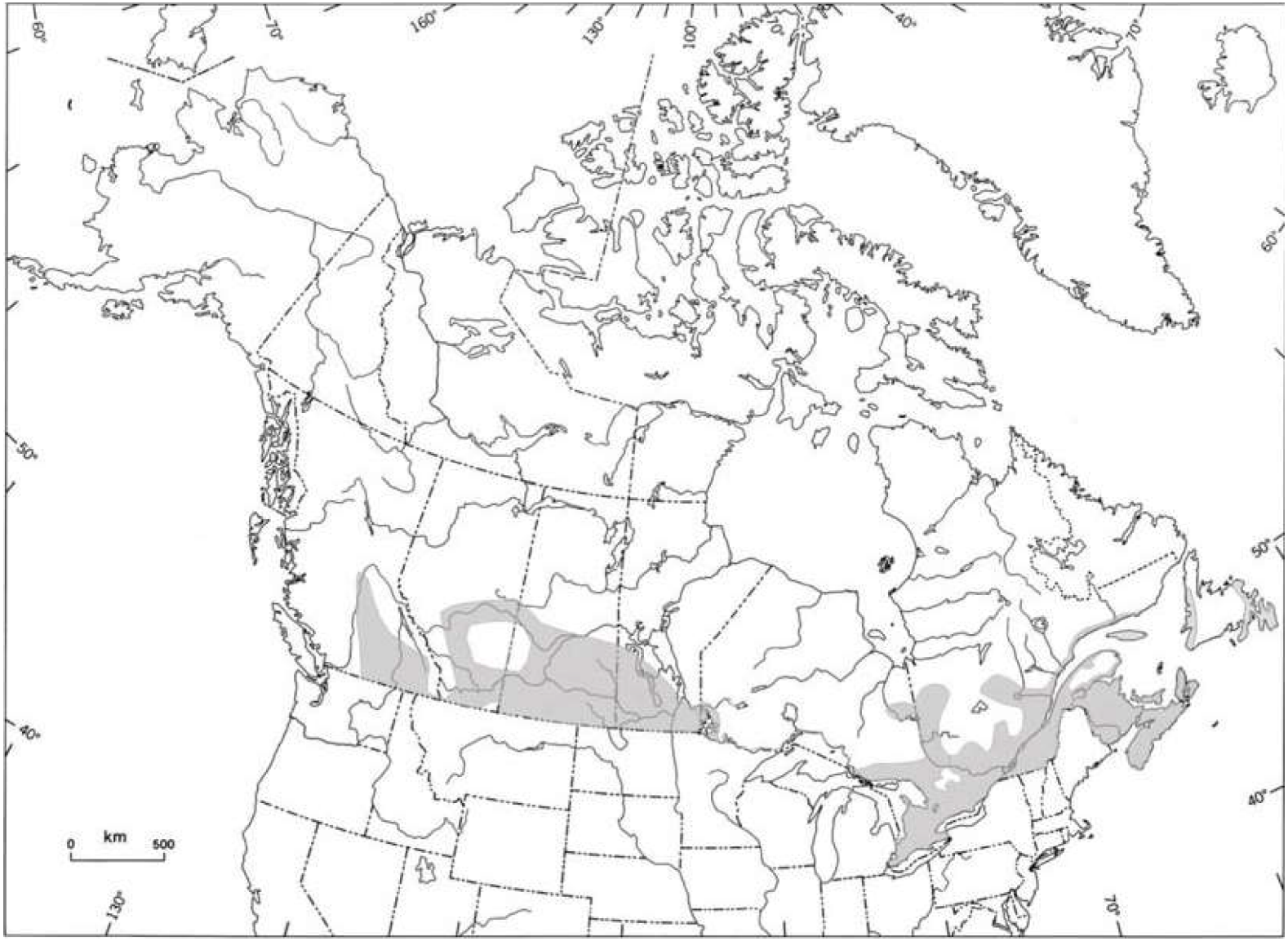
MILLENNIUM EMS Solutions Ltd.

PROJECT: 14-00201
DRAWN BY: JL
CHECKED BY: TB
DATE: JUNE 25, 2019

FIGURE
5.34-3

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-34-3 BBS ABMI 14-00201.mxd

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LEGEND

Bobolink Breeding Range

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

DISTRIBUTION OF THE BOBOLINK IN ALBERTA

COSEWIC, 2010

MILLENNIUM EMS Solutions Ltd.

PROJECT: 14-00201

DRAWN BY: JLAMBERTS

CHECKED BY: TB

DATE: JUNE 20, 2019

FIGURE

5.35-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-35-1 Distribution of Bobolink 14-00201.mxd

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R5 W5M | R5 W5M | R4 W5M | R3 W5M | R3 W5M | R2 W5M | R1 W5M

T11 | T10 | T9 | T8 | T7 | T6 | T5 | T4

Line Creek

TECK Elkview and Baldy Ridge Extension Project

Sparwood Ridge

Marten Wheeler

Teck Coal Mountain

Maycroft

Coleman

Blairmore

Frank

Bellevue

Hillcrest

Burmis

Cowley

Beaver Mines

A B C D E F G H I J K

GAS PLANT AND COMPRESSORS

LABEL	OWNER	DESCRIPTION
A	Devon	Multiwell Gas Battery 02-19-011-03 W5M
B		Compressor Station 04-13-009-04 W5M
C	Harvest Operations Corp.	Burmis Gas Test Battery 12-19-007-02 W5M
D	HOC Energy Corp.	Single Well Gas Battery 10-07-006-02 W5M
E	Legacy Oil & Gas Inc.	Gas Single-Well Battery 13-35-007-03 W5M
F	Nova Gas Transmission Ltd.	Interconnect 01-15-008-05 W5M
G	Shell Canada Limited	Interconnect 09-11-008-05 W5M
H		Single Well Gas Battery 10-01-006-03 W5M
I		Compressor Station 06-12-006-03 W5M
J		Multiwell Gas Battery 02-20-006-03 W5M
K		Gas Gathering System 16-07-007-02 W5M

LEGEND

- Gas Plant or Compressor
- Old Water Supply Dam
- Lost Lemon Campground
- Powderkeg Ski Resort
- Town
- Primary Highway
- Secondary Highway
- Trail
- Primary Highway
- Railway
- Surface Water Drainage
- AltaLink Castle Rock Ridge to Chapel Rock Proposed Transmission Line
- Alberta Transportation Highway 3 Realignment
- Regional Study Area
- Proposed Mine Permit Boundary
- Existing Golf Course Area
- Proposed Golf Course Area
- Provincial Border
- Historic Surface Mine
- Historic Underground Mine
- Michel Creek Coking Coal Project
- Existing TECK Coal Mine
- Forestry - Operations to 2032
- Forestry - Operations to 2045
- Existing Development/Disturbance

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

EXISTING AND PLANNED PROJECTS WITHIN THE VICINITY OF THE PROPOSED PROJECT

AltaLIS, 2019; MEMS, 2019; NRCAN, 2019; Riversdale, 2016

Coordinate System: NAD 1983 UTM Zone 11N

0 4 8
Kilometres

MILLENNIUM EMS Solutions Ltd.

PROJECT: 14-00201
DRAWN BY: JLAMBERTS
CHECKED BY: TB
DATE: JUNE 20, 2019

FIGURE
5.41-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-41-1 Planned Projects 14-00201.mxd

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APPENDIX 5.4-1: DRAFT FISHERIES AND AQUATIC MONITORING PLAN

Draft Fisheries and Aquatics Monitoring Program

Benga Mining Limited
Grassy Mountain Coal Project

July 2019

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1.0 INTRODUCTION

Benga Mining Limited (Benga) proposes to develop the Grassy Mountain Coal Project (the Project), located in southwestern Alberta. The Project will involve a surface open pit mine for metallurgical (steelmaking) coal, a coal handling and preparation plant (CHPP) with associated infrastructure, an overland conveyor system, which will parallel an existing high-grade access corridor and connect to a rail load-out facility, and a new section of rail track. The Project is currently undergoing a federal Environmental Assessment (EA) in accordance with *Canadian Environmental Assessment Act* (CEAA 2012), as well as a provincial EA under the *Environmental Protection and Enhancement Act* (EPEA).

As part of the Application, an aquatic effects assessment (CR#6/CEAR #44) was completed focusing on Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*; WSCT), which was identified as the primary aquatic ecology valued component (VC). WSCT is listed as threatened under the federal Species at Risk Act (SARA) and Gold Creek and Blairmore Creek watersheds contain watercourses and parts of watercourses identified as critical habitat for WSCT (DFO 2014). In November 2015, Fisheries and Oceans Canada (DFO) issued a formal habitat protection order under SARA for the designated areas identified in the Gold Creek watershed.

The following draft Fisheries and Aquatics Monitoring Program (the Program) has been developed for the Project aimed to verify predicted potential effects to WSCT in Consultant Report #5 (CEAR #42) and Consultant Report #6 (CEAR #44) as well as respond to the Joint Review Panel (JRP) information request (IR) 5.4 (JRP IR-5.4), which requested a draft aquatic monitoring, mitigation and adaptive management plan.

1.1 Purpose

The purpose of this overarching Program is to provide an approach to identify any Project-related effects to WSCT that are different than the predictions made during the environmental impact assessment (EIS), evaluate mitigation effectiveness through monitoring and adapt mitigation as necessary and possible based on monitoring results. The Program also provides information on the roles and responsibilities of Benga's employees and contractors and how monitoring results will be communicated to appropriate stakeholders.

This draft Program has been prepared using the most current information available to date regarding mitigation, monitoring and adaptive management related to the Project. Finalization of the draft Program will occur following additional consultation with regulators, Indigenous communities and stakeholders and is an anticipated requirement of the EPEA approval condition, should the Project be

approved. It is anticipated that this draft Program will be periodically updated and reviewed as per expected EPEA approval conditions.

1.2 Limitations

The final version of this Program will incorporate information that is not currently available, including the JRP Report, the Decision Statement, future stages of Project planning and feedback from Indigenous communities and stakeholders. Benga expects that finalization of this Program will involve the following steps, which are not necessarily sequential, and which may result in changes to the structure of this document.

- receive the JRP Report and Minister's Decision Statement following the JRP Hearing;
- receive the Alberta EPEA approval with conditions;
- understand the current state of relevant provincial and federal regulations and relevant guidelines to be addressed in the Program;
- continue engaging with regulators, Indigenous communities and stakeholders to develop more clarity around the indicators, metrics and thresholds or objectives to be used to evaluate mitigation effectiveness;
- finalize details of this Program considering future stages of Project planning and engineering, including technical, environmental and commercial details; and
- review final Program with regulators, Indigenous communities and stakeholders prior to finalization and submission to appropriate regulators as an anticipated condition of an EPEA approval.

2.0 OVERVIEW

The Fisheries and Aquatics Monitoring Program has been developed to address the following criteria:

1. Validate and verify the predicted Project residual effects to WSCT;
2. Decrease uncertainty and improve scientific understanding, following the Precautionary Approach; and
3. Ensure the population and distribution objectives of the WSCT Recovery Strategy (DFO 2014, 2019) are being met; and
4. Ensure the persistence and recovery of WSCT.

The EIS (CR#6) identified that WSCT population trends could be potentially influenced by the Project through Project footprint interactions, changes in water resources (groundwater and surface water), fluvial geomorphology (fish habitat), food supply (drift invertebrates), and water quality. After the

application of mitigation, the aquatic effects assessment predicted two Project residual effects, which will be counterbalanced through the Fisheries Offsetting Plan. They consisted of:

- changes to tributary and mainstem aquatic and/or riparian habitat resulting from the Project footprint; and
- changes to hydrology in Gold and Blairmore creeks potentially affecting WSCT habitat.

This Program has been developed to confirm that no additional effects are residual. An overview of the potential Project effects to WSCT and their linkages to the components of this draft Fisheries and Aquatics Monitoring Program is provided in Figure 2.0-1.

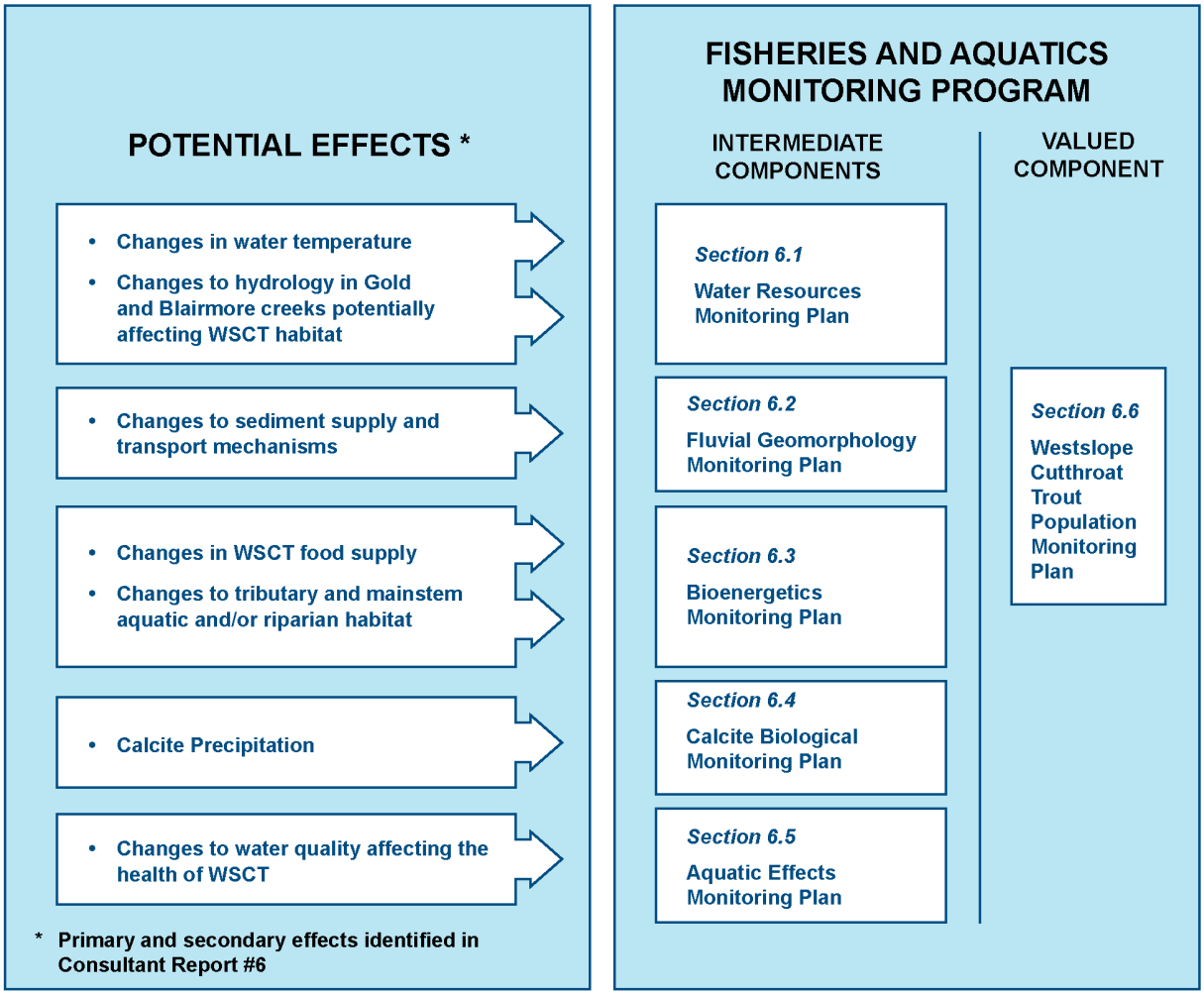


Figure 2.0-1 Linkage between potential effects to WSCT and the Fisheries and Aquatics Monitoring Program

2.1 Description of Receiving Environments

The Project is to be located along the eastern edge of the Rocky Mountain foothills approximately 90 km southwest of Fort McLeod, Alberta, in the municipality of Crowsnest Pass. The Project is situated on a ridge that divides the Blairmore Creek and Gold Creek Watersheds, with Blairmore Creek draining the west slopes and Gold Creek draining the east slopes. Blairmore and Gold creeks are both third order streams that flow in a generally southward direction to join the Crowsnest River, which eventually flows into the Oldman River. The mainstem of Blairmore Creek flows approximately 12.1 km through a watershed covering an area of approximately 50 km^2. The mainstem of Gold Creek is approximately 15.4 km long and has a watershed area of approximately 60 km^2. The Project is to be located in the Northern Continental Divide Ecoregion and in the Rocky Mountains Front Range Physiographic Region. Blairmore and Gold creek watersheds contain watercourses that DFO (2014) and Alberta Westslope Cutthroat Trout Recovery Team (2013) have designated as critical habitat for the Alberta population of WSCT.

3.0 REGULATORY STATUES, APPROVALS AND GUIDELINES

The Regulations, Approvals and Guidelines section of the Program will list relevant provincial and federal regulations, guidelines and approval conditions relevant to fisheries and aquatics mitigation and monitoring and provide a concordance of how they are addressed in the Program. In addition to the regulations and approvals listed above, the following guidelines were also used to shape the Fisheries and Aquatics Monitoring Program. They included

- *Fisheries Act*, including anticipated Coal Mining Effluent Regulation;
- *Species at Risk Act* (SARA);
- WSCT Recovery Strategy (DFO 2014), including population distribution objectives;
- Draft WSCT Recovery Strategy (DFO 2019);
- *Precautionary Principles*; and
- *Environmental Protection and Enhancement Act* (EPEA).

4.0 INDIGENOUS CONSULTATION

Indigenous consultation to date has focused on identifying traditional knowledge and valued components (VCs) related to fisheries, aquatic environment and water itself. This has been used as input into the EIS and the development of the Project.

Going forward, Benga has committed to developing an Indigenous monitoring program in cooperation with nearby First Nations to work in parallel with other western science-based monitoring programs. In addition, Benga will consult with Indigenous groups in developing all of

the monitoring programs through a series of workshops. Benga has committed to providing Annual Reporting documents to Indigenous groups highlighting the results from the monitoring programs and seeking any input that would help Benga improve monitoring and the effectiveness of mitigation measures.

5.0 MITIGATION PROGRAM

A mitigation program has been developed to minimize or eliminate potential effects to WSCT, as outlined in Table 5.0-1. Benga has already committed to these mitigation measures and expects that they would become part of the anticipated EPEA approval for the Project. Table 5.0-1 summarizes the objectives and planned mitigation of the mitigation program.

Table 5.0-1 Potential Project effects and mitigation

Potential Project Effects	Mitigation Objectives	Mitigation
Changes in water temperature, which may cause changes to the thermal regime, affecting WSCT habitat quantity and suitability	Minimize or eliminate changes in water temperature	• Maintain appropriate riparian reserves and management zones from watercourses, where feasible • Construction of online settling ponds for clean (non-contact) water and mine-influenced (contact) water in lowest reach of affected tributary streams • Fish salvage from affected fish-bearing reaches • Surface water management structure design and mitigation actions consistent with regulatory standards • Monitoring discharges and ambient variables in receiving environments to ensure that water quality is within tolerances for WSCT • Layout and design of the waste rock spoil areas within the affected watersheds reduces the area that is disturbed by construction • Collection, diversion and treatment of mine-influenced surface flows • Redirection of non-affected surface water flows around rock drains, where feasible (*i.e.*, clean water diversions) • Progressive reclamation to accelerate revegetation, reforestation and end land uses specified in the Reclamation and Closure Plan

Table 5.0-1 Potential Project effects and mitigation

Potential Project Effects	Mitigation Objectives	Mitigation
Changes in WSCT food supply in Gold and Blairmore creeks, which can directly affect WSCT as well as their habitat quantity or suitability	Minimize or eliminate changes in WSCT food supply	• Monitor flows to determine if any mitigation actions are needed to address potential changes in surface water flows in Gold and Blairmore creeks during the implementation of water management features that could affect invertebrate biomass
Changes to sediment supply, transport mechanisms and sediment yield, which can affect WSCT habitat quantity and suitability	Minimize or eliminate changes to sediment supply, transport mechanisms and sediment yield	• Water will be discharged to watercourses in a manner that does not cause erosion or other damage to adjacent areas • Potential increases or reductions in surface water flows in Gold and Blairmore creeks that could affect the natural flow regime will be mitigated (if necessary) by managing the timing, discharge volume and location of water to mimic the natural flow regime and maintain flow increases or reductions within acceptable limits • Implement erosion and sediment control based on industry standards • Disturbed areas (*e.g.*, access roads and banks) will be graded to a stable angle after work is completed, reclaimed and revegetated • Salvaged soil will be stored on-site and away from surface waterbodies • Erosion control practices will be applied to salvaged soil to reduce potential erosion and sediment transport off-site • Materials used for shoreline stabilization will be clean and free of fine sediments and contaminants • Mine-influenced runoff and pit water will be directed to existing or planned water management infrastructure (*e.g.*, settling ponds) • Site drainage and surface runoff will be managed through the incorporation of erosion control methods (*e.g.*, ditch blocks, silt fences) so that overland flow does not direct sediment-laden water into any natural watercourses • Water will be discharged to watercourses in a manner that does not cause erosion or other damage to adjacent areas

Table 5.0-1 Potential Project effects and mitigation

Potential Project Effects	Mitigation Objectives	Mitigation
Changes to surface water quality, which can affect WSCT habitat quantity and suitability and/or survival and reproduction, from surface water runoff, surface and groundwater interactions and discharge of mine-influenced water	Minimize or eliminate changes to surface water quality	• Clean-water (*i.e.,* runoff collected from natural non-disturbed areas; non mine-influenced water) will be directed around waste rock and pit areas • Water quality will be managed to comply with water quality criteria that are protective of aquatic health including WSCT • Techniques identified in the mine plan and water management plan to mitigate mine-influenced water aimed to avoid the potential for water quality effects that can affect fish and fish habitat
Calcite precipitation, which can affect WSCT habitat quantity or suitability, may result from surface runoff emanating from the Project footprint and discharge of treated effluent	Minimize or eliminate calcite precipitation	• Compact layout of the waste rock spoil areas within local watersheds will limit the area of waste rock that may come into contact with surface water systems • Calcite monitoring and management is proposed to monitor the potential formation of calcite in Gold and Blairmore creeks and to control precipitation of calcite to within acceptable level (if necessary)
Changes to aquatic and/or riparian habitat for WSCT associated with implementation of surface water management, mining and waste rock placement	Minimize or eliminate changes to aquatic and/or riparian habitat for WSCT	• Size of the Project's physical footprint has been minimized through proactive mine design • Existing infrastructure, rather than new infrastructure, will be used or upgraded where feasible and sustainable • Separate Fisheries Act Authorizations and/or SARA Approval, will be obtained prior to construction • Project footprint will be minimized to the extent possible through storing of waste rock in existing disturbed locations and making best use of existing facilities, including through backfilling mined-out pits • Offsetting measures will be implemented to counterbalance any permanent loss of fish habitat where serious harm to fish and fish (critical) habitat cannot be avoided
Changes to hydrology resulting in the alteration of aquatic habitat of Gold and Blairmore creeks, which can affect	Minimize or eliminate changes to hydrology	• Water will be pumped to the upper reaches of Gold Creek (above Caudron Creek confluence) to mitigate potential incremental reductions in flows in Gold Creek during low flow periods (*e.g.,* 1:10, 1:20) during operations, as deemed necessary

Table 5.0-1 Potential Project effects and mitigation		
Potential Project Effects	**Mitigation Objectives**	**Mitigation**
WSCT habitat quantity, suitability or connectivity through the implementation of the water management plan and mine operations		• Monitoring of groundwater-surface water interactions and contributions to Gold Creek as on-site water management features are implemented • Offsetting measures will be implemented to counterbalance any permanent alteration to, or destruction of, fish (critical) habitat, where serious harm cannot be avoided

6.0 MONITORING PLANS

The Program encompasses six plans: Water Resources, Fluvial Geomorphology, Bioenergetics, Calcite, Aquatic Effects, and WSCT Population. A monitoring approach has been developed for each these disciplines and is provided in the following sections.

6.1 Water Resources Monitoring Plan

The Water Resources Monitoring Plan is comprised of three components, as follows:

1. Groundwater-Surface Water Interaction Verification;
2. Surface Hydrology; and
3. Instream Flow Assessment Verification.

Each component is intended to be complimentary. Details on the planned monitoring are provided in the following sections.

6.1.1 Groundwater-Surface Water Interaction Verification

6.1.1.1 Goals and Objectives

The overall goal of this component is to evaluate the effects of Project activities on the survival and persistence of WSCT in Blairmore and Gold creeks, through fulfilling the following objectives:

1. Confirm surface water to groundwater fluxes
2. Evaluate groundwater-surface water interaction; and
3. Support mitigation or fisheries offsetting.

This monitoring component includes installation and monitoring of several well nests (*i.e.,* well pairs) adjacent to key reaches on Gold and Blairmore creeks to verify the groundwater-surface water interaction. Several proposed monitoring locations are also downgradient of planned sedimentation and surge ponds and may support monitoring and assessment of potential Project effects related to these water management infrastructure features.

6.1.1.2 Study Design

The proposed monitoring network will comprise the installation of 12 well nests (each comprising one shallow and one deeper monitoring well) adjacent to reaches of Blairmore and Gold Creeks. The well locations were chosen to allow for assessment and monitoring of vertical gradients (and fluxes) within key reaches of both creeks, potential groundwater effects associated with key water management infrastructure features (*e.g.,* sedimentation and seepage ponds), and more detailed characterization within an ephemeral reach of Gold Creek. Monitoring well locations, rationale, monitoring parameters and frequency are summarized below.

Monitoring Network

Reach Monitoring to Assess Surface Water Losses to Groundwater

Several existing hydrometric monitoring stations are located along Blairmore and Gold creeks to monitor total streamflow. Data from these stations indicates anomalous (*e.g.,* inconsistent) variations in the average annual unit runoff, losing reaches in both creeks (where streamflows decline between downstream stations), and areas with subsurface flow. This suggests that the stations are located in areas with differing relationships between surface water and groundwater (informing JRP IR-5.22 and JRP IR-5.24).

Groundwater monitoring well nests (*e.g.,* paired wells) are proposed within multiple reaches of both creeks to characterize local hydrogeologic properties, quantify vertical hydraulic gradients (*i.e.,* aid in characterization of gaining and losing stretches of the two main streams) and inform fish habitat planning. Five monitoring well nests (A1 – A5) are proposed in four reaches of Blairmore Creek, and seven monitoring well nests (B1 – B4, C1 – C3) are proposed in four reaches of Gold Creek.

Characterization of Ephemeral Reach of Gold Creek Near Lille to Support Mitigation Planning

Sections of Gold Creek (most notably in Reach 6 as classified in CR#6 Appendix A3) have also been found to be ephemeral, with surface water flows becoming subsurface or hyporheic throughout certain times of the year (*e.g.,* coincident with lower streamflows or lowered groundwater table conditions). Surface water flows within this reach also appear to be split between side channels and

the coarse valley fill (fluvial deposits). Because Gold Creek sustains a population of WSCT there is an interest in maintaining surface flows within this mainstem stretch of the stream (JRP IR-5.22).

Three monitoring well pairs (C1 – C3) are proposed in this reach, at locations with different proportions of surface (channel) flow and hyporheic or subsurface flow, based on field observations or flow measurements upstream and along this particular reach. An upstream well pair is proposed around the GC-3 transect, where surface flow losses are common in all but freshet conditions. A downstream well pair is proposed around the Lillie legacy coal pile area, where the Gold Creek channel has been observed dry multiple times. An intermediate well pair is proposed between these locations, where surface channel conditions are less known but may support greater channel flow given there are less braids in this area. The distance between these locations is approximately 1 km. The location of these proposed wells is tabulated in Table 6.0-1 and shown in Figure 6.0-1.

To support planning of potential stream modification the depth to groundwater, vertical hydraulic gradient, and thickness of unconsolidated deposits should be further explored. The thickness of unconsolidated deposits here should be determined to provide estimates of the groundwater flux (*i.e.*, verification of subsurface flow) in those deposits.

Source Monitoring at Proposed Surge Ponds, Sedimentation Ponds, and Seepage Interceptions

The mine site has several water management features (*i.e.*, sediment or surge ponds) that have the potential to alter the groundwater-surface water regime. Potential effects could include inducing higher hydraulic heads (*i.e.*, increasing the water table) and seepage interception systems may decrease hydraulic heads. As such, supplemental groundwater monitoring to characterize baseline conditions and allow for monitoring of potential project effects is warranted.

Seven of the monitoring well nests (A1 to A4, B2 to B4) have been located to allow for assessment of potential groundwater impacts associated with seven water management features, in addition to monitoring different reaches of Blairmore and Gold creeks.

Table 6.0-1 Overview of Proposed Monitoring Locations and Rationale

Monitoring Nest Location	UTM Coordinates		Description	Rationale
	Easting	Northing		
A1	684066	5508565	Upper Blairmore Creek (Reach 5)	Assess vertical flux, monitor conditions downgradient of northwest surge pond

Table 6.0-1 Overview of Proposed Monitoring Locations and Rationale

Monitoring Nest Location	UTM Coordinates		Description	Rationale
	Easting	Northing		
A2	684670	5507250	Upper Blairmore Creek (Reach 4)	Assess vertical flux, monitor conditions downgradient of western sedimentation pond
A3	685000	5504700	Mid Blairmore Creek (Reach 3)	Assess vertical flux, monitor conditions downgradient of southwest surge pond
A4	684900	5503500	Mid Blairmore Creek (Reach 2)	Assess vertical flux, monitor conditions downgradient of plant-site sedimentation pond
A5	683500	5500825	Lower Blairmore Creek (Reach 2)	Assess vertical flux in losing Reach overlapping inferred fault zone
B1	687430	5510725	Upper Gold Creek (Reach 9)	Assess vertical flux, characterize background conditions upgradient of mine
B2	687800	5508300	Mid Gold Creek (Reach 8)	Assess vertical flux, monitor conditions downgradient of northeast sedimentation pond
B3	687800	5506400	Mid Gold Creek (Reach 7)	Assess vertical flux, monitor conditions downgradient of eastern sedimentation pond
B4	687400	5504600	Lower Gold Creek (Reach 6)	Assess vertical flux, monitor conditions downgradient of southeast surge pond
C1	687500	5503750	Lower Gold Creek (Downstream Reach 6)	Assess vertical flux, monitor conditions in longitudinal profile along ephemeral / subsurface flow portion of Reach 6
C2	687560	5503370		
C3	687650	5503050		

680,000 682,000 684,000 686,000 688,000 690,000 692,000

5,512,000 5,510,000 5,508,000 5,506,000 5,504,000 5,502,000 5,500,000 5,498,000

Blairmore Creek
Gold Creek
Caudron Creek
Morin Creek
Green Creek
Crowsnest River
Livingstone Range
Blairmore Range
Grassy Mountain
Saskatoon Mountain
Coleman
Blairmore
Range Road 42A
Pollatt Creek
Morin Creek
Rocky Mountain Foothills
Canadian Pacific
27 Ave
16 Ave
3

BCT01 BCT02 BCT03 BCT04 BCT05 BCT06 BCT07 BCT08 BCT09 BCT10 BCT11

GCT01 GCT02 GCT03 GCT04 GCT05 GCT07 GCT08 GCT09 GCT10 GCT12 GCT13 GCT14

GC-H03 B1 GC-13
BL-03 BC-H03 A1
B2 GC-10 GC-H04
GC-17
A2 BC-07
B3 GC-H02
BL-02 BC-H02 A3
GC-04 B4 GC-H01
C1 GC-HLL
BC-03 A4
GC-02 C2
C3
BC-H01b
A5 BC-H01
BC-01
GC-HWSC
GC-01
CR-HWSC

LEGEND

- Macrohabitat Reach Break
- Highway
- Road
- Watercourse
- Waterbody
- Local Study Area

Monitoring Stations

- Hydrometric Station
- Groundwater well-nest
- Flow Prediction Node (SRK 2016)

Mine Infrastructure

- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Ponds and Ditches
- Construction Camp
- Covered Conveyor, Access Road and Powerline ROW
- Coal Handling Processing Plant and Infrastructure
- Proposed Golf Course Area

Critical WSCT Habitat

- Identified Westslope Cutthroat Trout Critical Habitat (greater than 99% pure)
- Near Pure WSCT (95% to 99% pure) Provincial Conservation Designation

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

Hatfield CONSULTANTS

TITLE

PROPOSED MONITORING OF HYDROLOGY AND SHALLOW HYDROLOGY, GRASSY MOUNTAIN MINE

Data Sources:
a) Fish Habitat data, Monitoring Stations, Hatfield (2016, 2019).
b) Critical WSCT Habitat data, Recovery Strategy for the Alberta populations of Westslope Cutthroat Trout (Oncorhynchus clarkii lewisi) in Canada [Final], Fisheries and Oceans Canada (2014).
c) Local Study Area, Mine Infrastructure, provided by MEMS (2014).
d) Base data, Government of Alberta.
e) Background Topographic Map, ESRI Online Service.
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 9083
DRAWN BY: SJ / EDITED BY: SJ
CHECKED BY: DB
DATE: June 26, 2019

0 1 2 4
Kilometres

FIGURE
6.0-1

Document Path: K:\Data\Project\MEMS9083\A_MXD_Report_Maps\Hydrology\MEMS9083_Monitoring_HydrologyHydrogeology_20190627_v0_2_SJ.mxd

Monitoring Parameters and Frequency

Following well installation, all wells will be developed, and slug tested to determine hydraulic conductivity. Top of well casing will also be surveyed to local hydrometric benchmarks and a regional datum.

Subsequent monitoring will be undertaken at every well nest and include:

- Continuous groundwater levels and temperatures, using dataloggers. Temperature monitoring in the monitoring wells will supplement planned monitoring of stream temperature at adjacent hydrometric stations. Differences in groundwater temperature fluctuations and stream temperature variations can be used to quantify groundwater contributions to streamflow at each location using analytical solutions.
- Quarterly monitoring of groundwater quality.

6.1.1.3 Field Methods

Well Drilling

Wells will be drilled using an air rotary drilling rig capable of advancing a minimum of 152 mm diameter temporary surface casing to a maximum depth of 20 meters below ground surface (m bgs), and capable of drilling in bedrock and unconsolidated (*i.e.*, silt to cobble) materials. A qualified field hydrogeologist will log each borehole for lithological descriptions using visual and manual protocols provided in the Unified Soil Classification System (USCS; ASTM 2006), and guide installations based on field interpretations. This information will include borehole depths and visual descriptions (including soil type, grain size, texture, color, plasticity, density and moisture content).

Monitoring well pairs will be located as close as practical to the stream, with the shallow well straddling the water table and completed to a minimum of 1.5 m below the water table and a maximum of 2.5 m below the water table (*i.e.*, a 3.0 m screen interval extending above ground surface). The deeper monitoring well will be installed with a 50 cm screen starting at a minimum of 3 m deeper than the well (Figure 6.0-2).

Upon completion of drilling and achieving the target depth and formation, the casing will remain in the borehole allowing a 51 mm schedule 80 polyvinyl chloride (PVC) solid riser pipe threaded onto a machine slotted screen to be lowered into the casing and installed across to the desired depth. All PVC pipe connections will be threaded to avoid the use of PVC primer and glue, which contain certain volatile hydrocarbon components. Once the assembled PVC

pipe has been lowered inside the casing, the casing will slowly be removed while a filter pack consisting of 10-20 graded sand will be placed in the borehole annuls around the screened interval to the top of the screen. The remaining annular space surrounding the solid riser pipe will be backfilled to 0.3 m from surface with dehydrated bentonite chips for the deep well as the casing is extracted to ensure completion of a proper installation. The solid riser pipe will be extended approximately 1.0 m above ground surface.

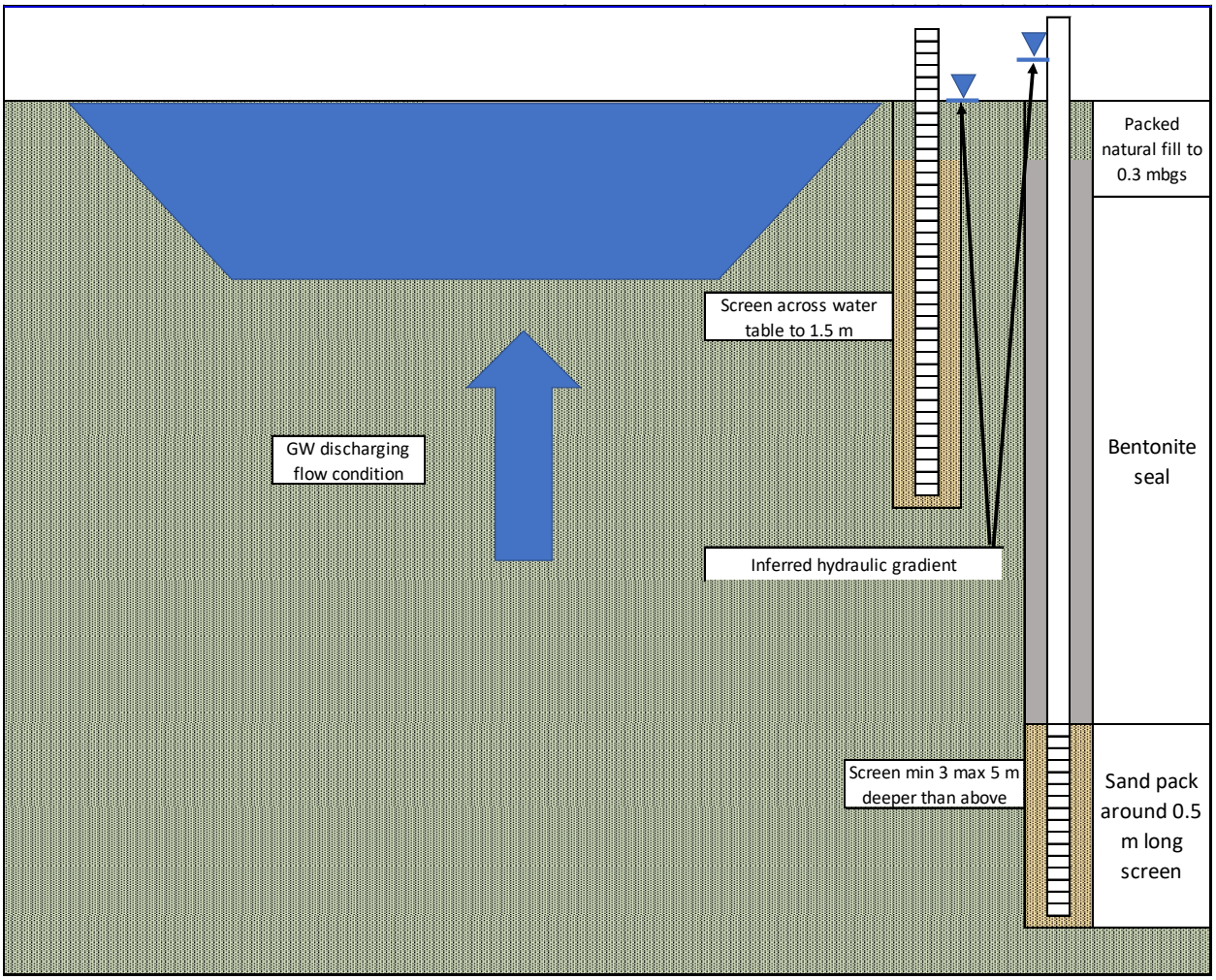


Figure 6.0-2 Typical Well Installation Sketch

6.1.1.3.1.1.1 Well Development

Monitoring wells will be developed upon completion of installation to remove fines from the vicinity of the well screen, minimizing the potential for impeded flows of groundwater from the formation into the well and also to reduce the turbidity of the groundwater during sampling events (should samples be collected).

Well development will be completed using weight bailers or Waterra© pumps and surge blocks to remove fines from within each monitoring well. Development will be continued until:

- at least three well volumes of groundwater have been removed;
- the monitoring well is purged dry; and/or
- field-measured groundwater discharge quality parameters have stabilized (*i.e.,* temperature, pH, electrical conductivity (EC), dissolved oxygen (DO) and turbidity fall to within ±0.5ºC, ±0.1 pH units, ±5% EC units and turbidity ±5% nephelometric turbidity units (ntu), respectively).

Groundwater levels will be measured with an electric sounding tape and recorded following well development and once the water level in the monitoring wells has stabilized. Well development records will also include the initial and final water level measurements, volumes purged, and field parameters collected during the development process.

6.1.1.3.1.1.2 Hydraulic Conductivity ('Slug') Testing

The hydraulic conductivity test will be conducted on the completed monitoring well by lowering a "slug" (*i.e.,* sealed and weighted section of PVC tubing with a known displacement) below the water level in the monitoring well and measuring the subsequent water level response (falling head test) over time. These measurements will be collected using a combination of a temporary pressure transducer installed at the bottom of the monitoring well in addition to manual water level measurements taken at regular intervals. Once the water level returned to 95% of the static pre-testing recorded depth, the slug is removed, and the water level response is measured using the pressure transducer and manual measurements (rising head test).

6.1.1.3.1.1.3 Continuous Level Monitoring

Monitoring wells should be outfitted with pressure transducers to continually monitor changes in water level, monitoring for changes in the vertical hydraulic gradient, and comparing pressure and temperature readings to the streams (at hydrology stations).

Continuous level monitoring combined with hydraulic conductivity testing results will allow for point estimates of groundwater discharge/recharge.

6.1.2 Surface Hydrology

Hydrology monitoring includes the continuous tracking and analysis of several hydrometric stations along key reaches of Gold and Blairmore creeks to confirm spatial and temporal

variability of runoff across the Project, assist in evaluating groundwater-surface water interaction and support mitigation or fisheries offset planning needs. The data may support monitoring and assessment of potential project effects related to the Project water management infrastructure features. Additional monitoring of flows and water levels at each feature is also likely to be required as part of EPEA or other permitting requirements, but these are outside the scope of the current document.

6.1.2.1 Goals and Objectives

This monitoring component will assess predicted Project effects on surface flows, and ultimately, support in the tracking of fish and/or aquatic metrics dependent on flows and/or water levels (*e.g.*, water quality, fluvial geomorphology, fish habitat). The plan will monitor the effectiveness of mitigation measures on which to adapt these measures as necessary based on monitoring results. The specific goals and objectives of the hydrology monitoring plan are to:

- **Goal 1**: Manage changes to surface flows (and flow-dependent variables) resulting from the Project.
  - Objective 1a: Reduce changes in flows and water levels in receiving watercourses and waterbodies.
  - Objective 1b: Reduce changes in the flood flows (and dependent variables such as channel geomorphology) downstream of the Project.
  - Objective 1c: Design closure drainage and pit lakes for hydrological sustainability and to support a viable aquatic ecosystem prior to release.
- **Goal 2**: Monitor hydrology, channel geomorphology and fish habitat related to the Project.
  - Objective 2a: Monitoring hydrology parameters to support final design objectives, assess operational performance, and support modification to design, configuration or operation if required.
- **Goal 3**: As appropriate, consider and incorporate adaptations to mitigation measures should measurement indicate that Project targets are not being met.
  - Objective 3a: Investigate monitoring results when results do not meet set targets or when complaints are received.
  - Objective 3b: As warranted, adapt mitigation when set targets are not being achieved.

6.1.2.2 Study Design

During the Project's baseline phase, the hydrological monitoring was comprised of 10 streamflow monitoring stations on Gold and Blairmore creeks (one operated by Water Survey of Canada). The monitoring station ID's, locations, and rationale are summarized in Table 6.0-2,

and shown in Figure 6.0-1. Except for one new proposed station, the locations of all nine stations will remain installed as during the Project's baseline data collection. By maintaining this consistency, measured data can be directly compared to the assessments performed during the EIS to verify effect predictions. The assessment nodes were selected to integrate potential Project effects on downstream watercourses and waterbodies, and comparison of these data with the upstream (reference) sites, during baseline and as Project effects come online, enables a Before-After-Control-Impact approach to be applied.

The monitoring frequency of surface water level, surface flow, and groundwater level (water quantity) will be continuous (15-minute intervals), using pressure transducers and dataloggers at stations:

- along Blairmore Creek, from background station BC-H03 to the station adjacent to the mine site (BC-H02), and downstream stations BC-H01/b;
- along Gold Creek, from background station GC-H03 to the stations adjacent to the mine site (GC-H04, GC-02, GC-01, GC-HLLL), and downstream station WSC 05AA030.

The Crowsnest River represents the receiving watercourse for both Gold and Blairmore creeks and is monitored year-round by Water Survey Canada at station WSC 05AA008.

Table 6.0-2 Proposed hydrometric monitoring on Blairmore and Gold Creek

Creek	Station ID	Easting	Northing	Period of Record	Rationale
Blairmore	BC-H01	683541	5500649	Sep 2013-Dec 2014 Mar 2016-present	Gauge towards the watershed mouth, designed to monitor watershed-scale flows and all changes due to Project developments (all upstream of here). Gauge is designed to be superseded by BC-H01b, less impacted by losses to underlying fault, once a robust concurrent flow relationship has been established between these gauges.
	BC-H01b	684111	5502731	Not yet started	Unit area runoff at BC-H01 lower than upstream, likely due to losses in thrust fault. This gauge will monitor runoff upstream of fault intersection, but downstream of project impacts.
	BC-H02	684976	5505089	Oct 2013-Aug 2014	Mid-reach gauge monitoring impacts of more southerly (downstream) project developments

Table 6.0-2 Proposed hydrometric monitoring on Blairmore and Gold Creek

Creek	Station ID	Easting	Northing	Period of Record	Rationale
	BC-H03	684065	5508565	Oct 2013-Aug 2014 May 2015-present	Upper watershed gauge, monitoring 'reference' streamflows not impacted by any project developments
Gold	05AA030 (Gold Creek near Frank)	688123	5498070	Sep 1975-present	Long-term Water Survey of Canada gauge monitoring flows near the mouth of Gold Creek, operated seasonally by WSC from mid-March to November. Discussions with WSC should be held to potentially annualize the flow gauging here, using potential solutions such as winter (December to mid-March) data collection by Benga.
	GC-HLLL	687480	5503760	April 2019-present	Downstream gauge in a flow-loss reach near Lille, monitoring relatively small channel flows (relative to GC-H01) where connectivity and habitat quality is typically degraded, and is the focus for potential future offsetting and stream restoration
	GC-H01	687478	5504579	Sep 2013-Dec 2014 Mar 2016-present	Mid-reach gauge designed to monitor flows and all changes due to Project developments (all upstream of here)
	GC-H02	687874	5506467	May 2016-present	Mid-reach gauge established in 2016 to support monitoring of higher flows near the confluence of Gold and Caudron Creeks
	GC-H04	687776	5508102	June 2017-present	Upper watershed gauge established in a relatively low-runoff reach with elevated predicted project flow impacts
	GC-H03	687594	5510958	May 2016-present	Upper watershed gauge established in 2016, monitoring 'reference' streamflows not impacted by any project developments

The proposed approach to surface hydrology monitoring (*i.e.*, water level, discharge) has been subdivided into the main project phases planned for the Grassy Mine. During all periods, monitoring methods will be the same as those applied and described in the EIS (CR#6, Appendix A2, A3). As the Project progresses, monitoring methods may be updated to reflect

evolving technologies and best practices. An overview of the main differences expected between mine periods are as follows:

- **Pre-Production**: Prior to mine construction occurring, the monitoring will remain unaltered from the 10 stations in Table 6.0-2 in order to:
  - Continue to improve knowledge of current and baseline water quantity conditions; and
  - Obtain data to refine the inputs and assumptions for flow-dependent modelling and predictions, such as chemical or constituent loading, instream flows, and mine water balances.
- **Construction, Operations and Decommissioning**: The construction and operation monitoring system will be the most intensive phase of the monitoring program, given that EPEA monitoring is expected at all locations where water is discharged from mine site water management features. The *Fisheries Act* monitoring will remain unaltered from Table 6.0-2, although by this stage it is expected that the BC-H01b station will have collected enough information to remove the need for existing BC-H01 station impacted by fault-line flow losses.
- **Closure Phase**: A number of EPEA monitoring sites will likely be removed given the reduction of active water management processes during this phase; however, the monitoring for *Fisheries Act* requirements will remain unaltered from the previous stage (nine stations) given the landscape changes (*i.e.,* reductions in undisturbed areas, increases in reclaimed areas) that will have occurred relative to baseline.

6.1.3 Instream Flow Assessment Verification

This component of the Water Resources Monitoring Plan includes the detection of changes in WSCT Area Weighted Suitability (AWS) at established microhabitat transects (within mesohabitat units) during the Instream Flow Assessment (IFA) in key reaches of Gold and Blairmore creeks. The purpose of this component is to verify predictions made during the IFA, evaluate whether adaptive mitigation (*i.e.,* flow augmentation) is required, and implement and monitor mitigation effectiveness, if necessary.

6.1.3.1 Goals and Objectives

This component will mitigate predicted Project effects on the fish habitat, as impacted by Project changes to flows and/or water levels. The plan will monitor the effectiveness of mitigation measures on which to adapt these measures as necessary based on monitoring results. The specific goals and objectives are to:

- **Goal 1**: Manage effects on flows (and flow-dependent variables) due to the Project.
  - Objective 1a: Reduce changes in flows and water levels in receiving watercourses and waterbodies.
  - Objective 1b: Reduce changes in the flood flows (and dependent variables such as channel geomorphology) downstream of the Project.
  - Objective 1c: Design closure drainage and pit lakes for hydrological sustainability and to support a viable aquatic ecosystem prior to release.
- **Goal 2**: Monitor hydrology, channel geomorphology and aquatic habitat related to the Project.
  - Objective 2a: Monitoring hydrology parameters to support final design objectives, assess operational performance, and support modification to design, configuration or operation if required.
- **Goal 3**: As appropriate, consider and incorporate adaptations to mitigation measures should measurement indicate that Project targets are not being met.
  - Objective 3a: Investigate monitoring results when results do not meet set targets or when complaints are received.
  - Objective 3b: As warranted, adapt mitigation when set targets are not being met.

6.1.3.2 Study Design

Spatial Network

Monitoring will continue into the Project operations phase, at (1) all 44 transects established for ongoing baseline monitoring within the IFA program, and (2) nine additional pool tail-out sites established for baseline spawning surveys during baseline monitoring, introduced in the next section. Several the transects for (1) also serve as hydrometric monitoring stations.

The IFA transects were focused on riffle, pool and run/glide mesohabitats which dominate the mesohabitat distributions along each creek. Five of these transects (BC-10, BC-11, BC-12 on Blairmore, GC-9 and GC-13 on Gold) were characterized with wetted-area substrate dominated by spawning gravels, which are essential to the spawning process and survival of WSCT in these creeks. Additional monitoring of spawning gravels, in addition to the above transects, was established at an additional nine sites (primarily pool tail-outs) with spawning gravels and high WSCT abundance (preferred suitability). Here, additional sampling was conducted including Wolman pebble counts, from which worst-case shear stress differences during the life of mine were calculated. By maintaining this consistency between baseline and proposed

Project-phase monitoring locations, measured data can be directly compared to the predictions and effects assessment to verify effects are consistent with predictions in the Project Update.

Figure 6.0-3 shows the location of all 53 monitoring transects proposed within this plan.

Sampling schedule

Project-area AWS estimates could theoretically be updated using the existing flow-hydraulic-habitat relationships developed using baseline, with Project-phase streamflow data as it becomes available through time. Ongoing monitoring of the flow-hydraulic-habitat relationships with transect data remain critical to capture changes in these relationships that may occur primarily due to (1) channel geomorphology and substrate changes during high-flow events, and (2) extreme low flow events (*e.g.*, representative of future occurrences when Project-related flow losses coincide with severe drought events) yet to be adequately captured within the existing flow-hydraulic-habitat relationships.

680,000 682,000 684,000 686,000 688,000 690,000 692,000

5,512,000 5,510,000 5,508,000 5,506,000 5,504,000 5,502,000 5,500,000 5,498,000

Blairmore Creek
Gold Creek
Caudron Creek
Morin Creek
Green Creek
Crowsnest River
Livingstone Range
Blairmore Range
Grassy Mountain
Bedrock 1
Cory's
Bone
Bridge
Mid-Reach
Headwaters I
Headwaters II
Coleman
Blairmore
BC-15/ H03
BL-03
BC-14
BC-13
BC-12
BC-11
BC-10
BC-07
BC-9
BC-8
BC-7
BC-6
BC-5
BC-4
BL-02
BC-H02
BC-3
BC-2
BC-1
BC-03
BC-0/H01b
BC-0/H01
BC-01
GC-27/H03
GC-13
GC-26
GC-25
GC-24
GC-20
GC-17
GC-19
GC-18
GC-17
GC-16
GC-15
GC-14
GC-9
GC-8
GC-7/H01
GC-6
GC-04
GC-02
GC-01
GC-HWSC
CR-HWSC
GC-23
GC-10
GC-22/ H04
GC-21
GC-13
GC-12
GC-11/H02
95 fish
GC-10
GC-5
GC-4
GC-3/ HLL
GC-2
GC-1
GC-0

LEGEND

- Macrohabitat Reach Break
- Highway
- Road
- Watercourse
- Waterbody
- Local Study Area

Monitoring Stations

- Spawning Survey
- Hydrometric Station
- Instream Flow Transect
- Flow Prediction Node (SRK 2016)

Mine Infrastructure

- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Ponds and Ditches
- Construction Camp
- Covered Conveyor, Access Road and Powerline ROW
- Coal Handling Processing Plant and Infrastructure
- Proposed Golf Course Area

Critical WSCT Habitat

- Identified Westslope Cutthroat Trout Critical Habitat (greater than 99% pure)
- Near Pure WSCT (95% to 99% pure) Provincial Conservation Designation

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

Hatfield CONSULTANTS

TITLE

PROPOSED MONITORING OF FLUVIAL GEOMORPHOLOGY, GRASSY MOUNTAIN MINE

Data Sources:
a) Fish Habitat data, Monitoring Stations, Hatfield (2016, 2019).
b) Critical WSCT Habitat data, Recovery Strategy for the Alberta populations of Westslope Cutthroat Trout (Oncorhynchus clarkii lewisi) in Canada [Final], Fisheries and Oceans Canada (2014).
c) Local Study Area, Mine Infrastructure, provided by MEMS (2014).
d) Base data, Government of Alberta.
e) Background Topographic Map, ESRI Online Service.
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 9083
DRAWN BY: SJ / EDITED BY: SJ
CHECKED BY: DB
DATE: June 26, 2019

0 1 2 4
Kilometres

FIGURE
6.0-3

Document Path: K:\Data\Project\MEMS9083\A_MXD_Report_Maps\Hydrology\MEMS9083_Monitoring_vs_Infrastructure_20190627_v0_5_SJ.mxd

A three-times annual schedule of IFA-related monitoring, at all transects, is proposed including sampling during (1) higher-flow period (*e.g.*, May to June), (2) lower-flow period (*e.g.*, August to September) and (3) intermediate-flow period around spawning time (*e.g.*, late-June to July). The monitoring for (3) also forms the primary data collection for the fluvial geomorphology component as discussed further in that section.

6.1.3.3 Field Methods

During all periods, monitoring methodology will be the same as those described in the EIS (CR#6, Appendix A3). As the Project progresses, monitoring methods may be updated to reflect evolving technologies and best practices. An overview of the main differences expected between mine periods are as follows:

At all 53 sampling sites to be monitored, the following sampling will be conducted:

- Hydraulic measurements of water-level;
- Visual/photo assessments annually during higher, moderate and lower flow conditions;
- Wolman pebble counts (annually during moderate flow conditions at or just before spawning); and
- Channel shape and slope assessments (annually during moderate flow conditions at or just before spawning.

Additional stream depth, width, velocity and flow data will be collected at nine joint hydrometric station and IFA monitoring transects and at various other transects, which provide reference stream flow values for other nearby IFA monitoring transects less suitable for calculation of streamflow.

6.2 Fluvial Geomorphology Monitoring Plan

6.2.1 Goals and Objectives

In concert with monitoring of discharge hydrology, WSCT population trends, and instream flows (IFA), the fluvial geomorphology monitoring will validate the predictions of the effects assessment of the mine development and determine the effectiveness of mitigating flow on channel morphology and sediment to inform adaptation of the mitigations as necessary (and possible) based on monitoring results. The specific goals and objectives of the monitoring plan are to:

- **Goal 1**: Monitor the effects of altering flows on channel morphology.

- Objective 1a: Document channel cross sectional morphology in Gold and Blairmore Creeks.
- Objective 1b: Document the condition of the Gold and Blairmore Creek bed and banks using photographs.

- **Goal 2**: Monitor the effects of altering flows on spawning substrate.
  - Objective 2a: Document gran size of spawning substrate in Gold and Blairmore Creeks.
  - Objective 2b: Document the location of spawning habitat in Gold and Blairmore Creeks.

The main purpose of monitoring will be to confirm that predictions made during the effects assessment remain valid, and to trigger the implement adaptive mitigation, where necessary. Monitoring may also identify new effects that might not have been predicted. Monitoring may also inform our understanding of the efficacy of mitigation measures that could be implemented by Benga (*e.g.,* flow augmentation), such as the effect of decreasing peak discharge and adding water at discrete nodes.

6.2.2 Study Design

Benga has designed the fluvial geomorphology monitoring for all phases of the Project including baseline, construction and operations, decommissioning and closure phases. The fluvial geomorphology monitoring program was developed in conjunction with the baseline hydrology and instream Flow monitoring component plans (Section 6.1) and the WSCT population monitoring plan (Section 6.6).

Channel morphology and sediment data will be collected to support the implementation of an environmental management program and to meet regulatory monitoring requirements. This will be achieved by on-going monitoring at select locations throughout the mine life. The monitoring is designed to meet the Project goals described in Section 6.2.1.

The plan is designed for adaptive monitoring. Additional key sites may be added to the monitoring if spawning habitat locations change through the lifecycle of the mine.

The monitoring plan includes 33 sites on Gold Creek and 20 sites on Blairmore Creek that will be monitored through the mine lifecycle. Twenty-eight sites on Gold Creek and 16 sites cross-sections on Blairmore Creek were used in the IFA study (CR#6, Appendix A3). Four additional sites on Blairmore Creek and five sites on Gold Creek were identified as preferred WSCT spawning locations. The sites used in the IFA and the spawning sites added for monitoring are identified in Figure 6.0-3

6.2.2.1 Goal 1: Manage the effects of altering flows on channel morphology due to the Project.

Monumented cross-sections will be surveyed annually following the freshet to document fluctuations in channel cross sectional morphology in Gold and Blairmore Creeks. Photographs of the bed and banks will be taken twice times annually to document the condition of the Gold and Blairmore Creek bed and banks. The Fluvial Geomorphology Monitoring Plan will be completed in conjunction with the IFA monitoring (Section 6.1.3).

6.2.2.2 Goal 2: Monitor the effects of altering flows on spawning habitat due to the Project.

Monitoring will document fluctuations in grain size of spawning substrate in Gold and Blairmore creeks. Grain size will be measured in the field annually following freshet. Wolman pebble counts will be completed with ($N > 100$) at the monitoring sites. The D_{84}, D_{50}, and D_{16} for each site will be compared annually to identify changes in bed sediment. The percent of sediment that is within the spawning grain size will be determined.

Monitoring will target defined locations of spawning substrate in Gold and Blairmore creeks. Spawning surveys are conducted annually and will form part of the WSCT Population Monitoring Plan (Section 6.6). The annual spawning surveys will identify the locations of WSCT spawning habitat. The location of spawning habitat will be compared annually to determine systematic changes in the location of spawning habitat through the lifecycle of the project.

6.3 Bioenergetics Monitoring Plan

6.3.1 Goals and Objectives

The overall goal of the Bioenergetics Monitoring Plan (BioMP) is to evaluate the potential changes to the survival and persistence of WSCT in Blairmore and Gold creeks. This plan will provide baseline information regarding food availability and fish condition, as well as a comprehensive methodology for monitoring fish condition in the LSA. The implementation of the BioMP will help the Project better understand potential effects to WSCT caused by up-land mine disturbance. The objectives of this plan will be to:

1. quantify the food energy provided to WSCT by their primary food supply, drifting invertebrates (aquatic and terrestrial);
2. quantify individual fish condition, based on relative weight (W_r);
3. integrate food energy, fish condition, and hydrological monitoring data (see Section 6.1) into a species-specific bioenergetics model;
4. quantify any changes in food supply, individual fish condition, and fish population condition;

5. determine the causes of any observed changes in food supply, individual condition, and/or population condition, to facilitate adaptive management and offsetting/mitigation programs;
6. present a standard methodology for data collection and interpretation for bioenergetics monitoring; and
7. help inform the development of a larger scale Fisheries and Aquatics Monitoring Program.

6.3.2 Description of Receiving Environments

6.3.2.1 Site Characterization

A full site characterization study will occur prior to as well as during the first implementation cycle of the plan. This will include riparian vegetation loss delineation and quantification, and dilution zone delineation downstream of each effluent discharge point on Blairmore Creek. These data will help identify suitable sampling areas/sites as well as identify potential confounding factors that may affect data interpretation.

6.3.2.2 Sample Area Selection

Site selection is an important factor when developing an effective BioMP. It will be important to capture sites/streams that will be directly impacted by receiving mine waters, as well as appropriate reference locations. Samples will be required to be taken from two types of exposure areas, and reference areas.

Exposure Areas

Mine exposure is a key part of the site selection process as mine influenced streams have increased potential for deleterious effects on fish condition. All effluent will be discharged to Blairmore Creek, however given the sensitive status of Gold Creek (designated critical habitat under the *Species at Risk Act)*, the reaches downstream of the mine are included in the study design. By monitoring Gold Creek for potential changes in fish condition, uncertainty associated with other influences not related to mine activity will be reduced.

Areas exposed to mine influences will be separated into two categories. These are defined as follows:

- **Effluent Exposure Area**: all fish habitat and waters that are exposed to effluent and frequented by fish; and
- **Riparian Exposure Area**: all fish habitat and waters frequented by fish at and downstream of areas where riparian vegetation has been removed.

It is foreseeable that some exposure areas will see effects from both effluent and riparian vegetation removal. However, all efforts will be made to delineate sample locations that will adequately distinguish between the two potential impact sources.

Reference Areas

Inclusion of reference streams allows the plan to provide context for the extent, degree, and trends of deleterious effects on fish condition occurring in mine-affected streams. Monitoring reference streams will be of particular importance with respect to evaluating potential long-term and large-scale spatial effects as they will provide information pertaining to natural environmental variability.

Reference streams were selected from areas in the LSA that were consistent over the long term (*i.e.*, not influenced by major development or anthropogenic disturbance) while also preferentially being located a sufficient distance from potential future mine development. As the reference streams need to mimic conditions in the mine-affected streams as closely as possible, parameters such as elevation, stream order, geology and channel morphology were also considered during the selection process.

Reference streams were selected using the following criteria:

1. characterization of exposure reaches by stream order, bedrock geology, spatial distribution and channel morphology;
2. review of reference sites from past studies in the area such as the baseline assessment (CR#6 Appendix A1), and select appropriate locations using reach characteristics; and
3. review additional locations to obtain reference streams that will adequately represent the spectrum of stream characteristics expected in the mine-affected streams.

The above criteria revealed several possible locations for reference streams. Those most relevant to the monitoring objectives are upper Blairmore Creek (above the proposed mine footprint) and Caudron Creek.

6.3.3 Study Design

Examples of existing bioenergetics monitoring plans are rare, thus the BioMP designed herein is considered a novel approach to monitoring fish condition. General methodology is based off professional experience designing and executing Environmental Effects Monitoring (EEM) programs, lessons learned during baseline data collection for the Project, and advice from experts in the bioenergetics modeling field.

The intent of this plan is to document the food supply and condition of fish, characterize any changes in either metric in response to mine activities, and determine the source of these changes. The proceeding sections outline the general concepts for capturing this information. Detailed field methodology and procedures will be outlined prior to the implementation of this plan.

6.3.3.1 Sample Timing and Frequency

Sampling will occur twice annually, during summer and fall. Terrestrial inputs to drift invertebrate assemblage are generally highest during summer, and fall should allow measurement of young-of-year fish. Two annual measurements for both food supply and fish condition will also help evaluate and calibrate the bioenergetics model.

6.3.3.2 Data Collection

Temperature Monitoring

Stream temperature is an important component of bioenergetics modeling, as it can influence energy output, consumption, and growth rates, and has been linked to the spatial distribution of WCT (Sloat *et al*. 2005; Deslauriers *et al*. 2017). Stream temperature will be monitored using continuous *in-situ* dataloggers placed at each established sample station and will be supplemented with long-term stream temperature data that is being collected at multiple hydrometric stations in Blairmore and Gold creeks. Dataloggers will be visited and read-out on a quarterly basis to mitigate potential data loss due to battery drain or loss of the units.

Quantifying Food Supply – Drift Invertebrates

Drift invertebrates are the primary source of food for WSCT and encompass both aquatic invertebrates drifting in the water column, and terrestrial or aerial invertebrates, drifting on the surface. By collecting drift invertebrate samples and determining the biomass (and the biomass of the respective aquatic and terrestrial components), the available food energy can be estimated for a given area.

Drift invertebrate assemblage data in the form of total abundance, diversity, and biomass is generally expressed per unit volume (m^3), where:

$$per\ unit\ volume\ (m^3) = submerged\ area\ (m^2) \times mean\ set\ velocity\ (^m/_s) \times total\ set\ duration\ (s)$$

- Biomass and flow will be the primary data used for interpretation.

- Characterizing the taxonomic composition of the drift using metrics such as richness, diversity, or presence/absence of certain taxa (depending on their propensity to drift) may prove useful for interpretation for specific projects.

Quantifying Fish Condition

The condition of an individual fish can be easily estimated by using a ratio between length and weight. When combined, the condition of each individual fish in a sample can then be used to estimate overall population health. These two parameters (length and weight) will be collected during all fish capture surveys (*i.e.,* electrofishing and minnow trapping). The method of determining fish condition will be Relative Weight (Wege and Anderson 1978).

Relative Weight (Wr)

Relative weight is a measure that compares the actual weight of an individual to its expected weight (standard weight) based on a standard weight equation (Blackwell *et al*. 2000). The equation [1] was first proposed 40 years ago for Largemouth Bass (Wege and Anderson 1978) and has been regularly used as a fish condition metric since (Blackwell *et al*. 2000). It can be used to infer whether a population of fish is well-fed and growing as would be expected (Blackwell *et al*. 2000). Relative weight is often expressed as an average and will be used in this study to examine the growth efficiency of WSCT within the study area at various size classes.

$$W_r = \left({}^{W}/_{W_s}\right) \times 100 \qquad [1]$$

Where W = Actual fish weight (g)

W_s = Standard Weight (g)

Standard weight equations are created based on regressions of the length-weight relationships of many fish populations across the species' range. The goal is to represent the weight of a fish in "good condition" by estimating the weight of a fish at the 75th percentile based on its length (Midas *et al*. 2013). For this plan, the standard weight equation [2] used was proposed for North American lotic rainbow trout by Kruse and Hubert (1997):

$$\log_{10} W_s = 3.099 \log_{10} TL - 5.189 \qquad [2]$$

where:

TL = total length (mm)

WSCT captured during field surveys will be measured for both fork length (FL) and total length (TL), thus avoiding any confounding factors due to requiring a conversion equation.

Relative weight can be highly variable, but generally a well-fed fish in good condition will have a W_r around 100 (Midas *et al*. 2013). Fish with $W_r > 100$ are above average and in very good condition, and fish with $W_r < 100$ are below average (Midas *et al*. 2013). Generally, fish with W_r between 80-100 are within the range of healthy populations (Anderson and Neumann 1996).

6.3.4 Field Methods

6.3.4.1 Temperature Dataloggers

Temperature and light dataloggers will be installed in 30 cm long PVC enclosures, and secured to the stream bed. Loggers will be set to record temperature and light intensity every 30 minutes. Additionally, stream temperature data collected at multiple long-term hydrometric stations (installed in both Blairmore and Gold creeks) will supplement sample station data.

6.3.4.2 Drift Invertebrates

Collection of drift samples requires flowing water and is, therefore, only suitable for erosional zones in freshwater habitats; moderate-flowing riffle areas in rivers and streams. Approximate site locations will be identified prior to commencement of the monitoring plan. However, exact site locations within the reach should be selected in the field to ensure that an appropriate environment is sampled. Detailed procedures will be outlined prior to the implementation of this plan and adapted from Cavanagh *et al*. (1997), Lewis *et al*. (2004), Hatfield *et al*. (2007), and MWLAP (2013).

6.3.4.3 Fish Condition

Fish will be collected using a combination of backpack electrofishing and minnow trapping. The procedures will be adapted from federal and provincial guidance (*e.g.,* AFMB 2013a, 2013b; ECCC 2012) with an emphasis on minimizing or eliminating potential harm and handling time. Federal guidance for non-lethal sampling recommends a minimum of 100 age 1+ fish from each sampling area (ECCC 2012). However, given the potential impact that such sampling effort would have on WSCT in the study watercourses, the BioMP will aim for collection and measurement of 50 age 1+ fish per site. Power analyses indicate that a total sample (*n)* of 250-500 fish should be sufficient to detect small-to-medium effects at a statistical significance threshold (p) less than 0.1.

6.3.5 Data Integration

Data collected as part of the bioenergetics monitoring field plans will be integrated using Fish Bioenergetics 4.0 (Deslauriers *et al*. 2017). This program integrates multiple environmental and

physiological inputs, including stream temperature, energy density and type of prey, the energy lost through movement and respiration, spawning/reproduction, and mortality. These variables will be input into existing bioenergetics models for WSCT (or generating a new model if species-specific models are not available) to generate curves and parameters such as growth rate, consumption, net production, and population dynamics, over the course of a year for a given cohort (life stage).

6.3.6 Quantifying Potential Changes in Response to Project Activities

Potential changes due to Project activities will be quantified by comparing the model outputs from reference areas to mine-affected areas. Coarse, visual comparisons will accompany more robust statistical comparisons. The refinement of study areas conducted during preliminary site selection should also facilitate comparison between both predicted effect sources (effluent and riparian loss).

6.3.7 Plan Assessment and Refinement

The BioMP will be refined as it progresses through the years. Given its execution will represent a novel form of monitoring, each successive year will be informed by lessons learned the previous season. As more detailed field data are captured, and analytical endpoints are refined, the plan can be updated to ensure site selection, field methodology, and data analysis are functioning as intended.

6.4 Calcite Biological Monitoring Plan

While calcite occurs naturally, its formation can be accelerated by runoff water from mines. It is not a human health concern, but excessive calcite build-up can alter the characteristics of streambeds by cementing rocks together and affecting habitat for fish as well as invertebrates. Spawning gravels are particularly sensitive to calcite deposition and concretion. WSCT require areas with appropriately sized gravels in which to create redds and spawn. Concretion of spawning gravels would negatively impact WSCT ability to successfully spawn, therefore lowering recruitment and the population's longevity. As such, a detailed calcite monitoring plan will be established to track calcite formations for the Project. Development of such a plan will ensure that potential effects due to calcite accumulation in the downstream environment are detected early so that appropriate mitigations can be employed if necessary.

6.4.1 Goals and Objectives

The goal of this plan is to (1) provide baseline information regarding naturally occurring calcite formations in the local study area (LSA) and (2) monitor calcite deposition in defined watercourses in the LSA. The implementation of the calcite monitoring plan will help the Project better understand effects to the receiving environment caused by upstream mine disturbance. The objectives of this plan will be to:

1. characterize naturally occurring calcite formations in the LSA;
2. monitor calcite formations in streams directly receiving mine waters as well as reference stream(s);
3. document changes to the calcite formations (temporally and spatially);
4. determine trends (*i.e.,* rates) of calcite deposition;
5. present a standard methodology for data collection and interpretation for calcite monitoring efforts;
6. inform any plans for calcite mitigation.

6.4.2 Stream Selection

Site selection is an important factor when developing an effective calcite monitoring plan. It will be important to capture sites/streams that will be directly impacted by receiving mine waters, as well as appropriate reference locations. This section describes the selection process for the plan.

6.4.2.1 Project-Affected Streams

Mine exposure is a key part of the stream selection process as mine influenced streams have increased potential for calcite deposition. As such, all reaches downstream of proposed mine discharges are included in the monitoring plan. All effluent will be discharged to Blairmore Creek, however given the sensitive status of Gold Creek (designated critical habitat under the *Species at Risk Act)*, the reaches downstream of the mine are included in the study design. By monitoring Gold Creek for potential increased calcite deposition, uncertainty associated with surface water/groundwater interactions will be reduced.

The mine influenced streams have been further differentiated into reaches. A complete breakdown of reaches will occur prior to any field sampling activities.

6.4.2.2 Reference Streams

Inclusion of reference streams allows the plan to provide context for the extent, degree and trends of calcite formation occurring in mine-affected streams. Monitoring reference streams will be of particular importance when examining long-term and large-scale spatial monitoring as they will provide information pertaining to natural environmental variability.

Reference streams were selected from areas in the local study area (LSA) that were consistent over the long term (*i.e.*,-not impacted by major development or anthropogenic disturbance) while also preferentially being located a sufficient distance from further mine development. As the reference streams need to mimic conditions in the mine-affected streams as closely as possible, parameters such

as elevation, stream order, geology and channel morphology were also considered during the selection process.

Reference streams were selected using the following process:

1. characterization of exposure reaches by stream order, bedrock geology, spatial distribution and channel morphology;
2. review of reference sites from past studies in the area such as the baseline assessment (CR#6 Appendix A1), and select appropriate locations using reach characteristics;
3. review additional locations to obtain reference streams that will adequately represent the spectrum of stream characteristics expected in the mine-affected streams.

The above criteria revealed several possible locations for reference streams. Those most relevant to the monitoring objectives are upper Blairmore Creek and Caudron Creek.

6.4.2.3 Sampling Stratification

Calcite is best assessed using a stratified approach. This approach is based on the hierarchy of spatial scales in stream networks. Using a spatial stratification style of approach allows for observations to be extrapolated over larger areas (Bisson *et al*. 2006). The three scales at which sampling could occur and which have been considered are: catchment, reach, and habitat unit.

Monitoring at the catchment scale for this study would not provide the spatial resolution required to inform and adequately trigger a mitigation response. Likewise, while monitoring at the habitat-unit scale would provide finer resolution, mitigation actions are not likely to be implemented at this scale. As such, monitoring at this scale would exceed the level of detail required for this monitoring plan.

Consequently, stream reach is the recommended spatial scale to be adopted as the sampling unit for the calcite monitoring plan. A stream reach is a portion of a stream that is smaller than a catchment, but larger than a habitat unit.

6.4.2.4 Reach Identification – Sampling Unit

Reaches for streams to be monitored were delineated using a desktop approach. Macrohabitat reach breaks were delineated in Gold Creek and Blairmore Creek mainstems based on the criteria described in Lewis *et al*. (2004) classifying reaches as "a homogeneous section of stream channel, characterized by uniform discharge, gradient, channel morphology, channel confinement, and streambed and bank materials." Detailed habitat assessments completed in May and October of 2016 identified reach breaks as:

1. changes in stream gradient;
2. changes in discharge, often where a significant tributary enters the mainstem; or
3. identified barriers to fish movement.

This approach for reach delineation aligns the Calcite Monitoring Plan with all other Project disciplines allowing for a more coherent, thoughtful analysis of data collected.

If during field studies, reach break observations differ from the those defined during the desktop exercise, data collected in the field will be used to better refine the reach length. As such, reaches may evolve over the length of the monitoring plan.

6.4.2.5 Within-Reach Replication – Sampling Sites

Sampling sites will focus on locations within each reach which contain spawning gravels. As this habitat is most sensitive to degradation resulting from calcite deposition, it will be important to monitor this specific type of habitat to better understand its susceptibility to calcite deposition in this system.

In order to understand variability within the sampling unit (stream reach), replication is required. Following methodology from other calcite monitoring plans, triplicate sampling will be performed within each reach (Teck 2014). Locations containing appropriately sized spawning gravels nearest 25, 50 and 75% of the total reach length will be sampled.

As all sampling units are anticipated to be over 300 m which will allow for triplicate sampling. As the plan evolves, reach lengths may change based on field observations. In the event changes to reach breaks occur, the following guidelines will dictate the number of samples collected per reach:

- Reaches <200 m – One sample collected over the entire length of the reach;
- Reaches <300 m – Collect one sample at the downstream end of the reach. A second sample beginning at 100 m will also be collected. Care will be taken to ensure sampling sites do not overlap;
- Reaches ≥300 m – Samples will be collected at 25, 50 and 75% of the total reach length.

6.4.3 Study Design

The Calcite Biological Monitoring Plan developed below for the Project is largely based off the calcite monitoring plan developed as part of the Elk Valley Water Quality Plan (Teck 2014). The ideas and methodology from the Teck (2014) plan were followed as it was developed by a team of experts with extensive collaboration from regulators. Teck has successfully implemented this calcite monitoring

plan for five years, demonstrating the effectiveness of the study design. The stratified approach taken also allows the methodology to be scaled to the size of system that requires monitoring.

The intent of calcite monitoring plan is to document the extent of calcite deposition, the degree to which deposition has occurred, as well as to characterize the calcite depositions. The proceeding sections outline the general concepts for capturing this information. Detailed field methodology and procedures will be provided prior to the implementation of this plan.

6.4.3.1 Sample Timing and Frequency

As the rate of change in calcite deposition is unknown for this system, annual sampling is recommended for the first three years of the plan. If after three years it is determined that sampling frequency is not adequate, it will be changed accordingly.

Annual sampling for the Calcite Biological Monitoring Plan will be undertaken in the fall. This will ensure any eggs deposited in redds/spawning gravels will have had an appropriate amount of time to incubate, emerge, and allow fry to migrate to lower energy lateral habitats before spawning gravels are disturbed. Sampling will be completed while field crews are stationed at site sampling for other monitoring plans. This will ensure data captured is compatible with other sampling plans while ensuring efficiencies in the Project are maximized.

6.4.3.2 Data Collection

Capturing the Extent of Calcite Deposition

The extent of calcite deposition will be measured in the field at each sampling site. These data will be used to extrapolate the linear coverage of calcite deposition over a reach.

6.4.3.2.1.1.1 Site-Level Extent

Calcite presence will be estimated by employing a modified pebble count (Wolman 1954 and CABIN 2009). The pebble count procedure typically has a participant systematically moving through the stream while periodically stopping and randomly selecting a particle to measure. This methodology is traditionally used to garner information pertaining to substrate size and embeddedness but can easily be adapted to also capture information regarding calcite presence.

The participant will randomly select a particle to be measured. All particles randomly selected will be included as datapoints, although only those larger than 2 mm will be measured. Particles <2 mm will be noted as fines but will not be measured. All measured particles will have their intermediate axis measured in mm, as well as a recording the presence (score = 1) or absence (score = 0) of calcite.

6.4.3.2.1.1.2 Linear Extent/Gradient

Desktop analysis will occur to estimate the extent of calcite deposition. The mean extent of calcite as a total percentage of spawning gravels available will be calculated. This will be done by the following formula:

$$Spawning\ gravels\ calcite\ coverage = mean\ site\ level\ extent * 100$$

Linear gradients of calcite extent will also be presented over the multiple sites and reaches sampled.

Capturing the Degree of Calcite Deposition

Degree is used to describe the level of stream bed concretion. This will be estimated by level of effort required to remove the particle form the stream bed. Levels of concretion will be scored as follows:

0 – Not concreted (negligible resistance to remove particle)

1 – Partially concreted (resistance, but removable)

2 – Fully concreted (immovable)

If the particle retrieved was too fine to visibly discern calcite presence/absence it will be assigned a concretion score of 0. This will be reported for each particle removed but will be specific to resistance created by calcite.

Type of Calcite Depositions

The type of calcite deposition will be recorded in addition to extent and degree. Types of calcite formations that can be visibly discerned in the field will include: calcified algae, calcareous laminate, calcified moss/tufa, barrage tufa, calcite scale, and insect tufa.

Rate of Change

After multiple years of data have been collected, it will be possible to examine the rate of change in extent and degree of calcite deposition.

6.4.4 Field Methods

Field crews will access targeted streams and sample while travelling upstream. As outlined above, as many as three sample sites will be located in one sample area. At each sample site, a pebble count will occur. One hundred particles will be selected, and data pertaining to calcite presence/absence, level of concretion, b-axis length and habitat type will be recorded. Additional notes will be taken on the type of calcite deposition and general site descriptions.

6.4.4.1 Calcite Deposition Index

The degree and extent of calcite deposition in each reach will be quantified in a calcite deposition index (CI). A singular CI value will be calculated for each sampling site. If more than one site is sampled in a reach, values will be averaged for the mean CI for the sampling reach (Teck 2016). CI will be based on the following equation:

$$CI = CI_P + CI_C$$

Where

$$CI = Calcite\ Index$$

$$CI_P = Calcite\ Presence\ Score = \frac{Number\ of\ particles\ with\ calcite}{Number\ of\ particles\ counted}$$

$$CI_c = Calcite\ Concretion\ Score = \frac{Sum\ of\ particle\ concretion\ score}{Number\ of\ particles\ counted}$$

Resulting CI values will range from 0 (no calcite present) to 3.0 (calcite present on all particles and fully concreted).

The normal range for the calcite index will be defined as the 2.5th and 97.5th percentiles (representing 95% of the values) of the distribution of the calcite index values observed in the reference areas sampled (Minnow 2016).

6.4.5 Plan Assessment and Refinement

The Calcite Biological Monitoring Plan will be refined as it progresses through the years. As more detailed field data is captured, the plan can become more refined and tailored to ensure site selection, field methodology and data analysis is functioning as intended.

6.5 Aquatic Effects Monitoring Plan

6.5.1 Goals and Objectives

The overall goal of the Aquatic Effects Monitoring Plan is to evaluate the effects of effluent released from the mine on the aquatic receiving environment of Blairmore Creek/Crowsnest River and verify that contact water from the mine does not adversely influence Gold Creek. The objectives of the plan will be to:

- develop a Surveillance Network Program (SNP) designed to provide a localized, more immediate dataset on which management decisions can be made; and
- develop a larger scale Aquatic Effects Monitoring Program (AEMP), which would meet federal EEM requirements under the expected *Coal Mining Effluent Regulations*.

6.5.2 Description of Receiving Environments

6.5.2.1 Site Characterization

A full site characterization will be provided prior to the first implementation cycle of the AEMP. This will include development and testing of various effluent tracer parameters, as well as plume delineation studies downstream of each effluent discharge point on Blairmore Creek. These data will help identify suitable sampling areas/sites as well as identify potential confounding factors that may affect data interpretation.

6.5.2.2 Sample Areas

Samples will be collected from one or more exposure areas and one or more reference areas. These are defined as follows:

- **Exposure Area**: aquatic receiving environment that is exposed to effluent. For the Project, this is Blairmore Creek. Given the sensitive status of Gold Creek (designated critical habitat under the *Species at Risk Act*) it will also be monitored for potential impacts. Results from the site characterization and plume delineation study may also necessitate including the Crowsnest River as an exposure area.
- **Reference Area**: water frequented by fish that are not exposed to effluent and that has fish habitat that as far as practicable is most similar to that of the exposure area. For the Project, this will be upper Blairmore Creek and Caudron Creek. If upper Blairmore and/or Caudron Creek are not sufficient, a reference area within LSA or RSA can be explored.

6.5.3 Study Design

Two distinct programs will occur under the Aquatic Effects Monitoring Plan:

- **Surveillance Network Program (SNP)**: The SNP will provide water quality data from a subset of sites located in the reference and exposure areas as well as the effluent on a weekly basis. Sites will be strategically situated close to the mine site and discharge points on Blairmore Creek. Water quality samples analyzed for a set of previously determined water quality variables. Providing data weekly will allow for a timely feedback loop to occur, which will help inform management decisions and trigger limits for sensitive analytes.

- **Aquatic Effects Monitoring Program (AEMP)**: An AEMP will be implemented at the mine once discharge begins. In November 2017, Environment and Climate Change Canada (ECCC) released a consultation document outlining the P*roposed Approach for Coal Mining Effluent Regulation* (ECCC 2017). This new regulation would require an EEM program at all coal mines that discharge effluent. The EEM program includes characterizing effluent, monitoring water quality, and assessing impacts to biota in the receiving waters. This AEMP is being developed in such a way that it will fulfil the EEM program requirements.

Components required to be monitored, frequency of sampling, and sample locations are outlined in Table 6.0-3.

Table 6.0-3 Aquatic Effects Monitoring Plan stations and activities

Station Location(s)	Monitoring Parameters	Monitoring Frequency	Description of Monitoring Activities
Effluent from each discharge	Water Quality (effluent subset)	Quarterly	Effluent from each discharge point will be analyzed for the parameters listed in Table 6.0-4.
	Sublethal Toxicity	2x a year	Effluent from each discharge point will be analyzed for sublethal toxicity responses from rainbow trout, *Ceriodaphnia dubia* and *Lemna minor*. Test organisms/sampling frequency will change based on results from first three years of testing.
	Acute Toxicity	Monthly	Effluent from each discharge point will be analyzed for acute toxicity to rainbow trout and D*aphnia magna*. Sampling frequency may be decreased based on testing results.
Surveillance Network Program stations	Water Quality	Weekly	Stations in both the reference and immediate exposure areas as well as the effluent will be monitored for a full set of WQ parameters.
Aquatic Effects Monitoring Program stations	Water Quality	Quarterly	A larger set of water quality variables than is monitored from liquid effluent will be monitored at the established AEMP sample locations four times annually.
	Sediment Quality	Once every three years	Sediment will be monitored for total organic carbon as well as particle size at all benthic invertebrate community monitoring stations.
	Benthic Algae	Once every three years	Benthic algae will be monitored for biomass and tissue chemistry.

Table 6.0-3 Aquatic Effects Monitoring Plan stations and activities

Station Location(s)	Monitoring Parameters	Monitoring Frequency	Description of Monitoring Activities
	Benthic Invertebrate Community	Once every three years	Benthic invertebrate communities will be sampled and evaluated by investigating various endpoints (density, evenness, richness, and Bray-Curtis index) as well as tissue chemistry.
	Fish Health	Once every three years	Fish health will be sampled and evaluated by investigating various effect indicators (growth, reproduction, condition and survival).

6.5.3.1 Water Quality

Water quality samples collected from effluent, SNP and AEMP station locations will be analyzed for the following parameters provided in Table 6.0-4.

Table 6.0-4 Core list of water quality analytes to be analyzed

Physical Parameters	Total and Dissolved Metals
Alkalinity	**Aluminum**
Electrical conductivity	**Arsenic**
Hardness	**Calcium**
pH	**Cadmium**
Temperature	**Chromium**
Total Dissolved Solids	**Cobalt**
Total Suspended Solids	**Copper**
Nutrients	**Lead**
Ammonia	**Iron**
Nitrite	**Mercury**
Phosphorus	**Manganese**
Sulphate	**Nickel**
Total nitrate	**Uranium**
Organics	**Zinc**
Total organic carbon	**Total selenium**
Dissolved organic carbon	

Collection of water quality data will help provide the necessary information to understand toxicity testing results, as well as help interpret the results from the biological monitoring studies.

6.5.3.2 Toxicity Testing of Effluent

Acute Toxicity Testing

Effluent will be required to be non-acutely lethal to fish and invertebrates. In order to monitor compliance, acute toxicity testing will occur. Effluent from each discharge point will be analyzed monthly for two different test species (rainbow trout and Daphnia magna). Any sample resulting in an acutely lethal response will trigger increase sampling frequency, with potential remedial measures to be taken.

Sublethal Toxicity Testing

In addition to acute toxicity testing, effluent will also be tested for sublethal toxicity. Sublethal toxicity will be sampled for twice annually once the mine is discharging. Samples will be tested for effects on fish early life stage development, invertebrate reproduction as well as plant and algae toxicity.

6.5.3.3 Benthic Algae

Benthic algae are an important component of benthic invertebrate habitat because they provide food and shelter for invertebrates. The biomass of benthic algae on hard substrates tends to increase with increasing levels of nutrients. As a result, benthic algae growing on rock (called epilithic algae) can be used as indicators of nutrient enrichment. Primary producers also present an opportunity to measure selenium in the food web. A benthic algae survey will be included as part of the AEMP sampling program, which will be to determine whether there is enhanced algal growth in response to effluent exposure, as well as monitor selenium uptake in exposed areas.

6.5.3.4 Benthic Invertebrates

Benthic invertebrate communities will be monitored in both the reference and exposure areas. The communities will be quantified as various endpoints. Endpoints include total benthic invertebrate density, Simpson's evenness, taxa richness, and the Bray-Curtis index. Each endpoint will be examined, and differences between the reference and exposure communities evaluated. Results of this evaluation will determine if benthic invertebrate communities significantly differ between the reference and exposure areas. Additionally, benthic invertebrates will be analyzed for tissue chemistry. Doing so will allow for additional monitoring of selenium uptake in exposed areas.

6.5.3.5 Fish Health

A fish health study is a proposed requirement of the upcoming EEM program. To comply, mines will be required to monitor fish populations in receiving environments for signs that exposure to effluent may negatively impact fish health. This will include monitoring growth, reproduction, condition factor, and survival in both the reference and exposure areas.

A key consideration when selecting a sentinel species is the mobility and residency time of that species relative to effluent exposure. Fish species that are resident in the aquatic system under investigation for most or all of their life cycle and exhibit territorial behavior or limited mobility/movement relative to the size of a study area are preferred because of the observed responses of these species are reflective of their localized environment. Species that are migratory or spend only a small proportion of their life cycle in the area under investigation are not suitable as sentinel species because exposure to effluent is minimal or transient.

It is also best practice that preference be given to species of relatively small adult size since age-at-first maturity and adult natural mortality vary in proportion to adult size. Reasoning being that the adult abundance of small species should respond more rapidly to stressors that affect fecundity and/or larval survival.

Fish present in the immediate study area (Blairmore and Gold creeks) do not contain any fish that would traditionally be considered appropriate as a sentinel species. Further discussions with ECCC would be required in order to determine how best to monitor fish health in the receiving environment given the baseline conditions.

An item specifically raised in JRP IR 5.4 focused on how WSCT eggs and/or fish ovaries could be monitored for potential selenium-related effects in a manner that is consistent with the objectives of the Recovery Strategy for WSCT but also considers potential sampling limitations to species at risk. Ultimately, given the sensitivity around actively sampling an at-risk fish species, makes this request relatively problematic. There are study options available to monitor for egg-development risks (*e.g.*, *in situ* early life stage tests using hatch boxes, see Chalmers *et al*. 2014). However, the actual study design and potential for implementation is best served in collaboration with regulators.

6.6 Westslope Cutthroat Trout Population Monitoring Plan

6.6.1 Goals and Objectives

The goal of the proposed Westslope Cutthroat Trout (WSCT) Population Monitoring Plan is to monitor the long-term persistence and sustainability of WSCT in Gold and Blairmore creeks. The objectives of this plan will be to:

- build on snorkel surveys and extend the current population trend monitoring data (2016, 2017, 2018, 2019) over a 10-year period;
- investigate with regulators the feasibility to continue with fry and juvenile density monitoring that was executed in 2016 and develop a trend monitoring dataset; and
- collect detailed fish distribution, habitat utilization and trend monitoring data to support the Fisheries Offsetting Plan.

These data will aim to establish information specific to WSCT population dynamics (population size, population demographics, WSCT distribution) over time to reduce uncertainty regarding the population trend and the long-term viability, persistence and sustainability of the WSCT populations inhabiting Gold Creek and upper Blairmore Creek.

6.6.2 Study Design

During baseline characterization, representative survey index sites were established, and annual data were collected for each site. Snorkel surveys were generally conducted in the spring (spawning), summer (rearing) and early winter (overwinter) seasons, focusing on abundance, fork length (FL) by class, and habitat use. This plan is designed to continue building a robust dataset characterizing the WSCT populations in Gold and Blairmore creeks by collecting repeatable data collected using consistent methodology over time. The location of the monitoring sites has been chosen to ensure all habitat types are ecologically represented including sites upstream and downstream of potential project effects.

The WSCT populations in Gold and Blairmore creeks will be monitored using adult/sub-adult population estimates and annual recruitment of fry/juvenile (0+, 1+) density estimates using the following metrics:

- population size;
- population demographics; and
- fish distribution.

The threshold or target of this plan is to ensure the persistence and recovery of WSCT populations during Project operations, decommissioning and closure within natural variation. The data collected as part of this plan will be used with data collected from other monitoring programs (including the proposed Fisheries Offsetting Plan) to generate a real understanding of WSCT population status.

6.6.2.1 Baseline

Baseline characterization began in 2016, and included spring spawning surveys, genetic sampling, condition factor (K), summer population assessments, employing a blended approach with both electro-fishing (fry/juvenile recruitment) and snorkel surveys (adult/subadult population estimates) and over-wintering surveys. Subsequently, to reduce the handling of WSCT, snorkel surveys were employed during 2017, 2018 and 2019 during spring spawning, summer rearing and overwintering. To characterize fry/juvenile recruitment without the use of electrofishing, visual counts of fry (young of the year) and juveniles (<10 cm FL) were completed during the snorkel surveys. Fork-length informs population size and demographic structure. These surveys will continue on an annual basis until Project construction and operations commence.

6.6.2.2 Construction, Operations and Decommissioning

The construction, operations, and decommissioning monitoring phase will continue to follow the annual baseline monitoring through the life of the project. The frequency of monitoring may be required to address specific potential projects effects on WSCT populations within the LSA and may require an adaptive approach to both monitoring and mitigation strategies to ensure defined population targets are maintained.

6.6.2.3 Closure

This monitoring phase will address potential effects the closure of the mining site may have on the WSCT populations.

7.0 ADAPTIVE MANAGEMENT

This Program has been developed to validate the predicted Project effects on WSCT. Benga recognizes there is an inherent uncertainty in these predictions given natural variation in the environment such as fluctuations in the WSCT population and climate change. Should monitoring detect Project effects that are different than those predicted, Benga is committed to implementing adaptive management measures such as additional mitigation or offsetting activities.

Contemporary adaptive management science relies on monitoring and management of species that are being conserved and managed over the long-term. A key concept of adaptive management is that

the world is uncertain and flexibility in resources management is crucial (Holling 1995, Holling and Meffe 1996). Like all scientific results and inference, effects predictions are subject to uncertainty. Uncertainty can stem from various factors. For example, uncertainty may be associated with various assumptions and limitations inherent in the data, the extent of current knowledge of the system under study, the collective biology of a species, and natural variability and resilience to change. Since as the degree of uncertainty increases about whether an activity would jeopardize the survival or recovery of WSCT, the likelihood decreases that a permit can be issued (Government of Canada 2016) all efforts will be taken to reduce the uncertainty in the predictions through monitoring, ready to instate changes if indicators show they are necessary.

Benga's adaptive management approach will involve establishing indicators and thresholds according to baseline characterization, improved practices based on research and monitoring results, and input from the public engagement and Indigenous consultation programs. As the Project proceeds, monitoring throughout all Project phases will allow WSCT targets to be reviewed and, if necessary, modifications can be made to site expectations.

Adaptive management is intended to respond to changes and advances in technology to meet specific objectives. Benga will incorporate adaptive management techniques as routine components in all of its environmental management activities. These techniques provide the opportunity to develop and fine-tune the monitoring program using data collected on-site and from other regional operators.

Benga will use the experience gained during the development of the Project, and other successes by the regional coal operators over the next 24 years, to manage and implement an effective monitoring program. Benga will work with other operators of coal mines, AEP, AER, DFO, ECCC, and local stakeholders, to further develop criteria and monitoring programs that clearly demonstrate progress toward reclaiming environmentally sound sustainable ecosystems.

With respect to Adaptive Management, Benga is committed to achieving continual improvement in environmental performance. The development and implementation of all monitoring and mitigation identified for the Project and housed in the monitoring and follow-up programs will be tracked in relevant management plans. As site conditions and monitoring dictate, or as new technology emerges, Benga will adaptively manage its site practices and monitoring program to meet the defined objectives. For some programs this would involve regular evaluation of predictive models; which would be clearly defined in each applicable management plan.

If a monitoring and follow-up program identifies that adverse environmental effects are greater than predicted, then Benga will evaluate whether they result in changes to the conclusions presented in the effects assessment. If changes are confirmed, then Benga will evaluate the need for revised mitigation

actions and management practices to manage effects. Where the need for revised mitigations is identified, they will be developed and implemented.

7.1 Adaptive Management Process Design

Once the problem has been identified and assessed, the design of the adaptive management program can commence, beginning with determining the best approach to adaptive management. The following are design considerations for the adaptive management program:

- data analysis methods and frequency;
- predicted trajectories for indicators; and
- triggers for action and potential adaptations.

Benga is confident in the mitigation measures selected but acknowledges that a formal process may be warranted to optimize the measures, as opportunities to refine aspects of the management strategies are available. This formal process includes the following points:

- predicted trajectories through time for the indicators;
- a monitoring plan designed to allow observed trends to be compared to predicted trajectories;
- triggers for action, should predicted trajectories and observed trends not align, and a plan of action if and when triggers are pulled.

7.2 Implement, Monitor and Evaluate

Once Project development begins, effectiveness monitoring will commence and observed trends will be compared to predicted trajectories. An evaluation of the monitoring results will determine if adaptations to mitigation need to be implemented. A sequence of actions is triggered if monitoring data indicate that environmental performance does not meet targets.

The mitigation described throughout the EIS (and as updated) will be incorporated into monitoring plans for the Project. Monitoring protocols will be established soon after Project development begins so that trends and progress can be evaluated. Should indicators meet targets or align with desired trends, business will be conducted as usual. Should indicators not meet targets or trends diverge from the desired trajectory, a sequence of Project-specific actions will be triggered. Prior to adjusting any mitigation, steps will be taken to investigate the observations, as necessary. If required, the following sequence will be followed:

1. Monitoring results will be verified and investigated.
2. Adaptations to mitigation will be identified and evaluated based on monitoring results.

3. Develop a work plan to adapt mitigation or monitoring, if required.

8.0 IMPLEMENTATION

8.1 Roles and Responsibilities

This section will be included in the final version of the Program and will outline specific roles and responsibilities for employees and contractors related to the implementation of the Fisheries and Aquatics Monitoring Program.

8.2 Information Management and Reporting

This section will outline how the monitoring results and adaptive management actions will be recorded, stored, tracked and made available to interested stakeholders. Accurate record keeping will be necessary to assess the implementation of the Program, to measure the effectiveness of management and to develop and implement any necessary improvements.

8.3 Change Management

This section will outline the process for altering any part of this Program, which may be required due to changes resulting from ongoing adaptive management.

8.4 Communication Management

This section will outline the process that will be used for communicating the results of the program to interested stakeholders.

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APPENDIX 5.5-1 : SELENIUM ATTENUATION CASE STUDIES

IN-SITU IMMOBILIZATION OF SELENIUM WITHIN THE SATURATED ZONES OF BACKFILLED PITS AT COAL-MINE OPERATIONS

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ABSTRACT

The removal of selenium (Se) from water using passive technologies at mine sites is challenging as a result of associated high flow rates. However, the chemical and hydraulic conditions of backfilled pits offer a potential means to bioremediate large volumes of water passively. Specifically, the oxidation demand associated carbonaceous waste materials in conjunction with long water residence times within backfilled pits can produce the suboxic conditions required to support the removal of Se from solution through a suite of microbially-mediated processes. Evidence for Se removal is provided from a study of a backfilled pit at a coal mine in Northern Canada. Redox conditions within the saturated backfill are mildly-suboxic, as inferred from low levels of oxygen, nitrate and the presence of dissolved Mn and Fe. Results show pronounced removal of dissolved Se within the saturated backfill, with concentrations decreasing from 40 µg/L (upgradient of saturated zone) to <1 µg/L within the saturated waste rock zone. The reduction in Se concentration was accompanied by a shift in Se speciation from dominantly selenate (Se^{VI}) to selenite (Se^{IV}) along the flow path. Nitrate-N values are also reduced to values below detection (<0.05 mg/L) in the saturated backfill. The data suggest that this relatively small backfilled pit achieves a Se removal rate ranging from 0.03 to 0.3 mg/day/$m^3_{wasterock}$ with a hydraulic residence time of 0.3 to 3 years. Collectively, the data imply that the saturated backfilled zones are serving as an effective site for the bioremediation of Se under mildly suboxic conditions.

KEY WORDS

Selenium removal rate, bioremediation, passive treatment

INTRODUCTION

The bioremediation of selenium (Se) from mine waters using passive systems (e.g., subsurface-flow biological reactors and permeable reactive barriers) has received considerable attention owing to the prevalence of elevated Se concentrations in coal-mine drainages (CH2MHill, 2013). Selenium is naturally abundant in rocks with sedimentary facies hosting carbonaceous shales and shales having particularly high levels; natural ranges documented are 206-280 mg kg^{-1} and 1–675 mg kg^{-1}, respectively (Fernández-Martinez and Charlet, 2009). These rock types typically make up a fraction of the waste rock material at coal mines and constitute a major source of selenium to groundwater and surface water receptors. Toxicity is manifested as reproductive impairment due to maternal transfer resulting in juvenile abnormality or embryo death (Chapman et al., 2009).

In coal mine wastes, Se may be associated with both reduced sulphur species (e.g., pyrite) and as discrete reduced Se compounds (e.g., elemental Se and selenides). The release of Selenium from source rocks is hypothesized through the following reactions:

Oxidation of selenide to selenite

$$FeSe_{(s)} + 3O_2 + 3H^+ + 5e^- \rightarrow SeO_3^{2-} + Fe(OH)_3 \quad (1)$$

Oxidation of selenite to selenate

$$SeO_3^{2-} + O_2 \rightarrow SeO_4^{2-} \quad (2)$$

Both selenite and selenate have an affinity to absorb onto ferric oxyhydroxides; however, the selenate molecule has a lower sorptive affinity rendering it more mobile (Su and Suarez, 2000, Lo and Chen, 1997, Zhang and Sparks, 1990).

The backfilling of wasterock into the voids of open pits offers considerable potential for Se management with respect to both remobilization and attenuation. From a remobilization perspective, the backfilling of waste rock below the water table in open pits will act to shut down oxidation mechanisms responsible for the release of Se to solution. In saturated settings, the oxidation of these reduced species is effectively curtailed, thereby reducing the potential for Se remobilization. This relates to the tendency of oxygen to become depleted in saturated pore spaces, and more importantly, to the diffusion-controlled replacement of dissolved oxygen to reaction sites, which is very slow. In terms of attenuation, the presence of suboxic conditions is a pre-requisite for effective Se attenuation in saturated settings, whereby the removal of Se can occur via: 1) adsorption of selenite; 2) precipitation of elemental Se; 3) precipitation of Se as inorganic/organic selenides; and 4) co-precipitation of Se with reduced sulphur. Suboxia is also required to reduce nitrate, the presence of which can inhibit Se reduction and selenite sorption (Dhillon and Dhillon, 2000). Since backfilled-pit environments have the potential to develop suboxia, these systems offer significant potential with regards to Se attenuation.

This paper summarizes the findings of a field-based hydrogeologic program that assessed the nature of Se behaviour in the saturated backfilled portion of a relatively small pit located in the Rocky Mountain Foothill region of northeastern British Columbia, Canada. The results have broad-scale application to the management of and treatment Se at coal mines and other mining environments that are characterized by Se enrichment (e.g., phosphate mines, metal mines).

SITE DESCRIPTION AND METHODS

The investigation was conducted at an active coal mining operation located in the Rocky Mountain Foothills in the northeastern portion of British Columbia, Canada. The Rocky Mountain Foothills are part of the continental-scale Foreland Fold and Thrust Belt forming the eastern margin of the North American Cordillera. Elevations range from 1,830 m to 2,130 m while precipitation ranges from 500 to 1,000 mm annually with more than 60 % falling as snow. The hydrogeology of the region consists of a shallow

water table (unconfined) system within the overlying surficial (quaternary-aged) sediments where present, and a bedrock system in fractured sedimentary rocks with hydraulic conductivity ranging from 10^{-10} ms^{-1} for a low-permeability shale to 10^{-3} ms^{-1} for a vuggy limestone. The foothills are underlain by a succession of marine and non-marine sedimentary rocks (B.C. Environment, 1994). This section provides a description of the pit shell physiology, characteristics of the backfilled (waste rock) material, the design of the porewater/groundwater monitoring network, methods for collecting and analyzing porewater samples.

Backfilled Pit Physiology

The coal reserve associated with the study site is situated on a small synclinal structure minimizing the strip ratio which resulted in the development of an elongated shallow open pit approximately ~1000 m long, ~150 to 200 m wide and ~50 m deep. Approximately 1.6 million tonnes of pulverized coal injection (PCI) grade coal was excavated from the pit using typical surface mining techniques relying on blasting and shovel methods. Mining of the pit was completed by 2006 and backfilling of the pit occurred in 2011. A total of 4.8 Mm^3 of waste rock was backfilled into the pit, and of this approximately 0.2 Mm^3 is saturated. The maximum depth of the waste rock in pit is on the order of 50 m (mean depth of about 28 m) with saturated thickness of approximately 22 m. The pit shell configuration and the placement of backfilled waste rock is shown in Figure 1. Table 1 summarizes the dimensions of the pit shell, as well as total and saturated backfilled waste rock material.

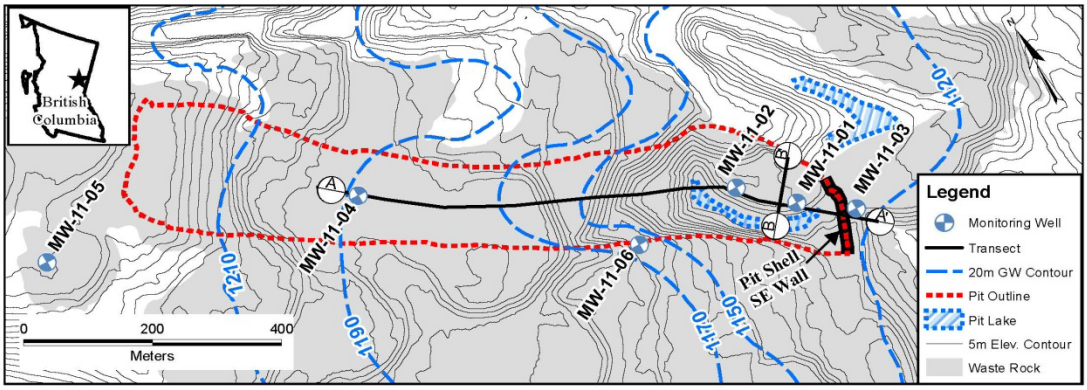
Monitoring Network

In November 2011, eleven (11) monitoring wells were installed with seven (7) of the wells completed as two monitoring well nests (MW11-01 and MW11-02). A dual rotary (Barber) rig was used to advance the boreholes through waste rock and bedrock and to install the monitoring wells. All monitoring wells consist of 2-inch schedule 80 polyvinylchloride (PVC). Table 2 summarizes the details of the monitoring well installations. Water quality profiling within the saturated portion of the in-pit dump was accomplished with the use of nested monitoring wells with 5-foot long screens (1.5 m) (Elci et al. 2001). The location of these wells with respect to the in-pit dump is shown on Figure 1. The monitoring wells were placed along the centerline of the pit shell bottom as determined from a 2011 Lidar survey. MW11-01 and MW11-02 consist of four (4) and three (3) nested wells, respectively, installed within the saturated backfilled waste rock. MW11-04 is screened across the bedrock/wasterock interface upgradient of the saturated zone, and it is assumed that groundwater within this well is representative of water flowing along the bottom of the backfilled pit and representative of non-attenuated source waste rock water. MW11-03 and MW11-06 were installed within bedrock adjacent to the pit to characterize background water quality and water levels.

Table 1. Summary of Backfilled Pit Characteristics

Description	Dimension	Units	Size
Pit Shell	Length	(m)	1100
	Width	(m)	125-205
	Depth	(m)	~50
	Area	(m^2)	171,792
	Volume	(Mm^3)	4,709,000
Waste Rock	Area	(m^2)	168,871
	Volume	(Mm^3)	4,761,000
Saturated Waste Rock	Depth (mean)	(m)	18.8[1]-20.3[2]
	Area	(m^2)	22,728[1]-23,973[2]
	Volume	(m^3)	197,000[1]-232,000[2]

Notes:
[1] winter low groundwater level; [2] freshet high groundwater level



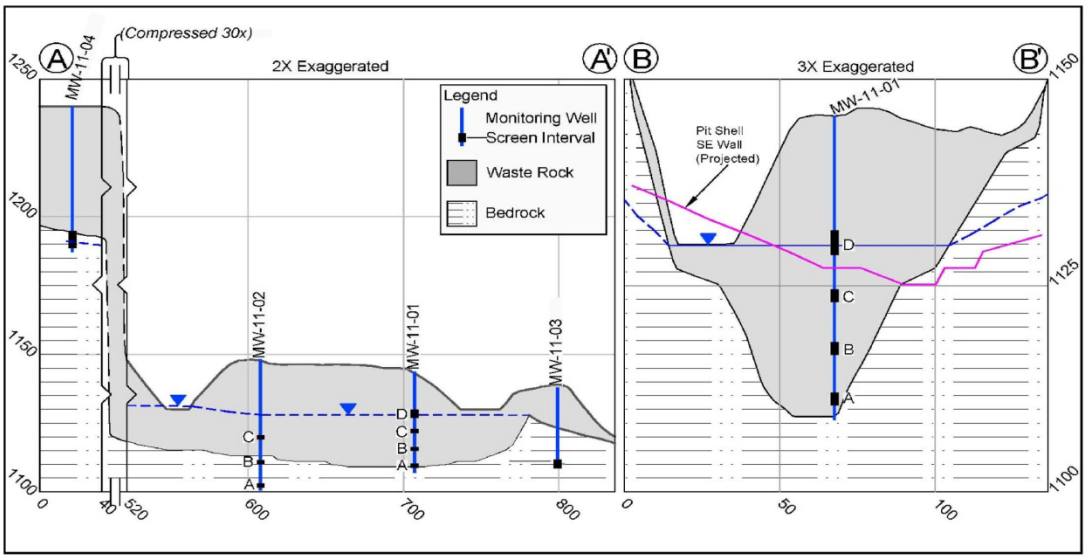


Figure 1. Study site map showing the physiology of the backfilled pit, instrumentation and water table surface map.

Table 2. Summary of monitoring well installations.

Monitoring Well	Screened interval	Instrumentation
Upgradient Well		
MW11-04	Waste rock	Levelogger®
Saturated Backfill		
MW11-02B	Waste rock/bedrock interface	-
MW11-02C	Waste rock, mid pit	HOBO® Levelogger®
MW11-01A	Waste rock/bedrock interface	HOBO®
MW11-01B	Waste rock, lower pit	Levelogger®
MW11-01C	Waste rock, water table	HOBO®
MW11-01D	Waste rock, water table	HOBO® Levelogger®
Peripheral Bedrock		
MW11-02A	Bedrock	HOBO® Levelogger®
MW11-03	Pit wall (southwest)	HOBO®
MW11-06	Pit wall (southeast)	Levelogger®

Notes: HOBO sensors provide hourly fluid conductivity data.

Porewater Monitoring and Sampling

Select monitoring wells were installed with Solnist Leveloggers® water level sensors and onset® HOBO® conductivity loggers for continuous (hourly) monitoring from November 2011 to March 2013. Table 2 summarizes the distribution of instrumentation among the wells. Manual measurements of water level and fluid conductivity were conducted during each groundwater sampling round. Three (3) rounds of sampling were conducted coinciding with anticipated variations in groundwater level associated with a freshet-dominated hydrologic system. As such, sampling occurred as follows: December 2011 coincident with fall low water levels; July 2012 representing freshet high water levels; and March 2013 representing the stream base flow and lowest water levels. All groundwater wells went through the process of development, purging and sampling. Wells were developed by the drillers using compressed air and air lift system. To minimize artifacts of sampling associated sample quality variability and error, monitoring wells were purged and sampled using the Low-Flow technique (Varljen et al., 2006; Elci et al. 2001). All monitoring wells with the exception MW11-03 were sampled using the QED bladder pump. MW11-03 was sampled using a Waterra inertial pump.

Porewater Sample Analysis

Groundwater samples were collected for bulk chemistry, anions, dissolved metals, Se speciation and microbial analyses. Samples for the general aqueous analyses were sent to ALS Laboratories of Burnaby, BC. Se speciation in water was completed at the Trent Water Quality Centre, Trent University similar to the method by Petrov et al. (2012). The ion chromatography-separation method for Se species followed

that of Wallschläger and Roehl (2001). Samples for screening of Se-reducing microbes were sent to Department of Metallurgical Engineering, University of Utah. Microbes from collected samples were analyzed by classical solid media (plating) and liquid culture techniques modified to enumerate both total microbes and Se reducers present.

RESULTS

Backfilled Pit Hydrogeology

Continuous water level readings from MW11-01D along with continuous fluid conductance readings from MW11-01D and MW11-01A are presented in Figure 2 for the period December 2011 to May 2013. Water level records show that freshet leads to an increase of 2 m in saturated thickness within the waste rock pile. Porewater conductance at the MW11-01D is approximately 300 µS/cm lower than observed at MW11-01A (800 uS/cm), likely an effect of recharge events through the waste rock. The effect of recharge, particularly during freshet, appears to reduce the fluid conductance within the saturated backfilled. However, the effect is more pronounced at the bottom of the pit (i.e., at MW11-01D). These data indicate there could a preferential flow path for water at the interface of the waste rock and pit bottom.

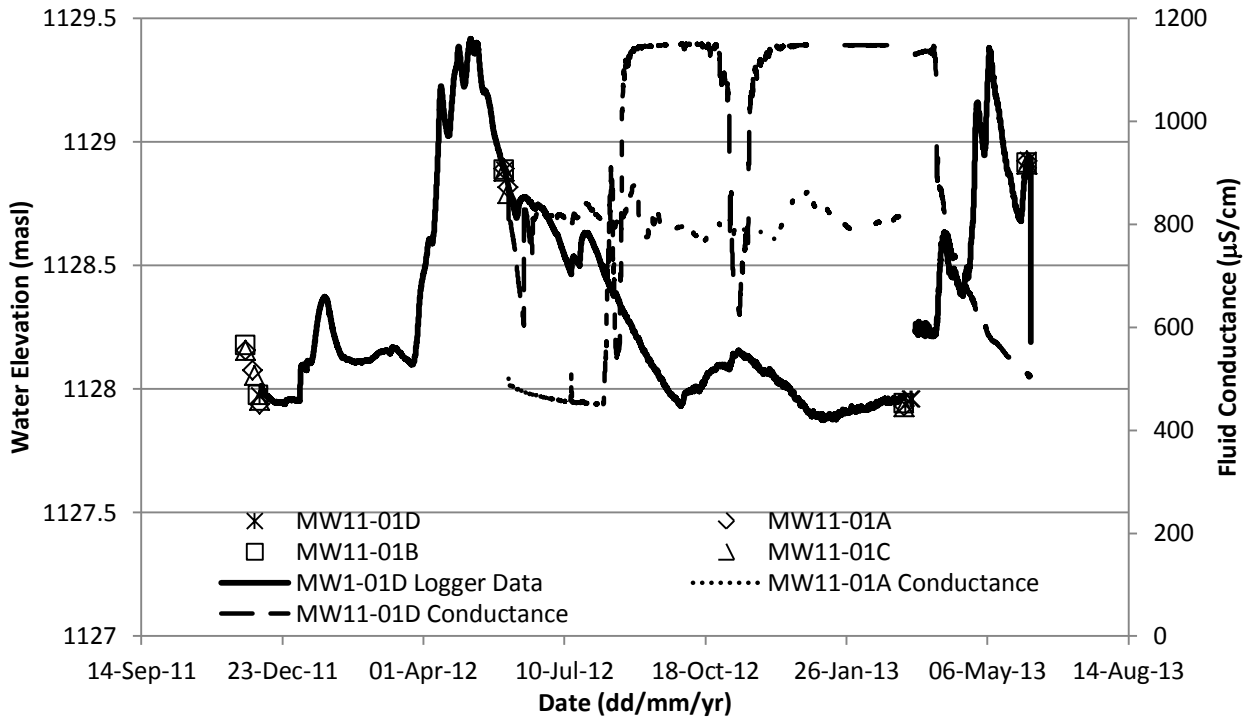


Figure 2. Water levels readings measured at MW11-01. Continuous readings are shown for MW11-01D which is screened across the water table. Manual measurements are also shown for MW11-01A,-01B, -01C and -01D.

The water table surface map shown in Figure 1 was generated using the manual water measurements observed during March 2013. In general, groundwater flow follows a south-easterly direction with deviations in flow patterns at a smaller scale due to influence of the pits. Within the saturated backfilled waste rock, water is predicted to flow relatively rapidly from the upper unsaturated zone to the downstream zone of saturation (~20 m in thickness). The water level within the lower saturated section of the pit is controlled by the southern pit wall which acts as decant point. This remnant bedrock wall produces the "bath tub" conditions within the lower portion of the in-pit dump. The greatest gradient, ranging from 10% to 20%, occurs between MW11-04 and MW11-01 due to the topographic relief between these two monitoring wells (see Table 3). The horizontal groundwater gradient between MW11-01 and MW11-02 is negligible, however; the variation in elevation between the in-pit water level and southern pit wall at MW11-03 is 1.4 % and 2.5% for winter and freshet conditions, respectively.

The groundwater heads within the bedrock at MW11-02A and -02B are 0.25 m lower than that within wasterock at MW11-02C, indicating groundwater flow is downward (data not presented). The gradient at MW11-02 was calculated to be 1.6%. The water elevation in MW11-03 is higher than MW11-01 and MW11-02 indicating an upward gradient in the southern pit wall on the order of 1%.

Conceptually, water flow through the pit consists of rainfall infiltrating downward through the waste rock and collecting along the pit bottom. Ponded water then follows along the pit floor to lower elevation where it pools in the lower portion of the pit within the 20 m-thick saturated zone. Groundwater exits the pit in two ways: 1) spillage over the bedrock ridge at the southeastern of the pit (see Section B-B' in Figure 1); and 2) downward flow through the underlying bedrock. Groundwater velocities along these flows paths are predicted to be markedly different as the hydraulic conductivity of bedrock making up the pit floor is likely three 3 to 4 orders of magnitude lower than that of the waste rock material. An estimate of waste rock hydraulic conductivity based on literature values for gravel yields a range of 10^{-4} to 10^{-5} m s^{-1} whereas, the hydraulic conductivity of the siltstone is predicted to be on the order of 10^{-7} to 10^{-10} m s^{-1} (Freeze and Cherry, 1979).

The groundwater flux through the lower pit floor (area = 24,000 m^2 see Table 1) is estimated to be 3.3 m^3/day (~0.04 L/s). Overflow at the decant point is dependent on the porosity of the waste rock material, an uncertainty in flow estimates. It is generally accepted that the porosity of end-dumped waste rock material could vary considerably thus varying the hydraulic conductivity. Estimates of the horizontal flux through the pit assumed a porosity that ranges from 25% to 40% and a hydraulic conductivity of 10^{-4} to 10^{-5} ms^{-1}. During winter, the horizontal flux component range from 43 to 430 m^3day^{-1}, whereas during freshet, the flux ranges from 80 to 800 m^3day^{-1}. Accordingly, the hydraulic residence time of the saturated backfilled pit ranges from 0.5 to 3 years during winter, and from 0.3 to 2 years during freshet (See Table 3).

Pit Water Quality

In general, water quality observed during the first round is artificially elevated as a result of drilling-related impacts. The disruption to the ambient geochemical environment by mechanical forces and injection of air during drilling can result in sampling artifacts associated with parameters associated with

sulfides (e.g., Se), as well as redox-sensitive parameters. Indeed, well development was insufficient to remove all artifacts of drilling for the first round of sampling. As a result of drilling artifacts in the first round of sampling, the following discussion considers only the results of the 2nd and 3rd sampling rounds (May 2012 and March 2013).

Redox reactions are integral to the biogeochemical processes controlling the attenuation of Se (Masscheleyn et al. 1993; Martin et al., 2011). Redox-sensitive parameters include dissolved oxygen (DO), dissolved nitrate (NO_3^-), dissolved manganese (Mn), dissolved iron (Fe), sulfate (SO_4^{2-}), and hydrogen sulfide ($\Sigma H2S = S^{2-}$, HS^- and H_2S). Inspection of the data in Table 4 for DO, nitrate, dissolved Fe, dissolved Mn show evidence of mild suboxia within the saturated portions of the backfilled pit. Dissolved oxygen concentrations were consistently elevated in the upgradient groundwater (MW11-04) ranging from 2 to 6.3 mg/L but for the remainder of the wells concentrations were generally below 0.7 mg/L. The presence of dissolved iron in the saturated backfill groundwater would mean that DO is less than observed. Likewise, nitrate levels at MW11-04 was observed at 1 mg/L and at less than detection limits for the peripheral and bedrock wells. Dissolved Mn values for wells screened in backfill (e.g., MW11-04, MW11-02C, MW11-01-A/B/C) show values ranging from 0.3 to 0.9 mg/L. Such values are likely indicative of Mn(IV)-oxide reduction. Similarly, the presence of slightly elevated dissolved Fe is indicative of suboxia.

Table 3. Hydrogeological parameters and estimates of flow through backfilled pit.

Well Pair	Gradient by Well Pairs (%)			Lithology	K[5]	Average Width of Pit	Saturated Thickness @ MW-11-01	Saturated Waste Rock Volume[6]	Porosity[5]	Saturated Waste Rock Pore Volume	GW Q	Pit Residence Time
	MW11-04: MW11-02C	MW11-02C : MW11-01C	MW11-1C: Seep		(m s^{-1})	(m)	(m)	(Mm^3)	(%)	(Mm^3)	(m^3/day)	(years)
Baseflow[1]												
MW11-04	19											
MW11-02C		-0.06										
MW11-01C			1.4	Wasterock[4]	1E-05	200	17.77	0.20	25	0.05	42.7	3
Spill Point - Seep[3]			1.4	Wasterock[4]	1E-04	200	17.77	0.20	40	0.08	426.7	0.5
Freshet[2]												
MW11-04	11											
MW11-02C		-0.05										
MW11-01C			2.5	Wasterock[4]	1E-05	200	18.75	0.20	25	0.05	80.4	2
Spill Point - Seep[3]			2.5	Wasterock[4]	1E-04	200	18.75	0.20	40	0.08	803.8	0.3

Notes:

[1] water levels observed on 8-Mar-13 during low winter low flow period

[2] water levels observed on 3-Jun-13 during mid-freshet flow period

[3] elevation of top of pit wall at MW11-03; active flow out of pit is assumed to occur as spill over remnant southern pit wall.

[4] waste rock assumed to have consistency of gravel.

[5] range of hydraulic conductivity and porosity values expected for gravel. Data from Freeze & Cherry 1979.

[6] value based on estimate derived from 1m resolution maps of original ground, mined out pit and waste rock surface (Lidar surveys).

Table 4. Porewater chemistry for general parameters and redox indicators for upgradient pit water, saturated backfill and peripheral bedrock. Data represent geometric means samples collected in December 2011, May 2012 and March 2013.

Parameter[1]	pH	Conductivity	Temp.	DO	ORP	Alkalinity[2]	DOC	NO_3^-	SO_4^{2-}	H_2S[3]	Mn-D	Fe-D
Units	(pH)	(uS/cm)	(°C)	(mg/L)	(mV)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Upgradient Pit Water												
MW11-04	7.1	1524	7.3	4.8	14	289	2.4	1.47	652	<0.001	0.0704	0.5370
Saturated Backfill												
MW11-02-B	7.1	1888	7.1	1.3	[4]11	286	3.7	0.447	893	<0.001	0.8268	0.1671
MW11-02-C	7.1	1725	7.0	0.6	[4]59	308	2.2	0.208	785	<0.001	0.4295	0.1180
MW11-01A	7.0	1327	5.7	1.4	90	329	3.3	0.116	443	<0.001	0.2577	0.0999
MW11-01B	6.8	1636	5.6	0.2	[4]59	345	4.3	0.200	781	<0.001	0.6321	0.1274
MW11-01-C	6.9	1664	6.6	[4]0.3	[4]-96	426	1.8	0.082	715	<0.001	0.4828	0.5342
Peripheral Bedrock												
MW11-02-A	7.1	1700	7.7	0.9	[4]-29	325	8.7	0.102	691	0.004	3.3168	0.8552
MW11-01-D	7.1	1151	7.5	0.4	[4]-90	379	4.8	0.085	282	0.002	0.6112	0.2858
MW11-03	7.2	581	3.2	0.3	[4]-118	338	3.9	<0.005	10	0.003	0.3944	4.5303
MW11-06	7.1	1080	4.3	1.1	[4]-88	565	4.7	0.096	25	0.005	0.0485	0.1278

Notes:
[1]Where concentration was below the method detection limit, concentration was set equal to detection limit value for statistical calculations
[2]Alkalinity = total ($CaCO_3$)
[3] H_2S as S
[4]Arithmetic mean shown due to negative values in dataset

Conversely, H_2S concentrations do not reveal evidence of SO_4^{2-} reduction as levels are below the limits of analytical detection (<0.002 mg/L) in all samples with the exception of the peripheral bedrock wells. Dissolved organic carbon (DOC) is present within the porewater of the backfilled pit, although at approximately half the concentrations observed within the peripheral wells. Under the current redox regime, sulphate represents a suitable proxy for waste rock drainage, and concentrations of this parameter can be used to further assess pit hydraulics. Figure 3 summarizes the sulphate levels during the three rounds of sampling. The sulphate levels in those wells screened across the wasterock-pitfloor interface, namely, MW11-01A and MW11-04, are considerably lower during the May 2012 sampling round under freshet recharge conditions. These fluctuations correlate well with the variations observed in the fluid conductance data in Figure 2 indicating that preferential flow paths along the pit floor may exist. Further, elevated sulphate levels in bedrock at MW11-02 (A/B) support the interpretation of water levels at this location which indicate a downward vertical gradient as background sulfate concentrations are typically less than 100 mg/L, as observed at MW11-03 and MW11-06.

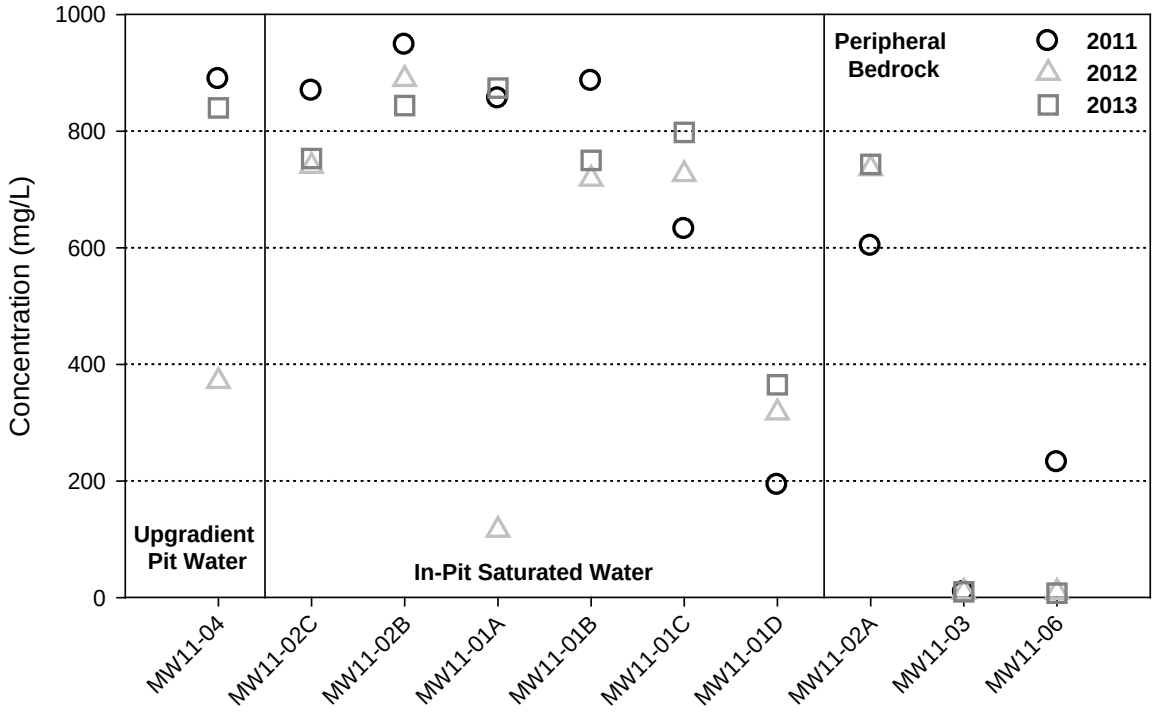


Figure 3. Sulfate concentrations measured in water for December 2011, May 2012 and March 2013 sampling rounds for upgradient pit water, saturated backfill and peripheral bedrock.

Selenium

Total Se, Se^{IV} and Se^{VI} concentrations measured during for each sampling round are summarized in Figure 4 while the mean concentrations 2nd and 3rd sampling rounds are shown in Figure 5. The highest Se levels are observed upgradient of the saturated zone (MW11-04), while the lowest values are observed in the peripheral bedrock wells. The Se levels in the in-pit saturated water are consistently below 1 µg/L. Inspection of the data shows a predominance of Se^{VI} at MW11-04, comprising on average 95% of the total Se inventory. The reduced form Se^{IV} is present, albeit at low levels (less than 2%). In contrast, the in-pit saturated water shows a predominance of Se^{IV}, on average making up 74% of the total Se inventory. Se^{IV} is also the dominant species within the peripheral bedrock making up 71% of the inventory. The in-pit saturated water contains less than 1% of the Se-T observed at MW11-04 suggesting that 99% of the Se-T entering the in-pit saturated zone is lost by attenuation through mechanisms which may include adsorption of Se^{IV}, precipitation of elemental Se, or precipitation of metal/organic selenides. This conclusion is supported in the shift in dominant Se species from Se^{VI} in the source water to Se^{IV} within the in-pit saturated water. The reduction in Se concentrations within the backfilled pit cannot be attributed to dilutionary processes, as revealed by the persistence of elevated SO_4 levels and inferred groundwater flow paths which do not indicate significant recharge of more dilute groundwater sources. In this regard, the backfilled pit can be viewed as a passive bioreactor, where suboxic redox processes promote denitrifcation and immobilization of Se.

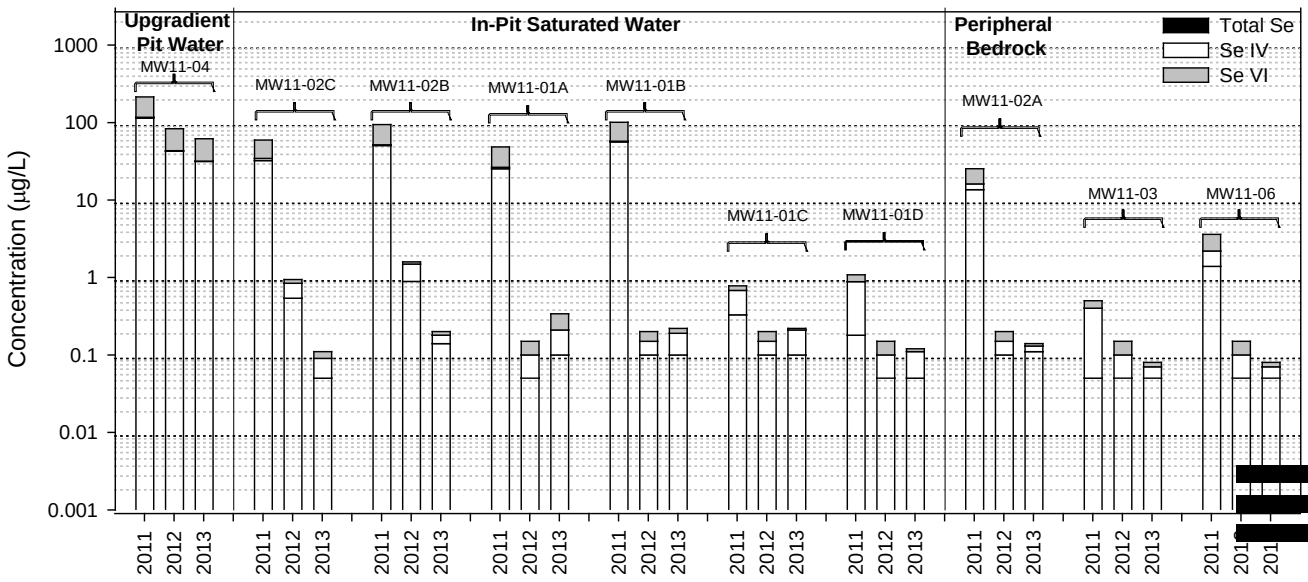


Figure 4. Summary of total selenium and selenium species concentrations in groundwater for upgradient pit water, saturated backfill and peripheral bedrock. All values in µg/L.

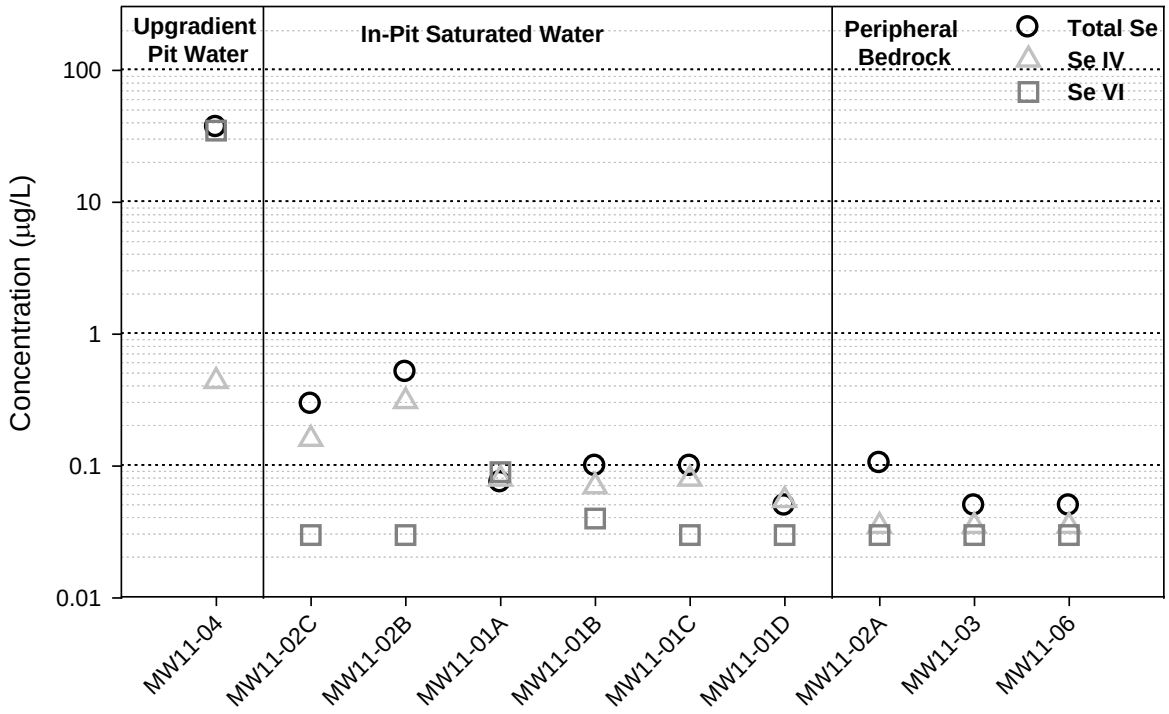


Figure 5. Geometric mean Se-T, Se^{VI} and Se^{IV} concentrations in groundwater of May 2012 and March 2013 sampling rounds for upgradient pit water, saturated backfill and peripheral bedrock.

Microbial Communities

Results of total microbial and Se-reducer counts in groundwater samples are summarized in Figure 6. Total microbial counts provide an indication of microbe population viability at time of sampling. The

microbial counts over the three sampling periods demonstrate variability in both saturated backfilled and peripheral groundwater wells. Se-reducers were recorded in only two samples in December 2011 (MW11-02C-FD) and March 2013 (MW11-04-FD). Although specific counts of Se-reducers were low and varied between sampling events, the potential for selenium reduction in the saturated backfilled is better characterized taken into account the results of the selenium containing media microbial analysis. Se precipitation was observed following two weeks of incubation in samples from MW11-02C-FD and MW11-04. Following a month of incubation, Se reduction was also detected, albeit at much lower levels, in samples MW11-02B and MW-11-03.

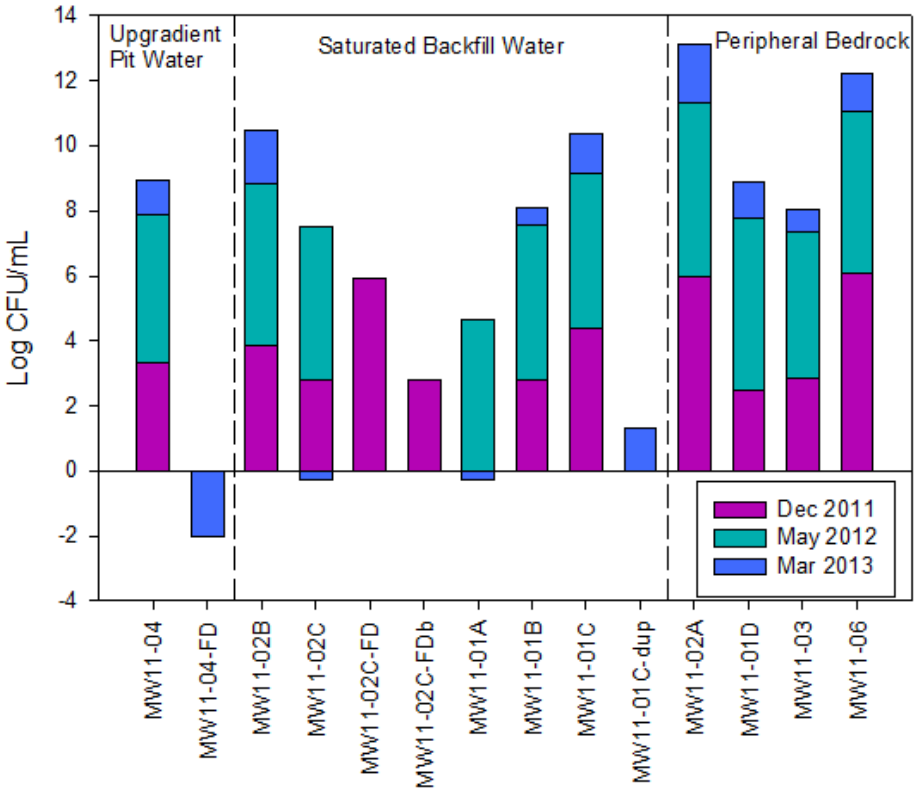


Figure 6. Summary of microbial plates counts for upgradient pit water, saturated backfill and peripheral bedrock.

Estimates of Selenium Removal Rates

Estimates a Se removal rates are not well constrained due to uncertainty in the upper concentration end member and flow through rate (i.e., water residence time). Nonetheless, in-situ Se removal rates were calculated based on the observed difference in total dissolved Se (Se-T) concentration between MW11-04 (upgradient pit water) and saturated backfilled porewater during both low (winter) and high (freshet) flow periods. The parameters for the Se removal rate estimates are summarized in Table 5. The mean Se-T concentration observed at MW11-04 for the May 2012 and March 2013 sampling rounds was 38 µg/L, and the mean concentration within the saturated backfilled porewater was less than 0.1 µg/L. As

discussed previously, pit flow through rate varies due to uncertainly in waste rock porosity values; accordingly a range of possible flow rates were considered. Overall, removal rates were calculated to range from 0.03 to 0.17 mg/day/m^3 of waste rock (winter low flow) and 0.06 to 0.33 mg/day/m^3 of waste rock (freshet flow) (Table 5).

Table 5. Summary of Se removal rates

Waste Rock Volume	Porosity	Flow Rate	Residence Time	[Se-T] In	[Se-T] Out	Se Loading Rate	Se Removal Rate
(m^3)	(%)	(m^3/day)	(years)	(µg/L)	(µg/L)	(mg/d)	(mg/d/m^3)
197000	25	42.7	3	38	0.1	1618	0.03
232000	40	426.7	0.5	38	0.1	16172	0.17
197000	25	80.4	2	38	0.1	3047	0.06
232000	40	803.8	0.3	38	0.1	30464	0.33

CONCLUSIONS

This paper represents the first known study of its kind in northeastern B.C. to rigorously examine Se behaviour in the saturated zone of a backfilled pit. The monitoring methods employed have specifically allowed delineation of the transport characteristics and bioremediation potential of Se within suboxic zones of the waste rock backfill. The results provide direct evidence of in situ Se reduction under mildly suboxic conditions, commensurate with nitrate reduction. Overall, the data suggest that a significant degree of Se attenuation is occurring within the backfilled pit under relatively short residence times. These results have direct application to coal mines globally that employ pit backfill as part of water/waste management planning. The data also suggest that for larger backfilled systems characterized by longer groundwater retention time, a higher magnitude of Se attenuation could be achieved. In this regard, this form of in situ bioremediation represents a possible means to treat large water volumes not accommodated by traditionally forms of passive treatment (e.g., wetlands, permeable reactive barriers).

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ENVIROGEN TECHNOLOGIES

Treatment of Selenium-Containing Coal Mining Wastewater with Fluidized Bed Reactor Technology

Proven Systems Provide Major Cost Advantages and "Best-in-Class" Performance

An Envirogen Technologies Whitepaper | August 2011



Introduction



In the coal mining industry today, selenium, in its many forms, is gaining attention. New regulations covering selenium discharge are either in place or being developed. It has been said that handling selenium wastes will increasingly become a limiting factor on the ability of the coal mining industry to grow. While a number of physical/chemical approaches show promise in selenium treatment, when considering optimal cost and treatment efficacy issues, biological treatment – particularly fixed-film biological treatment - is one of the most promising approaches to managing selenium-containing wastewaters. Envirogen Technologies offers a patented fixed-film fluidized bed reactor (FBR) biological treatment technology that has been proven as a 'best in class' approach for handling medium to high flow rates of selenium-containing wastewater. Envirogen FBR technology has several distinct features that make it ideally suited for the coal mining industry.



The noteworthy features of Envirogen FBR technology include its ability to consistently reduce selenium levels to less than 5 µg/L, shorter required residence times for treatment and a smaller overall footprint. Its flexibility in the choice of electron donor chemicals can translate into capital and operating cost savings with reduced solids generation. It also responds well to changes in feed flow and composition, consistently achieving discharge limit conditions. In addition, these systems can be modular, with all-weather protection where desired. These features, combined with decades of experience by Envirogen's team, allow the design and installation of FBR systems with capital costs that are a fraction of the cost of competitive fixed-film biological systems.

The selenium dilemma

Waste rock is generally the primary source of selenium in coal mining operations. When exposed to water, various selenium species will leach or migrate from the rock and enter the environment. Selenium occurs in various valence states from -2 to +6. The speciation of selenium plays a critical role in the effectiveness of any approach for removal, especially to low levels. In aqueous environments, selenium is most often found as the oxygenated anions of selenite, Se(IV) and selenate, Se(VI). Selenium in mine runoff most often occurs in the soluble form .Selenium is commonly found in mining wastewaters in concentrations ranging from 3 to >12,000 µg/L. The US National Primary Drinking Water Standard MCL is 50 µg/L for selenium. The National Fresh Water Quality Standard is 5 µg/L for selenium. The U.S. Fish

and Wildlife Service has recommended that the National Fresh Water Quality Standard be lowered to 2 µg/L to protect fish, waterfowl, and endangered aquatic species. Several states have followed with enforcement actions at these same low levels. In Canada, permits may require stakeholders to monitor levels in water or biota, or to comply with Canadian Water Quality Guidelines of 1 µg/L in surface waters. Province and local regulations may vary from these requirements.



Treatment of selenium in coal mining wastewaters presents a series of challenges. It can be present in relatively dilute concentrations and in streams with variable and often high flow rates. It is present in many soluble and particulate forms, which may affect process design and treatability. The conditions of influent selenium-containing wastewaters can vary widely, with issues such as temperature, pH, total dissolved solids and other contaminants present, affecting the ability to selectively and economically remove selenium. Treatment of selenium often results in the generation of a concentrated by-product requiring disposal, and re-release from residuals can occur. Beyond these issues, the physical environment of coal mining operations offers challenges such as remoteness and harsh and/or cold weather. Currently available selenium treatment technology (Table 1) includes biological treatment and a number of physical-chemical processes – such as ion exchange, membrane filtration and adsorption – that vary widely in efficiency and cost. Most treatment options remain either too costly and/or unproven for selenium-containing waste streams for reasons that include removal levels, variability in volume and composition of influents, system sizing and logistics considerations, as well as operating requirements.

Table 1
Overview of Technologies for Removal of Selenium in Water

Physical	Chemical	Biological
Reverse osmosis	Iron co-precipitation	Algal-bacterial Se removal
Nanofiltration	Zero valent iron	Algal volatilization
Ion exchange	Cupric co-precipitation	Heterotrophic microbial reduction
Ferrihydrite adsorption	Electrocoagulation	Constructed wetlands
Activated alumina adsorption	Enhanced cementation	Phytoremediation
	Photoreduction	
	Carbohudrazide	

Biological Treatment of Selenium-Containing Wastewaters

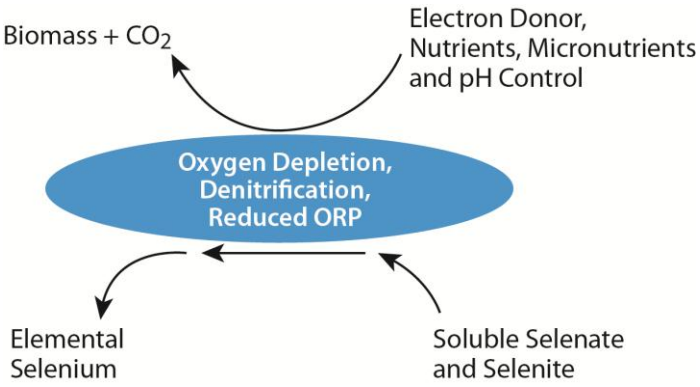
Biological treatment of selenium-containing wastewaters has been an area of significant interest in the coal mining community recently. In general, biological treatment offers a low cost alternative to more expensive physical and chemical treatment methods and is effective in cold climates. Additionally, it has the proven ability to meet regulatory selenium limits.

Biological systems catalyze the reduction of selenium. Selenate can be reduced to selenite, and both selenate and selenite can be reduced to elemental selenium.

$$SeO_4^{2-} + \text{organic carbon} \rightarrow SeO_3^{2-} + \text{organic carbon} \rightarrow Se_0 + CO_2 + H_2O$$

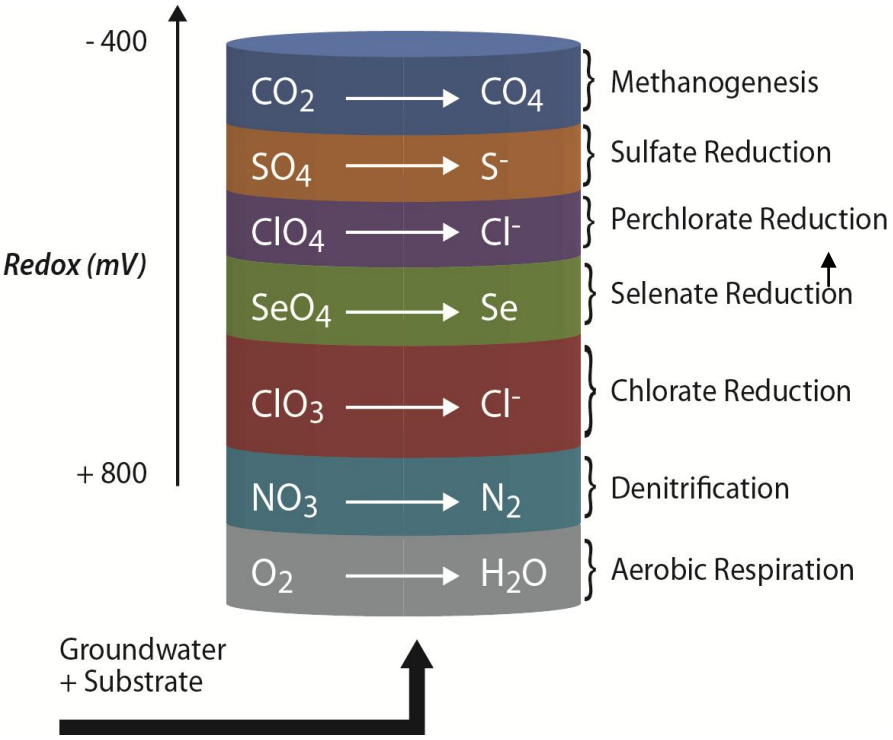
These reactions are desirable because elemental selenium is virtually insoluble and therefore can be removed from the environment through conventional liquid/solids separation and disposal. In biological treatment, the conversion of selenium anions to elemental selenium is accomplished via biologically catalyzed reduction. Selenium-reducing bacteria (Figure 1) are considered heterotrophic. They utilize organic carbon as their electron donor and selenate/selenite as their electron acceptors. Commonly used electron donor materials include methanol, acetate, citric acid and molasses. New 'designer' electron donors, generally composed of complex carbohydrates and organic process by-products that have been proven effective for selenium reduction and precipitation, are also available.

Figure 1: Selenium Reduction & Precipitation



One of the major issues in biological treatment of selenium is the presence of other anions in the influent streams. Both oxygen and nitrate are more favorable electron acceptors than oxidized forms of selenium. Figure 2 shows common anions and their order of biological reduction based on ORP. The order use of electron acceptors follows the more energetically favorable reactions first. Also, reduction enzyme systems appear to have evolved such that reduction enzymes are generally inhibited by electron acceptors that are more energetically favorable, particularly if the microorganism contains more than one reduction system.

Figure 2: Redox Profile of Biological Reduction



From a practical standpoint, these relationships are critical. The presence of either oxygen or nitrate will limit selenium reduction. Even in anoxic biological systems, the presence of nitrates is an important consideration in system design and the selection of microorganisms and electron donors. Many coal mining wastewaters contain high levels of nitrate that will be preferentially reduced before selenium, and must be removed before effective selenium reduction will occur. Sufficient electron donor material is required to reduce both nitrate and selenium. The FBR process offers the potential benefit of denitrification and selenium reduction in a single step.

Active, fixed-film biological treatment systems have received significant attention from researchers and the coal mining community because of their potential to work with a broad range of selenium concentrations in wastewaters – including very dilute streams – and for their ability to reduce selenium to very low levels. These outcomes are due to the fact that the heterotrophic bacteria are retained in the bioreactor for relatively long periods of time, improving the chance that they will come in contact with the contaminants and the ability of these systems to control reaction conditions more precisely. Additionally, because of the tendency of the microbes to attach to the solid media and to form dense biomass films, these reactors can have high biomass concentrations. This is especially the case with the Envirogen FBR technology.

Today, there are two different types of active, fixed-film systems that have received significant field testing with selenium-containing coal mining wastewaters – the fixed-film downflow filter (also known as a 'packed bed reactor' – PBR) and the fluidized bed reactor (FBR). In evaluating active, fixed-film bioreactor technology, the following issues are salient in choosing one of these approaches:

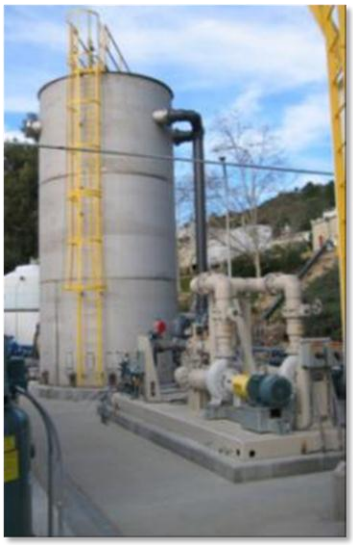
- Treatment efficacy/efficiency
- Hydraulic residence times
- System footprint
- Flexibility in handling variable & high flow rates
- Flexibility with electron donor material
- Ability to handle solids & metals
- Recovery from upsets
- Track record of technology
- Cost of capital
- Cost of operation
- Ease of operation

The remainder of this paper will present information related to Envirogen Technologies' fluidized bed reactor technology – and where applicable, compare and contrast technical and operating features with packed bed reactor technology.

Envirogen Fluidized Bed Reactor Technology

Proven technology with critical advantages for the coal industry

Envirogen's FBR is an active, fixed-film bioreactor that fosters the growth of microorganisms on a hydraulically fluidized bed of fine media. In this type of reactor, a fluid is passed through a granular solid material at velocities sufficient to suspend or fluidize the solid media.



In Envirogen FBR systems, media types include sand and activated carbon media that are manufactured to exacting specifications for hardness, shape, size, uniformity, density and impurity levels. The small fluidized media in the FBR provide an extremely large active surface area upon which microorganisms can grow while treating contaminants. A large biomass inventory is produced while maintaining thin films, reducing mass transfer limitations and offering high volumetric efficiency.

Envirogen manufactures both aerobic and anoxic FBR systems. Aerobic systems utilize air or oxygen for removal of organics. Anoxic FBR systems are the technology of choice for inorganic contaminants such as perchlorate, nitrate and selenium. Other distinguishing features of Envirogen FBRs include patented biomass control systems that are key to retaining media and steady-state operation and plug flow; custom molded parts; proprietary design of internal vessel components and proprietary and patented controls for chemical feed systems.

Base System Design

Envirogen FBR installations typically feature one or more vessels in single- or two-stage configurations, depending on influent water characteristics and discharge limits (Figure 3). A range of materials can be used for vessel construction, including stainless steel, fiberglass, lined-carbon steel or concrete. Prefabricated FBR vessels from 2- to 14-feet diameter and up to 30-feet in height are available – offering very deep beds in comparison to other fixed-film technology. This vertical orientation is one of the factors that contribute to the FBR's smaller footprint compared to packed bed reactors or other biological treatment systems. Field-fabricated concrete or metal vessels are also available for very large applications. Overall system packages are outfitted with fluidization pump(s), piping, valves, chemical feed pumps and controls that may be field assembled or pre-assembled based on client preferences. Most Envirogen FBR systems are equipped with programmable logic control and may be provided with a SCADA package, telemetry and motor controls options.

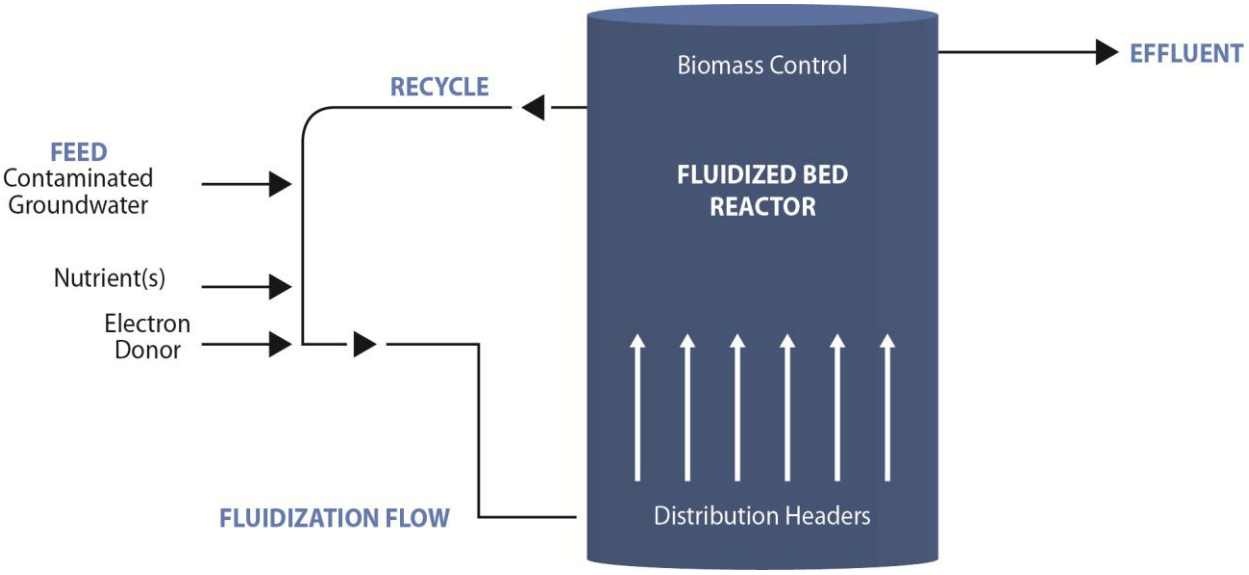
Figure 3: Envirogen FBR for Perchlorate Removal



System Operation

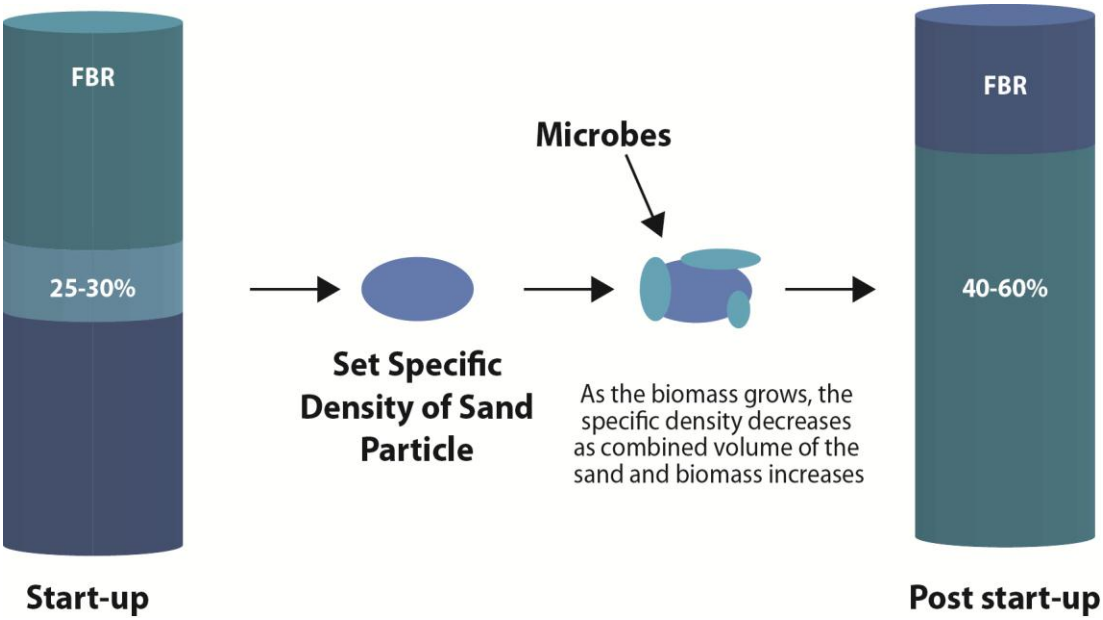
During start-up, the FBR is seeded with heterotrophic bacteria that are suited for nitrate and selenium removal (Figure 4). Electron donor materials and nutrients are pumped into the FBR to promote microbial growth.

Figure 4: Start-up of FBR system



Selenium-containing wastewater is pumped from a feed tank into the FBR in an upflow direction to suspend the media. As microorganisms grow on the media, the fluidized bed height expands (Figure 5).

Figure 5: Fluidization of FBR media



With time, a biofilm develops on the media surface. Nitrate and selenium reduction occur on this biofilm. Treated water from the FBR system is discharged to a downstream liquid/solids separation system where the biological solids and elemental selenium are separated. Thickened or dewatered bio-solids and elemental selenium are disposed.



One of the key features of operation is the technology used to fluidize the media bed and to uniformly distribute fluidization flow to the system. This is accomplished with the design and placement of the distribution nozzles and the sizing and arrangement of the header-lateral distributors. Uniformity of flow is critical to establishing steady-state plug flow conditions and the associated optimized performance.

Another key feature of these FBR systems is Envirogen's proprietary technology for biomass control. In all properly functioning biological systems some of the energy that is derived from the consumption of electron donor is used by the microbes for biomass growth. This results in the production of excess biomass or "yield" that must be removed from the bioreactor. In packed bed reactors this is accomplished with periodic backwash operations that remove large quantities of biomass using very high backwash rates – creating turbulence and shear to separate and wash out accumulated biomass.

In Envirogen's FBR systems biomass is removed in a steady-state manner with Envirogen's patented biomass control devices. These systems allow the FBR to operate with an optimized and consistently high biomass concentration, resulting in reliably high performance.

Limitations inherent in packed bed reactors render them incapable of handling high feed nitrate, selenium and suspended solids concentrations. This is due to problems of rapid plugging, nitrogen gas binding, channeling and high backwash requirements. With Envirogen's patented biomass controls, FBRs effectively handle feed loads that are greater than an order of magnitude higher then packed bed reactors.

Design Flexibility

The design flexibility available through utilization of the FBR with respect to vessel heights and configuration, materials of construction, modularity, Envirogen's patented bed height control, biomass

control, proprietary chemical feed configurations and flexibility in electron donor selection all combine to produce improved performance, reduced capital and operating costs, and minimized excess biomass production and associated processing and disposal costs. Furthermore, this allows for the use of alternate electron donors based on considerations of availability, cost and performance.

Advantages of the Envirogen FBR technology for the coal mining industry

Extensive testing of the Envirogen FBR technology has shown that it consistently offers highly efficient removal of selenium from coal mining wastewaters at dramatically lower cost levels than competitive technologies. Three aspects of Envirogen FBR systems support this success:

- The high performance nature of FBR treatment technology
- Proprietary & patented features of Envirogen's FBR systems
- Envirogen's decades of experience with FBR in treating inorganic contaminants

The following issues highlight the Envirogen FBR systems' performance advantages for the coal mining industry:

Optimization of microorganism efficiency

One of the key advantages of FBR technology over packed bed reactors is the lack of 'channeling' that occurs in FBR systems. Packed bed reactors tend to develop preferential pathways for flow due to solids build-up in the bed and nitrogen gas binding caused by conversion of nitrate to nitrogen gas. This can cause pressure drop in the typical fixed-film system as well as short-circuiting or partial flow by-passing. These deviations from steady state plug flow conditions result in reduced performance. In the fluidized bed reactor, because of the even distribution of flow, a very high fraction of the biomass within the bioreactor is utilized – meaning increased treatment efficiency. These issues directly affect the hydraulic residence time (HRT) required and explain why the footprints for Envirogen FBR systems are so much smaller than competitive packed bed bioreactors for the treatment of nitrate and selenium.

Steady-state operation

Envirogen FBR systems are designed to be operated continuously – meaning they do not require cyclical backwash operations. Packed bed reactors require periodic backwashing to slough off excess microbial growth, to eliminate channeling and to remove nitrogen gas pockets that have built up during the running part of the packed bed reactor operating cycle. Frequency of backwashing is related to the loading of contaminants in the influent stream and requires large pumps and intermittent operation. In addition to increased energy costs, backwashing limits the flow of wastewater through the entire system since it is necessary to remove the backwashed unit from service, recover, clarify and recycle the dirty backwash suspension. Recycled backwash water adds to the feed loading and thereby limits net throughput.

Perhaps more importantly, the biomass in the system requires time to regrow following a backwash, further increasing the required HRT. With higher loadings of feed nitrate, selenium and/or suspended solids, the backwashing requirements can become so excessive as to render the packed bed bioreactor ineffective or completely impractical.

Improved overall water quality

Besides selenium and nitrate, another parameter that may be of concern is soluble biological oxygen demand (BOD) or chemical oxygen demand (COD). Mine run-off waters are generally very low in BOD and COD. However, discharge from biological systems treating for these contaminants can contain excess un-reacted electron donor, resulting in soluble BOD or COD in the bioreactor effluent. This will depend on the electron donor used and the quality of the biological contacting system, both of which affect the completeness of the reactions.

For example, some grades of molasses contain a substantial fraction of non-biodegradable or difficult to degrade compounds that will exit the bioreactor as soluble BOD and COD. Allowing for flexibility in the choice of the electron donor(s) to be used, especially as this relates to two-stage operation, can allow the system operator to control treated water BOD and COD. Additionally, the plug flow characteristics of the FBR tend to result in more complete bio-reactions and lower treated water concentrations.

Smaller overall footprint

FBR systems have a smaller site footprint than other biological treatment systems. The key contributors to this feature are the vertical orientation of the FBR vessels and the efficiency of treatment (lower HRTs). Treatment efficacy is affected by a high concentration of biomass and the tall beds. This smaller footprint has a dramatic effect on construction and installation costs and schedules.

Dramatically lower hydraulic residence times

Despite having a smaller overall footprint, field studies have shown that FBR systems can achieve required performance with dramatically shorter HRTs than packed bed systems. This is due primarily to deep beds and steady-state plug flow operation. HRTs for typical FBR systems used in selenium treatment for coal mining operations are 1/3 to 1/10 those required for packed bed reactors.

Electron donor options

Envirogen offers the ability to customize electron donor materials based on decades of experience with the FBR technology. Key issues that are considered include treatment efficacy, overall water quality, operational ease of use, availability and cost. Table 3 shows a typical comparison of electron donor usage, costs and treated water quality as a function of alternate electron donors selection in a two-stage FBR system treating selenium and nitrate.

Table 3: Electron Donors Comparative Evaluation

	Molasses	MicroCg	1st stage Methanol 2nd stage MicroCg	1st stage Methanol 2nd stage Molasses
Usage L/day	4260	3135	1362 (1st stage) 627 (2nd stage)	1362 (1st stage) 852 (2nd stage)
US$/L delivered	0.373	0.528	0.396 (methanol) 0.528 (molasses)	0.396 (methanol) 0.373 (molasses)
US$/yr	580,000	604,000	317,700	312,900
FBR Effluent TSS mg/L	30	25	22.6	23.6
FBR Effluent filtered COD mg/L	100	50	20	30

Robustness of the system

Envirogen FBR systems have a proven history over the past 30 years, operating effectively over a wide range of feed flow rates and influent types. The systems are tolerant of high feed concentrations of total suspended solids (TSS) and metals. In addition, these systems have the ability to recover quickly from upsets such as power outages and loss of chemical feeds.

Modularity & extreme environment performance

In many cases, Envirogen FBR systems can be pre-fabricated for delivery to a coal mining treatment site. This contrasts with packed bed reactor systems which, because of their large size, are usually built-in-place. FBR systems may be supplied as prefabricated modules and associated equipment can be containerized in insulated and heated containers, per client requirements. This allows for ease of transportation and rapid installation – even in bad weather conditions.

Generally speaking, it is expected that biological treatment systems suffer loss of efficiency when used in cold weather environments (> 15^{o} C). Recent tests by Envirogen on selenium-containing wastewater at a coal mining site showed that the FBR system performed effectively at influent water temperatures down to 4o C.

Lower costs

One of the major advantages of employing an FBR in a selenium treatment application is a considerable cost advantage in system design and installation compared with other commercially available technologies. This is primarily due to smaller system footprints as well as the ability to manage issues such as suspended solids and waste disposal in a much more effective fashion, over a broad range of influent flow rates. A recent third-party analysis performed for the North American Mining Council showed that initial capital costs for an FBR system can be 1/3 or less the cost of a packed bed reactor system designed for similar treatment requirements.

Technology track record

Envirogen is an industry leader in the use of bioreactor technology, with over 150 systems installed in the United States. Envirogen FBRs have been used in similar reductive applications for more than 10 years in applications such as perchlorate and nitrate, where low levels (<4 ppb) are consistently achieved at high flows (6,000 gpm) and in high TDS streams. The same anoxic operating regime is used for selenium installations.

Recently, Envirogen FBR technology demonstrated the ability to achieve <5 ppb selenium over a 10-month period in treating mining leachate at a U.S.-based coal mining site. Competitive trials run at the same site indicated that Envirogen FBR systems were the 'technology of choice' for reliability and cost-effectiveness. Summary results for this trial are shown in Table 4.

Table 4: Operating results from 10-month coal mining trial (USA)

Constituent	Feed Concentration	Effluent Concentration
Dissolved Selenium	22 to 27 ppb Se	4.7 ppb maximum filtered Se
Nitrate - Nitrogen as N	6 to 8 mg/L	
Dissolved Oxygen	11 to 13 mg/L	
pH	7 to 9	

Full Scale System Design Summary

Parameter	Value
Flow	15,261 m^3/day (2,800 gpm)
Design Temperature	10°C
Number of Fluidized Bed Bioreactor Vessels (FBRs)	3
Size of Vessels	14 ft Diameter X 30 ft High
Design Hydraulic Residence Time	26.8 minutes

A four-month trial was also run at a Canadian coal mine – examining Envirogen FBR technology in the presence of high nitrate levels and at colder influent water temperatures. Table 5 shows results of this trial.

Table 5: Operating results from 4-month coal mining trial (Canada)

Constituent	Feed Concentration	Effluent Concentration
Dissolved Selenium	200 to 500 ppb Se	10 ppb maximum filtered Se
Nitrate - Nitrogen as N	15 to 40 mg/L	
Dissolved Oxygen	11 to 13 mg/L	
pH	7 to 8	

Full Scale System Design Summary

Parameter	Value
Flow	15,261 m^3/day (2,800 gpm)
Design Temperature	4°C
Number of Fluidized Bed Bioreactor Vessels (FBRs)	6 in 2 stages
Size of Vessels	14 ft Diameter X 28 to 30 ft High
Design Hydraulic Residence Time	56.9 minutes

Envirogen Lifecycle Cost Assurance Programs

In any environmental installation the most important – and often the most expensive – contributors to a treatment program are the performance and operating costs over its 10- to 20-year life. Developed to support all FBR installations, Envirogen Lifecycle Cost Assurance Programs are designed to ensure performance, to deliver low lifecycle costs and to guarantee the life of the assets. Elements of an Envirogen Lifecycle Cost Assurance Program range from basic O&M support services or the assignment of Envirogen supervisory and management personnel to comprehensive operations programs wherein Envirogen becomes a single line item on the operating budget for the system in question. They can even include financing options for system design, construction and installation. Envirogen Lifecycle Cost Assurance Programs are typically 10 to 20 years or more, with the length generally following the anticipated life of the system in question. Guarantees are provided for system performance, operating cost components, asset life and overall lifecycle cost. In addition, Envirogen can also provide guarantees for cost elements such as utility consumption and chemical usage for the life of the contract. Through the resources and experience that Envirogen Technologies brings to design, fabrication, installation, and long-term operation, significant value can be realized via an Envirogen Lifecycle Cost Assurance Program. These include:

- Predictable and guaranteed costs for the lifetime of the asset
- Guaranteed performance, repair and maintenance costs, and regulatory compliance

- Opportunities for cost reduction through process improvements, capital improvement and energy/chemical savings
- Risk protection via performance and cost guarantees
- Improved budget management (avoid unbudgeted cost excursions)
- Cost-effective access to industry specialists
- Continual process improvements
- Better utilization of capital
- A comprehensive EH&S Program

Conclusions

With selenium regulations having an increasing presence in the coal mining industry landscape, efficient, cost-effective treatment is critical to the growth of the industry. Envirogen FBR technology offers the industry's best, most broadly applicable solution to selenium treatment in systems that are field-tested and ready for design and deployment. The design of Envirogen's FBR systems ensures that selenium removal targets can be consistently and reliably met – at costs substantially below other commercially available competitive technology. The experience of the Envirogen team with FBR technology for decades ensures that the goals for a cost-effective selenium treatment program can be met today and in the future.

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LITERATURE REVIEW OF TREATMENT TECHNOLOGIES TO REMOVE SELENIUM FROM MINING INFLUENCED WATER

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LIST OF ABBREVIATIONS

ABSR - Algal-bacterial selenium removal

BCR- Biochemical reactors

BATs - Best available technologies

BDAT – Best Demonstrated Available Technology

CCME - Canadian Council of Ministers of the Environment

DMSe - Dimethylselenide

DMDSe - Dimethyldiselenide

EES - Enhanced evaporation systems

FGD - Flue gas desulfurization

FWS - Free water surface wetlands

GAC - Granular activated carbon

gpm - Gallons per minute

MIW - Mining influenced water

NF - Nanofiltration

PEI - Polyethyleneimine

RO - Reverse osmosis

SSF - Subsurface flow wetlands

TSS - Total suspended solids

UASBR - Upflow anaerobic sludge blanket reactors

USEPA - U.S. Environmental Protection Agency

ZVI -Zero valent iron

1.0 EXECUTIVE SUMMARY

Elevated aqueous selenium concentrations have been detected at multiple mine sites in Alberta and British Columbia. The waterbodies containing elevated concentrations, which exceed the Canadian Council of Ministers of the Environment (CCME) guideline for total selenium of 1 μg/L, range from creeks and rivers to large endpit lakes. The purpose of this paper is to provide a review of the literature for advances in the treatment of selenium in mining influenced water (MIW) and other waters containing selenium derived from non-mining sources. This review focuses on the types of technologies available, discusses the advantages and disadvantages of various treatment options, and identifies the stage of development of each technology, i.e., laboratory studies, pilot scale tests, or full scale treatment facilities. This review is limited to water treatment, which is one of three selenium management tools (Chapman et al. 2009). The other two management tools, prevention of selenium release and control of selenium in the environment, are not reviewed.

Significant research and development of selenium treatment technologies has occurred over the past two decades. The challenge of treating selenium to meet the stringent applicable standards of a few micro-grams per liter has led to testing of multiple physical, chemical, and biological treatment methods. Among these methods, proven full-scale treatment is currently being conducted by reverse osmosis, reduction by iron, active and passive microbial reduction, *in situ* microbial reduction, and wetlands. These methods are capable of meeting applicable standards, and provide a suite of tools to tackle the increasingly important issue of selenium in the environment. Some Canadian mine site discharge flow rates pose a significant design challenge. These rates can be on the order of 250,000 m^3/day (45,863 US gallons per minute), significantly greater than the highest selenium treatment plant flow rate of 7,630 m^3/day (1,400 US gallons per minute). Although full-scale treatment of selenium is proven, it has not been demonstrated for flow rates typical of the Canadian mine sites.

In the past five years, biological treatment has emerged as a leading technology for selenium treatment. Biological treatment offers a low cost alternative to more expensive physical and chemical treatment methods and is effective in cold climates. Additionally, it has the proven ability to meet regulatory selenium limits. Several different types of active microbial reduction biological systems are currently in operation, including Upflow Anaerobic Sludge Blanket Reactors and Anaerobic Fixed Film Bioreactors. Passive and *in situ* microbial reduction biological treatment systems have the lowest operating costs but have not been developed at full-scale to the same extent as active microbial systems.

2.0 INTRODUCTION

Elevated aqueous selenium concentrations have been detected at multiple mine sites in Alberta and British Columbia. The waterbodies containing elevated concentrations, which exceed the Canadian Council of Ministers of the Environment (CCME) guideline for total selenium of 1 μg/L, range from creeks and rivers to large endpit lakes. The purpose of this paper is to provide a review of the literature for advances in the treatment of selenium in mining influenced water (MIW) and other waters containing selenium derived from non-mining sources. This review focuses on the types of technologies available, discusses the advantages and disadvantages of various treatment options, and identifies the stage of development of each technology, i.e. laboratory studies, pilot scale tests, or full scale treatment facilities. Particular attention is paid to case studies demonstrating the potential of different technologies. Consideration is also given to technologies that are appropriate for the cold climate of the mine sites. This review is limited to water treatment, which is one of three selenium management tools (Chapman et al. 2009). The other two management tools, prevention of selenium release and control of selenium in the environment, are not reviewed.

3.0 SELENIUM CHEMISTY

Selenium is a metalloid found in Group VIA of the periodic table, below sulfur. It has similar chemical properties to sulfur due to its analogous electron distribution, which can make remediation in the presence of sulfur challenging. Selenium is present in the environment in both inorganic and organic forms, and in the solid, liquid, and gas phases. Although it can exist in six oxidation states, the II+ state is not known to exist in nature (Lenz 2008). The four most common, naturally occurring oxidation states are as follows:

- II- H_2Se, HSe^- , metal selenides, alkyl selenides, seleno-amino acids, seleno-proteins
- 0 Se^0 including trigonal (grey) and monoclinic (red) crystalline forms
- IV+ SeO_3^{2-}, $HSeO^{3-}$ and H_2SeO_3
- VI+ $SeO4^{2-}$ and $HSeO_4^-$

Inorganic forms include SeO_3^{2-}, SeO_4^{2-}, Se^0, H_2Se, and metal selenides (MeSe). Organic forms include alkyl selenides such as dimethylselenide (DMSe) and dimethyldiselenide (DMDSe), seleno-amino acids, and seleno-proteins including selenocysteine and selenomethionine. Selenocystein and selenomethionine are analogues of the sulfur-containing proteins methionine and cystein. Both DMSe and DMDSe are volatile, sparingly soluble, and relatively non-toxic, although both are bioavailable (Shrestha et al. 2006). The formation of organic selenium is typically biologically mediated.

Oxidized inorganic forms of selenium exist as highly soluble oxyanions in aqueous systems. Neither Se(VI) (selenate) nor Se(IV) (selenite) anions react with common cations such as calcium or magnesium, therefore they tend to remain in solution. Se(IV) species are more reactive than Se(VI) species and are easier to reduce to elemental selenium (Chapman 2000). Selenium oxyanions frequently associate with particles (e.g., sediments) and can be transported in particle-associated forms. Both selenate and selenite are bioavailable and have high potential for bioaccumulation and toxicity.

Elemental selenium exists in seven different crystalline forms and at least three amorphous forms. Elemental selenium is relatively insoluble and not readily bioavailable, making formation desirable during selenium remediation (Frankenberger and Karlson 1994). Nevertheless, elemental colloidal

selenium particles are easily transported through aqueous systems (Haygarth 1994). Inorganic reduced selenium species include insoluble metal selenides and the highly toxic hydrogen selenide (H_2Se), an analogue to hydrogen sulfide only formed under strongly reducing conditions. Hydrogen selenide is highly reactive and forms metal selenides or is substituted into metallic sulfide minerals such as chalcopyrite ($CuFeS_2$) and pyrite (FeS_2).

3.1 Oxidation-Reduction Reactions

Selenium speciation and therefore remediation is highly dependent on pH and redox potential (Eh). A simplified selenium-water system Pourbaix diagram showing major thermodynamically stable selenium species as a function of pH and Eh is shown in Figure 1 (Microbial Technologies 2005). This diagram assumes thermodynamic equilibrium; however, selenate and selenite are often found outside their predicted thermodynamically stable zones (Microbial Technologies 2005). Because selenite is more reactive than selenate, many treatment processes depend on the reduction of selenate to selenite. This process is energetically favored, but occurs slowly in natural systems.

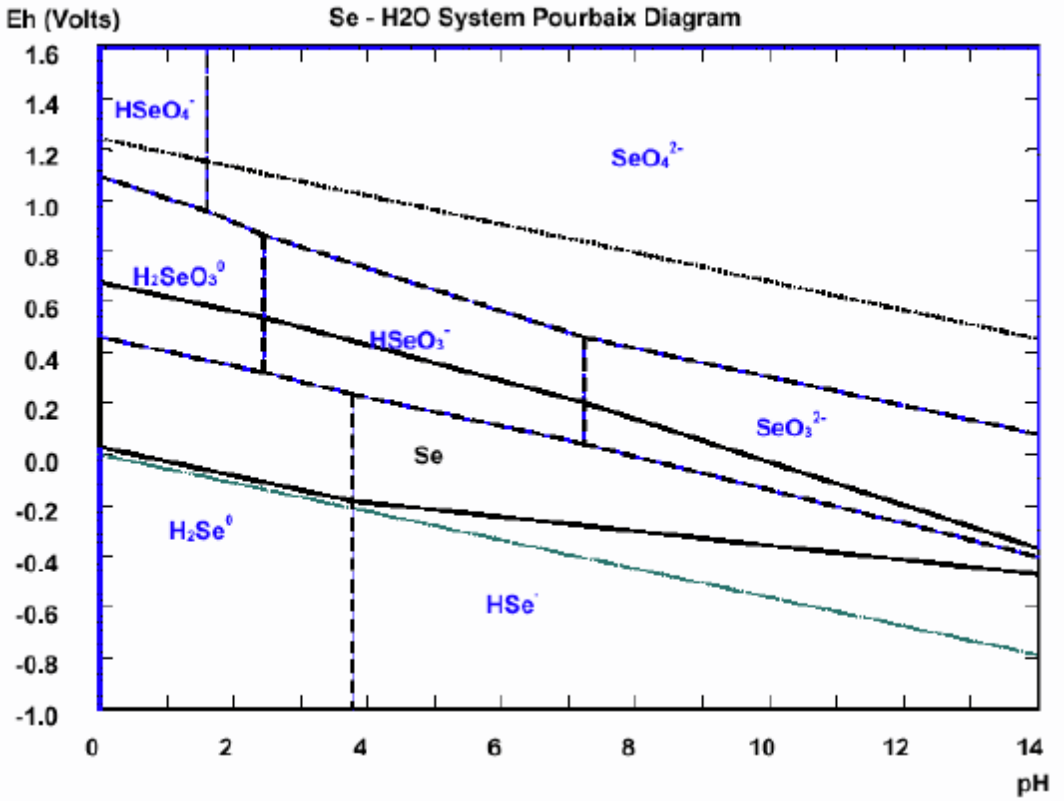


Figure 1. Eh-pH Diagram For The Se-H_2O System. From Microbial Technologies 2005.

3.2 Biologically-Mediated Reactions of Selenium

Biological systems can catalyze the reduction of selenium under normal environmental conditions. Anaerobic and aerobic bacteria, algae, fungi, and plants have all been shown to mediate these reactions (Masschelyn and Patrick 1993). Selenate can be reduced to selenite, and both selenate and selenite can be reduced to elemental selenium or alkyl selenides. These reactions are desirable because elemental selenium is less soluble and therefore less bioavailable and alkyl selenides such as DMse and DMDSe are highly volatile and only sparingly soluble in aqueous systems. These reactions have been encouraged for selenium remediation by creating conditions favorable to microbial growth, constructing wetlands, and applying selenium-bearing wastes or waters to plant-soil systems, a process known as phytoremediation (e.g., Zhang and Frankenberger 2003; Azaizeh et al. 2006; Bañuelos et al. 2005). Temperature, pH, moisture, time, season, concentration and speciation of selenium, and the addition of a carbon source all affect these reactions (Masschelyn and Patrick 1993; Lenz 2008).

Historically, these biologically-mediated reactions have been poorly understood, but recent advances have increased our understanding of these processes. Figure 2 illustrates the biochemical cycling of selenium in the environment by bacteria (adapted from Lenz 2008). Selenate and selenite can be reduced to elemental selenium, a process known as dissimilatory metal reduction, by anaerobic selenium respiration and non-specific selenium reduction by nitrate reducers, sulfate reducers, and archaea. Lenz (2008) suggests inhibition and competition with other anions such as nitrate (which prevent the reduction of selenium in their presence) can be overcome by including anaerobic selenium respirers in the microbial community. Selenium respirers will selectively reduce only selenium and are not affected by competing anions. This process is termed bioaugmentation when specific bacteria are added to an existing microbial population or biostimulation when conditions are manipulated to promote the growth of targeted microbial populations. Oxidation of elemental selenium back to soluble oxyanions can also be mediated by bacteria under oxidizing conditions. Generally, rates of re-oxidation are three to four orders of magnitude slower than microbial reduction (Tokunaga et al. 1994). Solubilization of selenium can occur when elemental selenium is reduced to selenides; however, selenides readily react with metal cations, forming microbiologically induced metal selenide precipitates. Microorganisms can also re-oxidize metal selenides.

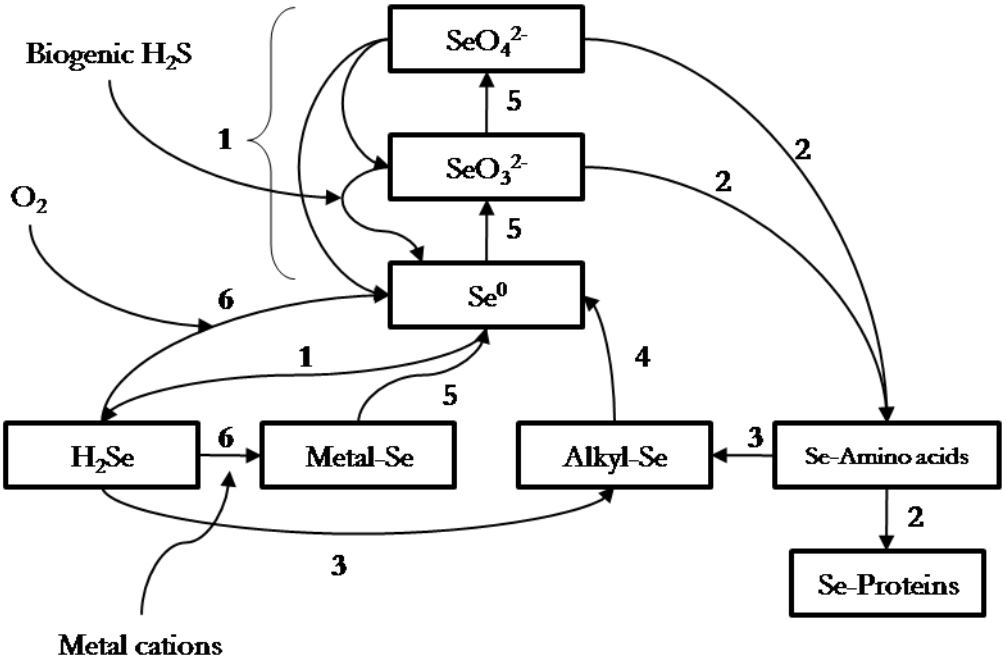


Figure 2. Biochemical selenium cycling with 1) Dissimilatory Reduction, 2) Assimilatory Reduction, 3) Alkylation, 4) Dealkylation, 5) Oxidation, and 6) Bio-induced Precipitation. Adapted From Lenz 2008.

4.0 TREATMENT TECHNOLOGIES

Since attention was first focused on selenium over 25 years ago at Kesterson National Wildlife Refuge, California a number of treatment technologies have been developed. These technologies can be divided broadly into three categories: physical treatment (e.g., reverse osmosis, ion exchange); chemical treatment (e.g., iron precipitation, cementation); and biological treatment (e.g., bioreactors, wetlands). An overview of treatments is provided in Table 1.

Physical treatment technologies include reverse osmosis, nanofiltration, ion exchange, and evaporation. All of these technologies are well understood and have been applied to water treatment in other industries; however, with the exception of reverse osmosis, these technologies have only been developed at a laboratory or pilot scale for selenium removal. Ion exchange is strongly affected by the presence of other ions and in many mining applications sulfate is present at concentrations several orders of magnitude greater than the selenium. This increases the secondary waste volume and reduces the selenium removal efficiency. Other considerations include the production of a selenium concentrated waste stream that requires disposal or further treatment and high capital and operational costs.

The most common types of chemical treatment involve selenate reduction to selenite or elemental selenium, adsorption of selenite, and precipitation of the sorbed and elemental species. Other chemical treatments include cementation, electrocoagulation, and photoreduction. Electrocoagulation and photoreduction have not been demonstrated beyond the laboratory level. Ferrihydrite precipitation with concurrent adsorption of selenium on the ferrihydrite surface is a U.S. Environmental Protection Agency (USEPA) Best Demonstrated Available Technology (BDAT). Since chemical treatment depends on the reactivity of selenite, a step to reduce selenate to selenite is required. Chemical treatment can be expensive, and requires the disposal of chemical sludges or solids that contain selenium.

Biological treatment is emerging as a cost-effective treatment option to remove selenium by either reducing or volatilizing the oxyanions. Several pilot demonstration projects indicate biological systems can treat both selenate and selenite to below regulatory standards. Biological treatments include volatilization of selenium, both passive biochemical reactors (BCRs) and active bioreactors, and constructed wetlands. Historically, there have been problems with the biological removal of selenium in the presence of elevated nitrate concentrations found in agricultural waters; however,

recent research suggests the need for pre-treatment of nitrate can be overcome by proper selection of microbial communities. While advances have improved the understanding of biologically-mediated selenium treatment, the processes governing selenium removal are still not completely understood. Additionally, care must be taken to prevent re-oxidation and mobilization of reduced selenium after treatment.

These technologies are discussed in greater detail below. Additionally, summaries of the technologies presented are listed in Tables 1-7. Table 1 contains an overview of the treatment technologies. Tables 2, 3, and 4 provide additional detail on physical, chemical, and biological treatment methods, respectively. Tables 5, 6, and 7 provide a summary of case studies for physical and chemical, active microbial, and passive microbial treatment, respectively.

4.1 Physical Treatment

4.1.1 Membrane Filtration

Membrane separations rely on semi-permeable membranes to purify the fluid being treated. During membrane separation, a pressure gradient is applied across the membrane, forcing water through the membrane while retaining the contaminants. Both reverse osmosis (RO) and nanofiltration (NF) are membrane filtration processes, but they require different membranes. Unlike RO, NF utilizes a hydrophobic membrane layer to reject multivalent ions. Because of this, NF is operated at much lower pressures than RO. Recently, low pressure (low energy) membranes for RO have been developed, lowering operating costs significantly.

For both processes, pre-treatment may be required to prevent membrane fouling, particularly if the water contains elevated levels of hardness (Ca, Mg) or total suspended solids (TSS). Membranes are typically expected to last two to three years. In addition, both processes produce a concentrated waste stream that must be disposed of properly. Disposal options include evaporation, deep well injection, and biological treatment.

Membrane filtration is a reliable, well understood treatment option for the removal of selenium. Historically, high operating costs have been a drawback to the implementation of membrane filtration processes; however, recent advances in NF and low pressure RO have lessened this concern. Likewise, fouling has been addressed with new flow regimes that continually clean the membrane surface during operation, although fouling can remain a problem depending on water chemistry.

Other disadvantages of membrane filtration include waste disposal and pre-treatment requirements. The pre-treatment requirements include filtration to remove fines and colloidal material and also preheating. For most efficient operation of the RO system, the water temperature must be increased to greater than 70 °F, preferably to 85 °F. The brine produced is typically 20% to 30% of the influent flow depending on the influent water quality.

RO has been implemented successfully for both drinking water and industrial wastewater treatment, and the USEPA currently lists RO as one of the best available technologies (BATs) for selenium removal (Twidwell et al. 2000). RO has also been used successfully to treat MIW, both at Barrick's Richmond Hill Mine (Microbial Technologies, 2005) and at an undisclosed metal mine in the Western US (Gusek et al. 2008).

At the Barrick Richmond Hill Mine, RO is used to polish selenium from mine water after treatment by iron reduction and precipitation. Selenium is reduced from 12-22 ppb to about 2 ppb at flows of 200 US gallons per minute (gpm). The RO unit is operated at pressures of 250 psi and greater. As of 2005, filtration pre-treatment was required to remove TSS. During winter months, water is heated to 15 °C to prevent crystallization caused by depressed salt solubilities that are a result of cold temperatures. Additionally, a softening plant is being considered for the treatment of gypsum scaling resulting from elevated calcium concentrations.

To date, no known pilot or operational studies have been published on selenium removal by NF. Kharaka et al. (1996) used NF at a laboratory scale to remove selenium from agricultural drainage. Results showed greater than 95% selective removal for selenium and more than 90% removal for other multivalent anions. NSMP (2007b) also tested a thin-filmed composite RO membrane for the removal of 15 µg/L selenium and 5 mg/L nitrate using water from the Warner Channel, CA. RO removed 97% of the selenium, but only 46% of the nitrate.

Chellam and Clifford (2002) also demonstrated NF for the removal of uranium, molybdenum, selenium (both selenite and selenate), and thorium on a laboratory scale using groundwater contaminated by uranium mill tailings. RO and low pressure RO were tested as well. Water was pretreated using ferric coagulation, flocculation, settling, and filtration at a pH of 10. Ferric coagulation was effective at removing radium and thorium. Molybdenum, selenium, and uranium were highly retained by RO and NF membranes. In particular, selenium demonstrated a 96-98% removal rate at pH 10 for all three membranes tested.

Golder Case Study (Closed Gold Mine, California, US)

Golder has implemented RO treatment for selenium at multiple sites with success including a former uranium mill closure, a chemical plant closure, and a gold mine closure. At a former historic gold mine site in California, Golder utilized RO to treat impounded water for reduction of selenium from approximately 60 µg/L to < 5µg/L. The RO treatment system was implemented on an emergency basis to prevent the impounded water from overto`pping into a drinking water reservoir located below the mine. Trailer-mounted RO systems were leased along with prefiltration and manganese removal columns. The flow to the system was greater than 100 US gpm and was operated for approximately four months. The system was operated at approximately 40% selenium recovery due to the high TDS of the influent water. The brine was returned to the impoundment and the system was operated until the levels in the impoundment were reduced to acceptable levels.

Golder also evaluated implementation of a permanent RO facility to treat the waste rock leachate. The permanent facility was designed at 60 US gpm and included an evaporator for brine management. The capital cost of the system was estimated at $5,200,000 (US dollars [USD]) and the O&M cost at $18 (USD) per thousand gallons of water treated.

4.1.2 Ion Exchange

During ion exchange, a contaminant ion from solution is reversibly exchanged for a more desirable, similarly charged ion attached to an immobile solid surface. Frequently the solid surface is a synthetic resin, but natural, inorganic zeolites can also be used. Depending on the ion exchange resin selected, the process can be used to remove a suite of ions from solution or to preferentially remove only specific ions. Once the resin becomes saturated, it can be regenerated and placed back into service for further contaminant removal. Regeneration involves washing the resin with a solution to remove sorbed contaminant ions and produces a concentrated contaminant waste stream that may require further treatment before disposal. Selective ion exchange is generally considered to be more cost effective than RO (Frankenberger et al. 2004).

Ion exchange is a well established process commonly employed to treat industrial wastewater, but until recently, ion exchange has not been successful in removing selenium from MIW due to the competition between sulfate and selenate. Sulfate and selenate have very similar chemical properties but sulfate levels in MIW are frequently elevated compared to selenate concentrations. (Sulfate is typically reported in the parts per million range while selenate is usually reported in the parts per

billion range.) Thus, ion exchange resins quickly become saturated with sulfate and stop removing selenate.

Advantages of ion exchange include selective removal of selenium using a well understood technology. The disadvantages include competition with sulfate anions, the need for backwashing and regeneration of the resin, fouling, and secondary waste disposal.

Polyamine-type weakly basic ion exchange resin has been shown to effectively remove selenate over a wide pH range of 3-12; however, increases in sulfate concentrations significantly reduced selenate adsorption (Nishimura and Hashimoto 2007). During laboratory studies, a 0.3 molar ratio of sulfate to selenate showed a decrease in the amount of selenate adsorbed to the resin. A 50 % decrease in adsorbed selenate was detected when the molar ratio of sulfate to selenate was increased to 2. To overcome this problem, $BaCl_2$ was used to reduce aqueous concentrations of sulfate and selenate by precipitation as $BaSO_4$ and $BaSeO_4$, respectively. Ion exchange was then used as a polishing step to further reduce selenate concentrations. The combination of precipitation followed by ion exchange polishing reduced initial total selenium concentrations from 1 g/L to below 0.1 mg/L. Adsorbed selenate could be eluted from the resin using small volumes of 1 M HCl.

A novel silica polyamine resin made from polyethyleneimine (PEI) impregnated with zirconium was recently tested in the laboratory for selenium removal using process solutions from the Kennecott Mining Company (Hughes et al. 2006). The Zr-WP-2 resin was found to remove selenate and selenite up to pH 8. The Kennecott process solution contained 0.93 mg/L selenium as both SeO_4^{2-} and SeO_3^{2-} and 80 mg/L SO_4^{2-} at pH 4. Zr-WP-2 removed selenium to less than 1 µg/L. Sulfate co-loading was observed on the resin, but selectivity over sulfate was calculated as 67:1 and 103:1 for selenate and selenite, respectively. Zr-WP-2 can be regenerated using 1 M H_3PO_4.

4.1.3 Evaporation

Solar evaporation has been considered for selenium treatment in California (NSMP 2007a). Both simple evaporation ponds and enhanced evaporation systems (EES) have been examined. EES accelerates evaporation rates by spraying water in the air. In a study cited by NSMP, evaporation ponds reduced selenium concentrations by only 25% in the San Joaquin Valley. Solar evaporation utilizes large, shallow ponds that provide a potential avenue for exposure and bioaccumulation of selenium in birds. In addition, sediments accumulated during evaporation require disposal. Advantages include no pre-treatment requirements and insignificant energy requirements. (EES will

have higher energy requirements). Solar evaporation is likely unsuitable for selenium removal from MIW due to the prevailing cold climate where operations are typically located and the high potential for selenium exposure to wildlife. An alternative to solar evaporation is the use of mechanical evaporators to produce concentrated brine followed by crystallization, drying, and solid waste disposal. This process typically has high operational costs and has not been investigated for selenium removal from MIW.

4.2 Chemical Treatment

4.2.1 Selenium Reduction using Iron

Zero valent iron (ZVI) is used to reduce selenium oxyanions to elemental selenium. Ferrous cations can also reduce selenate to selenite and subsequently remove selenite by adsorption to iron hydroxides. In an aqueous environment, ZVI can be oxidized to ferric (Fe^{3+}) and ferrous (Fe^{2+}) ions. These ions react with hydroxyl ions present in water to form ferric and ferrous hydroxides. Selenate is reduced to selenite while ferrous iron is oxidized to ferric iron. Selenite then adsorbs to the ferric and ferrous hydroxide surfaces and is removed from solution. Iron reduction removal mechanisms are as follows:

$$SeO_4^{2-} + ZVI \rightarrow Se° + Fe^{2+}/Fe^{3+}$$
$$SeO_3^{2-} + ZVI \rightarrow Se° + Fe^{2+}/Fe^{3+}$$
$$SeO_4^{2-} + 2Fe(OH)_2 + H_20 \rightarrow SeO_3^{2-} + 2Fe(OH)_3$$

Lovett (2008) used fibrous ZVI (steel wool) to remove selenium from MIW at Catenary Post in a continuous flow reactor. Inlet concentrations of selenium varied from 5 µg/L to 14 µg/L. Over 250 days, effluent concentrations of selenium did not consistently achieve the regulatory limit of 5 µg/L. Results indicated a minimum 5 hour contact time is required to remove selenium to regulatory levels. Additionally, selenium removal may be temperature dependent. Problems with the treatment process included formation of iron oxides, passivation of the iron, exhaustion of the iron, and cost.

In 2007, the NSMP (2007b) ran a pilot scale reactor to remove selenium from drainage water collected from Warner Channel in California using the principles described above; however, rather than using ZVI, ferric and ferrous chloride were added. The pilot system was built by Kemira/ORCA and included flocculation and filtration, with equal doses of 2.5 mg/L ferric and ferrous chloride. The system treated 10 US gpm with a mean selenium concentration of 15 µg/L. Approximately 95% of the total selenium was present as selenate, with the remainder as selenite. The system did not remove

any selenium; however, the pilot system was only available for one day, preventing the process from being optimized on site due to time limitations.

Iron or zinc reduction is also used at three operational facilities to remove selenium from MIW (Microbial Technologies 2005). At Barrick's Richmond Hill Mine, ZVI is used to reduce selenate to selenite, followed by ferric sulphate precipitation at pH 4.5. The process is only able to remove selenium to concentrations of 12-22 ppb, and RO is used as a polishing step to reduce selenium to effluent regulations. Meridian Dry Valley Mine use zinc powder to reduce selenate to selenite, followed by iron salt precipitation at an acidic pH. At another mine site, ZVI and ferrous sulphate at pH 4.5 are used to reduce selenate to selenite. Ferric chloride is then added to form ferric hydroxide, which co-precipitates the selenite.

While iron reduction can significantly decrease selenium concentrations, it has been applied with varying success for meeting regulatory standards. Morever, high operational costs and sludge disposal are disadvantages of this process. Treatment may also be temperature dependent.

4.2.2 Ferrihydrite Co-Precipitation

Ferrihydrite co-precipitation of selenium is a USEPA BDAT for the removal of selenium from wastewater. Selenium is removed by adsorbing to the iron surface and subsequent precipitation of ferrihydrite from solution. The reaction is as follows:

$$Se^{4+} + FeCl_3 + 4H_2O \rightarrow Fe(OH)_3 \bullet Se + 8H^+$$

Twidwell et al. (2000) reviewed ferrihydrite co-precipitation and concluded that:

- Selenite is adsorbed much more effectively than selenate; therefore selenate should be reduced to selenite before ferrihydrite co-precipitation.
- Adsorption of selenite depends on having oxyhydroxide present; amorphous ferrihydrite appears to be more effective than crystalline ferrioxyhydroxides.
- The higher the selenite concentration, the more effective the process appears to be.
- Available data suggest the best pH for selenite adsorption ranges between 4 and 6, producing 85-95 % removal of selenite; pHs greater than 7 show drastic decreases in adsorption.

- Selenate adsorption may be strongly affected by the presence of sulfate, bicarbonate, and aqueous silica species.

Only one pilot study has been undertaken to demonstrate ferrihydrite co-precipitation and long term studies of the stability of ferrihydrite co-precipitation waste have not been performed. In 2001, the USEPA conducted a 1 US gpm pilot demonstration at the Kennecott Utah Copper Corporation's Garfield Wetlands-Kessler Springs site (MSE 2001). The water contained 1,950 µg /L selenium, primarily as selenite. Using an iron concentration of 4,800 mg/L, the mean effluent selenium concentration was 90 µg/L. The minimum reported selenium concentration was 35 µg/L.

Although ferrihydrite co-precipitation is a USEPA BDAT, consistent removal to regulatory levels of selenium has not been proven. Additional disadvantages include sludge disposal, uncertainty with respect to the long term stability of the sludge, and high operational costs typical of chemical treatment.

4.2.3 Catalyzed cementation

Catalyzed cementation is a treatment process that removes selenium by cementation to the surface of iron particles (MSE 2001). During treatment, proprietary catalysts are added to enhance cementation to the iron surface at a lowered pH. Catalyzed cementation can remove both selenate and selenite from solution.

Advantages of catalytic cementation include its ability to reduce selenium below 5 µg/L. Additionally, the process does not appear to be highly temperature dependent. Unfortunately, the process has not been widely tested. Other disadvantages include high chemical costs and solid waste disposal requirements. Additionally, no long term studies of the stability of the cementation waste have been undertaken.

Catalyzed cementation was tested as part of the USEPA demonstration project for selenium removal at Kennecott's Garfield Wetlands-Kessler Springs site (MSE 2001). Water with total selenium concentrations of 1,950 µg/L (primarily as selenate) was tested at a flow rate of 1 US gpm. Even after extensive optimization in the field, the lowest effluent concentration achieved was 26 µg/L. Continued optimization in the laboratory achieved a mean effluent selenium concentration of 3 µg/L.

4.2.4 Electrocoagulation

During electrocoagulation, water is treated using electrolysis with graphite or stainless steel cathodes in conjunction with a metal anode (e.g., Al, Fe, Zn, Ni, etc.). Anode material selection is dependent on the wastewater composition. When a voltage is applied across the electrodes, insoluble precipitates are formed from ions of the metal electrode and selenium, arsenic, or other metals present in the water. Contaminant removal depends on the composition of the water, the material and configuration of the electrodes, and the electric current. Electrocoagulation can reduce sludge production significantly compared to other chemical processes such as iron reduction. A disadvantage of this process is that it has not been tested at the pilot or full scale and the process has high capital and operation and maintenance costs.

A hybrid electrocoagulation-microfiltration process was tested in the laboratory using industrial wastewater from copper production to remove selenium, arsenic, copper, lead, zinc, and cadmium (Mavrov et al. 2006). Water was pretreated using lime neutralization and sedimentation followed by electrocoagulation. After electrocoagulation, water was filtered using a microfiltration flat sheet ceramic membrane and it then underwent a final lime neutralization step. During experiments, good adsorption and co-precipitation of selenium with iron hydroxides generated during electrocoagulation were observed. The iron hydroxide fines were completely removed by microfiltration. Selenium was reduced by 98.7 % from 2.32 mg/L to 0.03 mg/L using an anodic current density of 4.8 mA/cm^2. Arsenic (99.9 % removal), copper (> 98 %), lead (> 98 %), zinc (> 99.9 %) and cadmium (> 99.9 %) were also removed from the wastewater.

4.2.5 Photoreduction

Photoreduction has been studied on a laboratory scale for the removal of selenium (Nguyen et al. 2005). During photoreduction, UV light is used to generate electron-hole pairs on the surface of a photocatalyst. Contaminants absorbed to the surface of the photocatalyst undergo redox reactions induced by the electrons and holes created by the exposure to UV light. The treated species are then desorbed and the surface of the photocatalyst is regenerated.

TiO_2 has been found to be an effective photocatalyst for the reduction of both selenate and selenite in solution. Nguyen et al. (2005) found that using UV light at wavelengths less than 380 nm at a pH of 3.5 in the presence of TiO_2 and formic acid will reduce Se(VI) and Se(IV) to Se(0). Concentrations of 20 – 40 µg/L of selenate and selenite were tested with UV exposure times ranging between 2 and 8

hrs producing final effluent concentrations between 31 and 1 µg/L total selenium. The reduction of Se(VI) proceeded more slowly than Se(IV), presumably due to poorer adsorption of Se(VI) onto the surface of TiO_2. The formation of toxic H_2Se was observed during photoreduction, and was removed by a scrubber containing CuSO4 and NaOH in series.

4.2.6 Selenium Adsorption on Peanut Shells

Selenium removal by adsorption to peanut shells has been studied on a laboratory scale (El Shafey 2007). This process has only recently been developed and is not well characterized, but peanut shells are readily available at low cost. Before treatment, peanut shells are treated with strong sulfuric acid to carbonize the shells while partially oxidizing the cellulose and hemicelluloses and fragmenting the lignin. The sulfuric acid treatment results in a carbonaceous material with functional groups for both the sorption and reduction of selenium. Selenite sorbed to the material at an optimal pH of 1.5. As pH increased, sorbtion capacity decreased. Sorption was also found to be temperature dependent. Removals as high as 63% percent were observed for 25 mg/L selenide solutions.

4.3 Biological Treatment

4.3.1 Algal Volatilization of Selenium

Selenium can be removed from sediments or water through biological volatilization by plants, algae, and microbes (Bañuelos et al. 2005). The biological conversion of inorganic selenium to methylated species (i.e., dimethyl selenide, dimethyl diselenide) is termed biomethylation. The methylated species are lost from soils and water through volatilization to the atmosphere. This is considered a favorable remedial pathway as the volatile selenium species are far less toxic (Bañuelos et al. 2005). Depending on the location, volatilization to the atmosphere can remove the selenium from an area of high soil or aqueous concentrations to an area that is selenium deficient.

Algal treatment has been demonstrated on bench, pilot, and demonstration scale levels. Algal treatment occurs via enhanced cyanobacterial and algal growth through nutrient addition. These additional nutrients increase algal biomass, thereby increasing selenium volatilization rates (Fan et al. 1998). Cyanobacterial mats and the green algae Chlorella have been shown to actively volatilize over 60% of selenite from an aquatic medium with initial selenium concentrations ranging from 10 to 10,000 µg/L (Fan et al. 1998). In addition to treatment by volatilization, the algal biomass generated also serves as a carbon source to support microbial selenium reduction processes. In essence, the

algae volatilize selenium while alive, and once the algae die, the algal detritus supports microbial selenium reduction. Additional selenium removal also likely occurs via algal uptake of selenium (Yu and Wang 2004).

A demonstration scale algal-bacterial selenium removal (ABSR) facility in California operated from 1997 to 2003 and treated between 2.5 US gpm and 19 US gpm of agricultural drainage water. The system included nutrient addition to promote algal growth as well as carbon addition (e.g., molasses) to promote microbial selenium reduction. In 2003, the algal component was discontinued because experiments showed the algal component did not significantly increase the overall selenium removal rate (Fisher 2004). Carbon addition alone was continued as the primary treatment.

Algal treatment has also been shown to be effective in concert with in situ carbon treatment of pit lakes (Harrington 2002). After the initial carbon amendment decreases the bulk of the selenium via dissimilatory microbial reduction, algal blooms in subsequent years provide enough biomass to keep the lake under reducing conditions and thereby retain elemental selenium in its reduced, insoluble form.

The advantages of algal treatment are low cost and the ability to implement the process *in situ* on existing water bodies or as a unit process in an active treatment plant. The disadvantages include the difficulty of generating sufficient biomass to promote biological reduction and the inability to treat selenium to regulatory levels. As with any biological process, the rate of algal treatment will decrease with decreasing temperatures and the process therefore may not be suitable for cold sites.

4.3.2 Microbial Reduction Treatment

Microbial reduction of selenium is well-documented (Quinn et al. 2000; Oremland et al. 1989; Fujita et al. 2002; Zhang and Frankenburger 2003; Cantafio et al. 1996) and has been implemented successfully in full-scale treatment plants. This process is commonly referred to as biological treatment. The process consists of the reduction of soluble, oxidized selenium ions (selenate, selenite) to insoluble elemental selenium. The microbial reduction of selenium depends on oxidation-reduction reactions in which the treatment substrate (e.g., molasses, wood chips, dried distiller's grain solids) serves as the electron donor and selenate and selenite serve as the electron acceptors. The generalized formula for this process is (Oremland et al. 1989):

$$4CH_3COO^- + 3SeO_4^- \rightarrow 3Se^\circ + 8CO_2 + 4H_20 + 4H^+$$

This process can be carried out in an active plant which typically requires feed pumps for nutrient addition, tanks, and water heaters. The process can also be in a passive bioreactor which can operate without electricity or continuous nutrient inputs. A more detailed description of these two technologies follows.

4.3.2.1 Active Microbial Reduction Treatment

Active microbial reduction can be accomplished by utilizing a variety of reactor configurations the selection of which is dependent upon a number of factors including flow rate, selenium concentration, and the matrix of other contaminants. Simple systems such as ponds have been utilized and more complex systems capable of higher loading rates such as fixed film systems have also been successful is reducing selenium levels.

Upflow anaerobic sludge blanket reactors (UASBRs) have been pilot tested for the removal of selenium. UASBRs anaerobically treat contaminants using dense, granulated sludge particles suspended in the reactor. Wastewater is distributed at the bottom of the reactor and flows vertically up through the sludge particles where microbial treatment occurs. The effluent is collected at the top of the reactor, and may undergo further treatment (e.g., settling and recycling of sludge particles) before discharge. When selenium is treated by UASBRs, a carbon source such as molasses or ethanol is required to act as electron donor and effectively reduce oxidized selenium to elemental selenium. Precipitated selenium particles can be incorporated into granular sludge particles or suspended in the water, where they are recovered in a post-treatment filtration or settling step.

Considerations for the design of UASBRs include water composition, loading, the upflow velocity, and pH. Advantages include the ability to treat high loading rates to regulatory limits using a smaller footprint than passive systems. Disadvantages include the need for pre-treatment removal of suspended solids that inhibit floc formation, sludge retention, post-treatment capture of suspended elemental selenium particles present in the effluent, and temperature dependence.

The Adams Avenue Agricultural Drainage Research Center operated pilot tests for the removal of selenium in San Joaquin Valley agricultural drainage by UASBRs over three years in the early l990s (Owens 1998). Influent total selenium concentrations were about 500 µg/L in the presence of 3 mg/L nitrate as nitrogen. Methanol was fed to the system at approximately 250 mg/L. Complete nitrogen removal was observed, while selenium removal varied from 58% to greater than 90%. Lenz (2008)

also operated a series of pilot scale UASBRs over the course of several years. Among his conclusions were:

- For non-specific selenium reduction, the ratio of selenate to sulfate should be greater than 1.92×10^{-3} to reduce competition with sulfate and maintain complete selenate removal.
- High concentrations of sulfide did not interfere with selenate removal; therefore it may be possible to combine sulfide precipitation of metals with selenium removal in MIW.
- Selenium respiring microorganisms were able to efficiently reduce selenate even in the presence of elevated sulfate and nitrate concentrations.
- Selenium reduction is temperature dependent, and decreases in temperature can induce production of alkylated selenium species (e.g., DMSe or DMDSe).

General Electric's ABMet® (formerly Applied Bioscience's BSeRTM process) is another active microbial reduction process used to treat selenium. ABMet® has been demonstrated at both pilot and full scale operational levels in MIW and flue gas desulfurization (FGD) wastewaters, respectively (MSE 2001; Sonstegard et al. 2008). ABMet® is a plug-flow, anaerobic bioreactor in which a selenium-reducing bacterial biofilm is supported on granular activated carbon (GAC). The system is inoculated with a mixture of proprietary and indigenous microorganisms, and reducing conditions are maintained by feeding a molasses-based nutrient mixture to the system. Advantages of ABMet® include a small footprint and proven performance. Disadvantages include the need for pre- and post-treatment steps to remove suspended solids, backwashing to prevent plugging and short-circuiting of flow, and temperature dependence. In addition, capital costs can be high due to the large volumes of GAC required.

ABMet® was a pilot demonstration technology at the USEPA Kennecott demonstration program (MSE 2001). During six months of operation, the process was able to lower the concentration of selenium from 1,950 µg/L to below 2 µg/L with hydraulic retention times as low as 5.5 hours. ABMet® is also used to treat selenium in FGD wastewaters at Duke Energy and Progress Energy in North Carolina (Sonstegard et al. 2008). At Progress Energy, during 9 months of operation, average selenium removal was 99.3%, with consistent removal of selenium from 1,500 µg/L to less than 10 µg/L in the presence of high dissolved solids levels.

Golder Case Study (Undisclosed gold mine, South Dakota, US)

Golder designed and constructed an active treatment system that includes microbiological reduction to remove selenium at closed mine site in South Dakota, U.S (Gusek et al. 2008). The treatment system is designed to treat pH-neutral, waste rock leachate characterized by high TDS (approximately 5,000 to 15,000 mg/L), high hardness, and high sulfate concentrations. The average influent selenium concentrations are approximately 70 μg/L, the discharge limit is 4.6 μg/L, and the maximum design flow is 700 US gpm. The process flow includes the following systems:

- Conventional multimedia filtration with polymer addition for TSS removal;
- Reverse Osmosis (RO) for TDS management and volume management during peak flows. The RO system includes influent water heating (including a boiler and heat exchanger), anti-scalant addition, and membrane cleaning; and,
- Active microbial reduction treatment to remove selenium from the RO reject stream. Treated biological effluent is recombined with RO permeate to meet the discharge limit for TDS and is discharged to surface water. Any excess bio-treated brine is discharged to the local municipal wastewater treatment system.

The microbial reduction treatment system achieves removal of selenium to residuals less than 10 μg/L and the discharge limit is achieved by blending with the RO permeate prior to stream discharge. The approximate O&M cost is $6 (2005 USD) per thousand gallons of water treated, although the majority of this cost is for the RO process and sewer surcharge for the brine discharged to the sewer. Cost evaluations completed to determine the optimal treatment strategy estimated that the O&M cost would increase to $13 (USD) per thousand gallons of water treated if disposal of the excess brine to the local sewer system were not available and additional treatment of the brine were required. At the time of the development of the treatment process, the client was utilizing a chemical reduction process for selenium control at an O&M cost greater than $15 (USD) per thousand gallons of water treated. The combination of RO and a microbial reduction treatment system is beneficial because it meets stringent selenium surface water discharge limits while allowing the installation of a treatment system with a large range of treatment capacity, from 70 to 700 US gpm (average 250 US gpm), in a 1 acre treatment facility relatively small space.

The advantages of active biological treatment include the ability to meet regulatory limits, a small footprint, and lower operating costs compared to stand-alone RO and chemical treatment. The disadvantages include high capital costs and the need for pre-treatment.

4.3.2.2 Passive Microbial Reduction Treatment

Passive microbial reduction of selenium typically consists of a gravity flow reactor containing a solid organic media. The organic media slowly degrades and provides a carbon source to sustain the microbial reduction of selenate and selenite to elemental selenium. Examples of successfully-implemented organic media include hay, wood chips, sawdust, rice straw (Pahler et al. 2007; Zhang et al. 2007). The media can also contain an alkalinity buffer such as limestone. These systems, also known as biochemical reactors (BCRs), have been successfully inoculated with selenium reducing bacteria or with a generic inoculum such as cow manure. BCR effluent can contain elevated levels of biochemical oxygen demand and total coliforms and may require a polishing step in order to comply with regulatory standards. Because this is a relatively new technology that has been developed over the past 20 years, the long-term performance of BCRs, including the required media replacement interval, is not well understood. BCRs are typically used to treat contaminants that precipitate or are biologically removed under reducing conditions, such as metals, nitrate, and sulfate. Full-scale BCRs have been constructed in the US, Canada, Europe, and South Africa. Golder has designed and/or constructed one full-scale and two pilot BCRs for selenium removal in addition to performing multiple bench studies.

Golder Case Study (Undisclosed gold mine, Montana, US)

A BCR is being used at an undisclosed gold mine in Montana to treat selenium (Blumenstein et al. 2008). The first of two modules of a full-scale BCR was constructed in fall 2007 with a design flow rate of 10 US gpm, to treat waste rock seepage. The BCR cell typically reduces influent selenium concentrations of 20 μg/L to below the laboratory detection limit (1 μg/L), which is below the applicable regulatory standard. An additional module is planned to expand the total treatment capacity to 20 US gpm.

The advantages of passive microbial reduction treatment are low capital and O&M costs; BCRs operate virtually unattended. The disadvantages include the large area required to treat high flows and the lack of understanding of long-term performance, particularly at cold sites. The design and construction cost of the first module was about $200,000 (USD). The annual operating costs are estimated at $0.30 (USD) per thousand gallons.

4.3.3 In Situ Microbial Reduction Treatment

In situ treatment of pit lakes with a carbon amendment is another type of passive microbial reduction treatment which consists of amending a pit lake with nutrients, including a carbon source, to remove selenium. The carbon amendment often consists of soluble organic compounds (e.g., molasses, ethanol) that serve as an energy source (i.e., electron donors) which promote the growth and activity of selenate- and selenite-reducing microorganisms indigenous to the site. The goal of the carbon amendment approach is to create and maintain geochemically reducing conditions in the deeper portions of the water column to achieve reduction and subsequent sequestration of selenium within the lake sediments. It is vital that anaerobic conditions are maintained on the lake bottom to prevent re-oxidation and mobilization of selenium.

Depending on site conditions such as the lake mixing regime, it may be necessary to reapply the amendment to maintain anaerobic conditions throughout the water column and prevent the remobilization of elemental selenium. The process, ostensibly patented by Alexco Resources Inc., results in anoxic conditions that are lethal to aquatic life. Therefore, the process is suitable only to waterbodies that do not contain aquatic life. This treatment method has effectively reduced selenium concentrations in pit lakes at the Sweetwater uranium mine in Wyoming (Harrington 2002) and the Gilt Edge Superfund Site in South Dakota (Harrington et al. 2004). The Sweetwater mine pit lake has an average depth of 60 feet, a surface area of 60 acres, and a total volume of 1.25 billion gallons. The initial selenium concentration was 0.45 mg/L. The lake was treated in 1999 with 1.1 million pounds of carbon and other nutrients and within six weeks the selenium concentrations were reduced to levels below the applicable standard of 0.05 mg/L. Selenium concentrations remained below the standard two years after the initial application.

The advantages of this process are its low cost, and the ability to treat a large volume of water while meeting stringent regulatory limits. The disadvantages include the generation of toxic, anoxic conditions, and uncertainty with respect to the long-term stability of precipitated selenium.

4.3.4 Wetlands

Engineered treatment wetlands are divided into two categories: subsurface flow wetlands (SSF) and free water surface wetlands (FWS). In an SSF system, water flows below the surface of a crushed media, such as gravel or sand, and the media surface is planted with aquatic plants. A FWS system is similar to a natural wetland or marsh, with water flowing over the surface of a planted treatment cell.

Wetlands are complex systems characterized by multiple processes including aerobic and anaerobic biological activity, settling and filtration, volatilization, and phytoremediation. The principle selenium removal mechanisms are volatilization and plant uptake (Frankenburger et al. 2004; Azaizeh et al. 2006). A secondary wetland removal mechanism is biological reduction in anaerobic sediments.

Lab-scale SSF treatment of selenium has demonstrated removal of selenium to below 0.2 μg/L (Azaizeh et al. 2006). SSF testing for selenium removal on a larger scale has not been reported. Selenium removal in full-scale FWS wetlands has been well-documented. A 36-hectare constructed wetland near San Francisco, CA receives oil refinery wastewater from Chevron's Richmond refinery with selenium concentrations between 20 and 30 μg/L. The wetland treats 10,000 m^3/day and achieves effluent selenium concentrations of less than 5 μg/L. Volatilization accounts for 10 -30% of the total selenium removal (Frankenburger et al. 2004). A primary concern with FWS systems is that wildlife are drawn to these systems and are thus likely exposed to toxic levels of selenium. The oil refinery wetland led to elevated selenium concentrations in birds (Lemly 2003) and consequently steps were taken to reduce its attractiveness to wildlife. SSF treatment largely avoids any exposure to wildlife because of the subsurface water flow.

The advantages of wetland treatment are low capital and O&M costs and the ability to treat high flows and achieve effluent concentrations that comply with regulatory standards. The disadvantages include the large area required, removal mechanisms that are not completely understood, and the risk of creating a wildlife hazard. Furthermore, the performance of these systems at cold sites has not been documented.

5.0 CONCLUSIONS

Significant research and development of selenium treatment technologies has occurred over the past two decades. The challenge of treating selenium to meet the stringent applicable standards of a few micro-grams per liter has led to testing of multiple physical, chemical, and biological treatment methods. Among these methods, proven full-scale treatment is currently being conducted by reverse osmosis, reduction by iron, active and passive microbial reduction, *in situ* microbial reduction, and wetlands. These methods are capable of meeting applicable standards, and provide a suite of tools to tackle the increasingly important issue of selenium in the environment. Some Canadian mine site discharge flow rates pose a significant design challenge. These rates can be on the order of 250,000 m^3/day (45,863 US gpm), significantly greater than the highest selenium treatment plant flow rate of 7,630 m^3/day (1,400 US gpm). Although full-scale treatment of selenium is proven, it has not been demonstrated for flow rates typical of the Canadian mine sites. This review is limited to water treatment, which is one of three selenium management tools (Chapman et al. 2009). The other two management tools, prevention of selenium release and control of selenium in the environment, are not reviewed.

In the past five years, biological treatment has emerged as a leading technology for selenium treatment. Biological treatment offers a low cost alternative to more expensive physical and chemical treatment methods. Additionally, it has the proven ability to meet regulatory selenium limits. Germane summary statistics of these methods are provided in Tables 6 and 7 for active and passive biological-based systems, respectively. For cold climate sites, BCRs and *in situ* microbial reduction appear to be treatment processes worthy of additional study which is currently underway. A brief summary of this effort follows.

Golder conducted pilot testing of algal volatilization and bench and pilot testing of BCR treatment at the Cardinal River Operations site in 2008. The algal volatilization testing resulted in total selenium removal rates of up to 30% (Golder 2009) at a relatively low cost. Bench testing of the BCR technology demonstrated 90% removal of total selenium (Golder 2008). The results of the pilot BCR will help determine the cold weather performance of the technology and provide greater insight to passive microbial treatment methods.

The treatment of endpit lakes presents a unique situation which may allow certain methods to be effective that would not otherwise be considered. Treatment of endpit lakes by *in situ* microbial reduction appears to be an effective, low-cost option, although the process may be subject to patents.

Additionally, endpit lakes could be used as deep-water disposal for RO brine. Limnological studies at the Cardinal River Operations site indicate that some pit lakes may be stratified; the hypolimnion does not mix with upper layers of the lakes (Wolanski 1999). Thus, the hypolimnion of a permanently stratified lake could provide ideal conditions under which to store RO brine. Another option may be to continuously treat endpit lake water with a BCR cell which discharges back to the lake. A relatively small BCR (20 US gpm) could treat over 10 million gallons of lake water per year. Furthermore, the high organic load in the BCR effluent would likely generate anaerobic conditions in the hypolimnion which would result in partial *in situ* microbial reduction and subsequent stabilization of elemental selenium on the lake bottom. These lake treatment options would probably temporarily degrade lake water quality in order to treat selenium or stabilize reduced selenium in the hypolimnion. If degradation of the lakes is not permitted, these options may not be feasible.

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TABLES

Table 1
Overview of Treatment Technologies

Treatment Type	Technology
Physical	Reverse Osmosis Nanofiltration Ion Exchange Evaporation
Chemical	Iron Reduction and Precipitation Ferric Coagulation and Filtration Cementation Electrocoagulation Photoreduction
Biological	Volatilization Active Microbial Reduction Passive Microbial Reduction In Situ Microbial Reduction Wetlands

Table 2
Advantages and Disadvantages of Physical Treatment Processes for Selenium Removal

Treatment Technology	Technology Description	Advantages	Disadvantages	Development Stage
Reverse Osmosis	Pressure-driven separation through a semi-permeable membrane that allows water to pass through while rejecting contaminants	Reliable, well understood process that is scalable; can achieve regulatory limits	Membrane fouling; may require pre-treatment; high operating pressure; brine disposal	Full Scale
Nanofiltration	Low pressure membrane separation based on molecular size and ionic charge that allows water to pass through while rejecting contaminants	Reliable, well understood process that is scalable; low operating pressures; can achieve regulatory limits	Membrane fouling; may require pre-treatment; brine disposal	Laboratory
Ion Exchange	Reversible exchange of contaminant ions from a process stream with more desirable ions of a similar charge adsorbed to a solid surface	Selective removal of selenium using a reliable, well understood process that is scalable; can achieve regulatory limits	Backwashing and regeneration of resin are required; waste disposal; sulfate competition; inability to remove selenate	Laboratory
Evaporation	Vaporization of pure water to concentrate contaminants as a solid or in a brine stream	Insignificant energy requirements; no pre-treatment requirements	Large footprint; dependent on solar radiation levels and temperature; disposal of accumulated sediments; pathway for Se exposure to wildlife; regulatory limits may not be achievable	Pilot

Table 3
Advantages and Disadvantages of Chemical Treatment Processes for Selenium Removal

Treatment Technology	Technology Description	Advantages	Disadvantages	Development Stage
Selenium Reduction Using Iron	Use of ZVI or Fe(II) for SeO_4^{2-} and SeO_3^{2-} reduction and subsequent precipitation	Proven technology to reduce Se concentrations	High chemical consumption; waste disposal; long term stability of waste is unknown; may be temperature dependent; does not consistently achieve regulatory limits	Full Scale
Ferrihydrite Co-Precipitation	Removal of Se by adsorption to amorphous ferrihydrite	EPA best available demonstrated technology	High chemical consumption; waste disposal; long-term stability of waste is unknown; most effective with selenite	Pilot
Catalyzed Cementation	Removal of Se by cementation onto an iron surface and subsequent settling	Effective removal of both selenate and selenite	High chemical consumption; waste disposal; long-term stability of waste is unknown; does not consistently achieve regulatory limits	Pilot
Electrocoagulation	Formation and removal of selenide precipitates by electrolysis	Effective removal of selenate and selenite; low sludge production	High capital and operational costs; may require pre- and post-treatment; technology not proven to reduce Se below regulatory limits	Laboratory
Photoreduction	Reduction of SeO_4^{2-} and SeO_3^{2-} to elemental Se using UV light in the presence of a TiO_2 catalyst	Minimal sludge production; recoverable elemental selenium fraction	High energy requirements; process not well characterized; production of toxic H_2Se gas	Laboratory

Table 4
Advantages and Disadvantages of Biological Treatment Processes

Treatment Technology	Technology Description	Advantages	Disadvantages	Development Stage
Algal Volatilization	Volatilization of methylated Se by stimulating algal growth through the addition of nutrients, including carbon	Low cost, *in situ* treatment process	Difficulty stimulating sufficient algal growth; inability to reduce Se below regulatory limits; temperature dependent	Pilot
Active Microbial Reduction	Microbial Se reduction to Se° by the active addition of nutrients, carbon, and/or energy	Proven technology to meet regulatory limits; small footprint; lower operating costs compared to physical and chemical treatment	High capital costs; pre-treatment may be required; plugging by Se precipitates; re-oxidation and mobilization of Se possible	Full Scale
Passive Microbial Reduction	Passive flow system constructed with materials promoting microbial reduction of Se without the active addition of chemicals or energy	Low capital and O&M costs; little to no active supervision required; ability to meet regulatory limits	Long term performance not well understood; large footprint; may require effluent polishing; temperature dependent; re-oxidation and mobilization of Se possible	Full Scale
In Situ Microbial Reduction	Microbial reduction of Se by the *in situ* addition of a carbon source to promote reducing conditions	Low cost; *in situ* treatment of large volumes of water; ability to meet regulatory limits	Generation of anoxic conditions toxic to wildlife; long term stability of precipitated Se is unknown; multiple applications of carbon may be required; lake turnover can be problematic; patented process	Full Scale
Wetlands	Engineered system constructed using wetland vegetation, soils, and associated microbes to promote biological removal of Se by reduction or volatilization	Low capital and O&M costs; ability to treat high flow rates; ability to meet regulatory limits	Potential wildlife exposure to elevated Se levels; large footprint; incomplete understanding of removal mechanisms; may be temperature dependent; re-oxidation and mobilization of Se possible	Full Scale

Table 5
Physical and Chemical Case Study Details

Source	Description	Scale	Length of Operation	Location	Flow Rate	Water Quality			Cost (USD)	Reference
						Parameter	Influent	Effluent		
MIW	Se reduction by steel wool	Pilot	8 mo	Catenary Post	NA	Se	5 - 14 µg/L	> 5 µg/L	NA	Lovett 2008
MIW	Ferrihydrite co-precipitation	Pilot	6 mo	KUCC Garfield Wetlands-Kessler Springs	1 US gpm	Se	1,950 µg/L	90 µg/L	NA	MSE 2001
MIW	Catalytic cementation	Pilot	6 mo	KUCC Garfield Wetlands-Kessler Springs	1 US gpm	Se	1,950 µg/L	26 µg/L	NA	MSE 2001
MIW	Reverse Osmosis	Full Scale Temporary	4 mo	Closed gold mine, California	100 US gpm	Se	60 µg/L	<5 µg/L	NA	Golder case study
MIW	Iron reduction and precipitation Reverse Osmosis	Full Scale	NA	Barrick Richmond Hill Mine	200 US gpm	Se	100 µg/L	2 µg/L	Capital: $1.5 million (2005 dollars) Operating: $10 - $18/1,000 gal.	Microbial Technologies 2005
MIW	Selenium reduction w/ zinc powder and iron co-precipitation	Full Scale	NA, ongoing	Meridian Dry Valley Mine	NA	NA	NA	NA	NA	Microbial Technologies 2005

Note: MIW - mining influenced water.
NA - information is unavailable

Table 6
Active Microbial Reduction Case Study Details

Source	Description	Scale	Length of Operation	Location	Flow Rate	Water Quality			Cost (USD)	Reference
						Parameter	Influent	Effluent		
Agricultural	Upflow Anaerobic Sludge Blanket Reactor (UASBR)	Pilot	2 yr	California	NA	Se	500 µg/L	50 µg/L	Operating: $1.23-1.48/1,000 gal (2005 dollars)	Owens 1998
MIW	BSeR™ (GE ABMet®)	Pilot	6 mo	KUCC Garfield Wetlands-Kessler Springs	1 US gpm	Se	1,500 µg/L	< 2 µg/L	Operating: $1.32/1,000 gal (2001 dollars)	MSE 2001
MIW	Anaerobic fixed film bioreactor using activated carbon support	Full Scale	2 yr, ongoing	Goldcorp's former Wharf Resources Mine, Lead, SD	40-300 US gpm	NO_3^- SeO_4^{2-} As	30 mg/L 15 µg/L 70 µg/L	<1 mg/L <5 µg/L <1 µg/L	Capital: $1 million Operating: $0.57/1,000 gal (2005 dollars)	Microbial Technologies 2005
MIW	Anaerobic fixed film bioreactor using activated carbon support	Full Scale	NA, ongoing	Zortman-Landusky gold mine, MT	75-300 US gpm	NO_3^- SeO_4^{2-} CN^-	200 mg/L 500-700 µg/L 300-400 µg/L	<10 mg/L 100 µg/L 200 µg/L	Capital: $3 million Operating: $2.38/1,000 gal (2000 Dollars)	Microbial Technologies 2005
Flue-Gas Desulfurization	GE ABMet®	Full Scale	9 mo, ongoing	Progress Energy Roxboro Station	1400 US gpm	Se	1,500 µg/L	< 10 µg/L	NA	Sonstegard et al. 2008
MIW	Anaerobic fixed film bioreactor using high surface area media support	Full Scale	2 yr, ongoing	Undisclosed gold mine, Western US	250 US gpm	Se TDS	70 µg/L 16,000 mg/L	< 10 µg/L	Operating: $5.71/1,000 gal (2008 dollars)	Gusek et al. 2008

Note: MIW - mining influenced water.
NA - information is unavailable

Table 7
Passive Microbial Reduction, *In Situ* Microbial Reduction & Wetlands Case Study Details

Source	Description	Scale	Length of Operation	Location	Flow Rate	Water Quality			Cost (USD)	Reference
						Parameter	Influent	Effluent		
MIW	Free Water Surface (FWS) wetland	Pilot	NA	Undisclosed gold mine, Nevada	10 US gpm	Se pH	40 µg/L 7.5	16 µg/L	NA	Gusek et al. 2008
MIW	Biochemical Reactor (BCR) with FWS wetland polishing	Pilot	NA	Undisclosed gold mine, Nevada	6 US gpm	Se pH	22 µg/L 2.7	< 5 µg/L	NA	Gusek et al. 2008
MIW	BCR	Pilot	18 mo	Brewer Mine, South Carolina	1 US gpm	Se	1,500 µg/L	50 µg/L	NA	Gusek 2000
MIW	BCR	Pilot	6 months, ongoing	Sand and Gravel Pit, Colorado	10 US gpm	Se	20 µg/L	2 µg/L	Capital Cost: $80,000 Operating: $0.30/1,000 gallons (2008 dollars)[1]	Pahler et al. 2008
MIW	BCR with FWS wetland polishing unit	Full Scale	1.5 yrs, ongoing	Undisclosed gold mine, Montana	10 US gpm	Se	20 µg/L	< 1 µg/L	Capital Cost : $225,000 Operating $0.30/1,000 gallons (2008 dollars)[1]	Blumenstein et al. 2008
Oil Refinery Wastewater	FWS wetland	Full Scale	NA, ongoing	Chevron Oil Refinery, Richmond, CA	1,835 US gpm	Se	20 - 30 µg/L	< 5 µg/L	NA	Frankenburger et al. 2004

Note: MIW - mining influenced water.
NA - information is unavailable
[1] - BCR operating costs assume 2 hours of labor per month at $60/hr for system operation and maintenance.

Mine Design for In-Situ Control of Selenium and Nitrate

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Abstract

This paper describes an approach for designing and developing a coal project for in-situ control of selenium and nitrate in contact water from the mine as an alternative to engineered water treatment plants. The design integrates water management, pit design and sequencing such that completed open pits can be backfilled and used as in-situ bioreactors for attenuating selenium and nitrate. The attenuation process is well established and proven at different scales but the hydraulic design of the backfilled pit and operational control of carbon dosing will have to be developed through phased field tests carried out concurrently with full-scale design. Results of the initial on-site pilot test are presented.

Keywords: coal, selenium, nitrate, in-situ, biological, treatment, suboxic, anaerobic

Introduction

Selenium (Se) is a naturally occurring substance and an essential element required for the health of humans, animals, and some plants. However, selenium has also become a contaminant of potential concern throughout the world. Mining, power generation and agriculture are among the largest emitters of selenium world-wide (Lemly 2004).

Selenium management at mining operations typically involves:

- Source control measures to limit release from oxidizing sulphide minerals such as subaqueous disposal and low permeability covers; and
- Interception and collection of contact water for passive or active selenium water treatment.

Selenium concentrations in mine water are project specific and vary widely. Concentrations can approach 1 mg/L at sites with pronounced selenium leaching (Dockrey 2012). In comparison, the freshwater ambient chronic water quality criterion for selenium recommended by the United States Environmental Protection Agency is 0.0031 mg/L for lotic (flowing) waters (US EPA 2016). In some cases, the recommended water quality criterion for selenium could therefore be exceeded if seepage or discharge from a mine exceeds 0.5% of the total streamflow. The orders-of-magnitude difference between selenium concentrations in mine water and receiving water quality criteria means that some mining projects are required to achieve near-complete capture and treatment of all mine water from a project area to comply with instream selenium criteria.

Over the last three decades, the growing understanding of ecological effects that can be caused by selenium in aquatic environments has prompted industry to develop better and more reliable selenium water treatment technologies. Historically, selenium water treatment processes have relied on chemical reduction of selenate to selenite or elemental selenium using reducing agents such as zero-valent iron followed by ferric-coprecipitation for removal of residual selenite (CH2M Hill 2013). However, chemical processes are costly and tend to increase concentrations of dissolved components, which must subsequently be removed. In addition, the processes were not able to reliably achieve effluent concentrations required by discharge permits (Golder 2009). In the 1990s, several selenium water treatment technologies that rely on biological reduction for removal of selenium were developed and have been adopted by the mining industry (CH2M Hill 2013).

Biological removal of selenium from water relies on anaerobic microorganisms, which reduce oxidized forms of selenium, such as selenate, to more reduced forms (selenite) or to elemental selenium, which can

then be removed from water by co-precipitation or precipitation. The process occurs naturally in wetlands and in suboxic lake sediments and has also been observed to occur in backfilled open pits at a closed coal mine (de Souza 1999, Bianchin 2013). The biological water treatment process also removes nitrate, which is another water quality parameter of potential concern for the mining industry. Nitrate in mine water is primarily due to dissolution of ammonium nitrate-based explosive residuals.

Although biological treatment has been proven on an industrial scale, the treatment process is relatively costly to implement and operate, particularly since water treatment often is required in-perpetuity. Lower cost treatment options, such as gravel reactors or in-pit anaerobic biological treatment, are emerging as real alternatives to mechanized treatment plants. In addition to lower cost, the in-situ treatment systems may also improve treatment performance.

This paper presents the approach used for integrating mine design and in-situ selenium management for the proposed Grassy Mountain Coal Project located in Southern Alberta and discusses design and operational control of in-situ treatment systems.

Methods

Geochemical characterization of the coal deposit and host rock at the Grassy Mountain Coal Project identified oxidizable and leachable selenium and a high likelihood of selenium concentrations exceeding water quality targets in waste rock seepage at the proposed mine. Located on a mountain ridge near the headwaters of Blairmore Creek and Gold Creek, the Project area occupies a sizable portion of the local catchment areas (Figure 1). Therefore, the capacity of the creeks to assimilate mine water discharge is limited. From the inception of the Project, it was clear that efficient collection of mine water and selenium water treatment would be required to meet receiving water quality guidelines in the downstream environment.

In a traditional approach to mine design, mine engineers are tasked with development, and later optimization, of an economic mine design that includes an open pit or under-

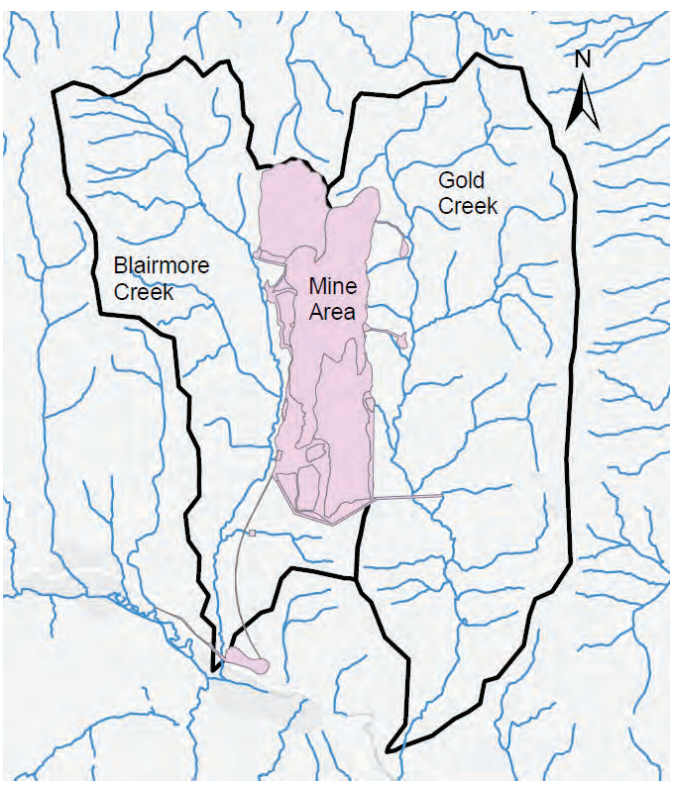


Figure 1 Ultimate Mine Footprint and Adjacent Catchments

ground mine development schedule and design of waste rock storage areas. Water management features are then designed to accommodate the most economic mine design. However, the high efficiency capture and water treatment required to manage selenium for the Project meant that the mine design had to accommodate water collection and water treatment for the project to be feasible. Selenium mitigation measures that were incorporated in the mine design included:

- A mining sequence that allowed for timely conversion of mined-out open pits to saturated in-situ anaerobic bioreactors to allow for attenuation of selenium and nitrate.
- Maximizing in-pit placement of waste rock to facilitate seepage capture.
- Design of ex-pit waste rock area foundations for seepage collection.

The conversion of mined-out open pits to anaerobic bioreactors for removal of selenium and nitrate is the key aspect of the proposed mine design and water management approach and therefore the focus of the discussion in this paper. Suboxic conditions in pit water promote the conversion of soluble selenate ions (SeO_4^{2-}) to selenite (SeO_3^{2}) or elemental selenium metal (Se^0). Selenite is less soluble and tends to adsorb to mineral surfaces. Elemental selenium is insoluble. Therefore, the conversion of selenate causes the reduced selenium species to become attenuated. Nitrate (NO_3^-) is reduced to nitrogen gas (N_2) (Martin 2009). A key requirement is the presence of dissolved organic carbon that provides electrons for these processes. The carbon in turn is oxidized to carbonate as bicarbonate and dissolved carbon dioxide.

In-situ attenuation of selenium using suboxic or anaerobic biological processes is well researched and has been demonstrated at different scales in various configurations. Luek (2012), for example, describes a pilot-scale biological reactor with a media comprising mulch, manure and gravel. In-situ biological treatment was used in a batch configuration for removal of dissolved selenium and uranium from a pit lake at the Sweetwater Mine in Wyoming in 1999 (Paulson 2004). However, there are to date no publicised examples of backfilled open pits that have been specifically designed and operated as biological reactors for removal of selenium. For the Grassy Mountain Project, the approach was therefore to develop an understanding of the process kinetics and process control strategy in parallel with the mine development by implementing on-site field trials at increasing scales.

Conversion of the open pits to anaerobic bioreactors involves some of the same design considerations as in mechanical reactor design used for active water treatment plants:

- At least one pit with sufficient hydraulic retention time must be available for water treatment early in the mine life by the time selenium and nitrate impacted mine water is produced on site.
- Subsequent open pits should ideally be hydraulically connected to the downstream-most open pit such that selenium and nitrate treatment can occur in a series of in-situ pit reactors with a single discharge point.
- The combined volume of the in-situ bioreactor (i.e. open pits backfilled with waste rock) must provide sufficient residence time for complete selenium and nitrate attenuation to occur for a range of flow and temperature conditions.
- Placement of backfilled waste rock should be planned in a way that would facilitate hydraulic control of mine water passing through the in-situ bioreactors in the open pits.

Suboxic conditions required for the attenuation process are generated by microorganisms that consume oxygen and other electron acceptors such as nitrate as they metabolize carbon. Therefore, unless existing concentrations of dissolved organic carbon are sufficient, addition of organic carbon and nutrients in the mine water is required for the process to work and is also the main process variable for controlling in-situ bioreactors. Molasses and methanol are readily available and relatively low-cost sources of organic carbon that have been used in similar in-situ treatment applications and in active water treatment plants (Martin 2009). The dose of organic carbon required depends primarily on the concentration of dissolved oxygen and nitrate in the mine water. Approximately 3 g

of methanol is stoichiometrically required to attenuate 1 g of nitrate.

The rate at which suboxic conditions develop determines the time required for attenuation and consequently the hydraulic residence time required for the in-situ bioreactor. In an active water treatment plant, the residence time required is in the order of hours. The residence time required to achieve complete attenuation of selenium and nitrate in an in-situ bioreactor at the Grassy Mountain site is unknown; however, case studies of full-scale treatment systems using similar processes indicate that the hydraulic residence time required is on the order of a few weeks (Poulson 2004, Martin 2009).

Implementation of in-situ bioreactors requires an understanding of the process stoichiometry, kinetics and performance response to varying carbon types and doses. The goal of the first small-scale field trial was to evaluate these factors.

The first field test was conducted in the summer of 2017 and was intended as simple, small-scale reactors that would yield basic information on the stoichiometry and kinetics of the treatment process for a limited set of conditions. Another objective was to establish and test operating and monitoring procedures that could be transferred to subsequent larger-scale tests and eventually to full-scale operations.

Seven 45-gallon (170 Litre (L)) plastic barrels were used as small-scale reactors. Each barrel was filled with coarse waste rock and coal reject from historical mining activities in the project area. No organic material or microbial seed was added. A 1,000 L tote elevated above the barrels was used as a feed tank for the test. Feed water flowed by gravity through the test barrels. Feed flow rates were controlled by adjusting drip valves installed at the inlet on each barrel. The test setup required no power.

The barrel setup was first tested hydraulically by feeding a sodium chloride tracer solution through each barrel and monitoring the conductivity of the effluent. The tracer test demonstrated that feed flow could be controlled reliably to yield a hydraulic retention time of approximately two weeks. Reactive tests were conducted next. The feed water tote was filled with water and charged with nitrate (80 mg/L as nitrate-N) and selenate (1.3 mg/L as sodium selenate). Pails with dissolved carbon or water (for the controls) were connected to the feed water inlet of each barrel. The flow of dissolved carbon or water from the pails were also controlled by drip valves. Flow from the feed tote and from the carbon (or water) totes were approximately equal, which resulted in a combined feed with approximately 40 mg/L nitrate-N and 0.650 mg/L of selenium.

Pails containing carbon solution were replaced weekly to prevent degradation of the organic carbon in the pail. Each barrel was equipped with three inlet ports, which allowed operators to switch ports in the event biofouling blocked the flow of influent – a common problem in fixed-bed bioreactors.

Table 1 shows the test conditions used for the seven barrels. The control barrel (1) was filled with waste rock and received feed from the tote but no carbon (only water) was added to the pail. Barrels 2 through 5 received low (75% of stoichiometric demand) or high (110% of stoichiometric demand) doses of either methanol or a 50:50 mixture of methanol and molasses (by weight). In barrels 6 and 7, 5% and 20% the waste rock had been replaced by coarse coal material. The purpose of these barrel tests was to evaluate whether organic carbon leaching from coal would be sufficient to generate suboxic conditions.

Results of the reactive test are illustrated in Figure 2. Chloride concentrations in the barrel effluent (residual from the tracer test) decreased relatively uniformly for all barrels, except for the control barrel, which saw higher feed flow from the feed tote than the other six barrels. Selenium concentrations in the effluent from the four barrels that were dosed with methanol or methanol and molasses were reduced to less than 0.015 mg/L compared to a concentration of 0.200 mg/L in the control after approximately two weeks. The barrels with coal reject (6 and 7) appeared to show some attenuation when compared to the control barrel (1). However, a concentration increase in the control barrel was considered a consequence of the greater rate of flow from the feed tote as evidenced by the greater nitrate and selenium concentration. When normalized for flow, the reactive response of the coal reject barrels is the same as

the response of the control barrel. Nitrate-N concentrations in the barrels dosed with carbon were less than 0.1 mg/L after two weeks compared to approximately 20 mg/L in the control barrels. The dose or type of organic carbon did not appear to affect the rate or extent of degradation.

Table 1 *Test Barrel Carbon Type and Dose*

Barrel #	Carbon Type	Carbon Dose
1	Control	None
2	Methanol	Carbon 1, Low Dose
3	Methanol	Carbon 1, High Dose
4	Methanol + Molasses	Carbon 2, Low Dose
5	Methanol + Molasses	Carbon 2, High Dose
6	Coal Reject	5% of Barrel Volume
7	Coal Reject	20% of Barrel Volume

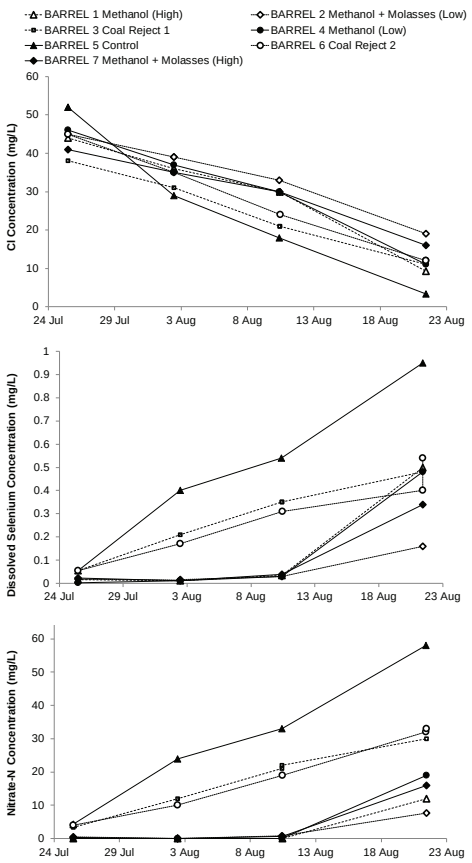


Figure 2 *Chloride, Diss. Selenium and Nitrate-N Concentrations in Test Barrel Effluent*

Attenuation of selenium and nitrate was sustained in the barrels for approximately two weeks after which concentrations of selenium and nitrate rebounded. This occurred due to a loss of carbon in the feed solution. Despite efforts to prevent carbon degradation in the pails with carbon solution, a biofilm formed on the inside of the tubing that supplied carbon to the barrels. The biofilm likely metabolized the readily degradable carbon before it reached the barrel inlet. This unintended loss of organic carbon illustrates the importance of maintaining anaerobic conditions in the in-situ bioreactors. Subsequent, larger-scale tests will use 100% methanol as a carbon source, which in its pure form is toxic to microorganisms, to circumvent this problem.

The barrel test demonstrated that attenuation of selenium and nitrate can be accomplished in a simple flow-through reactor using a rock media and a simple organic carbon source. The test also validated the operability of the bioreactor system, demonstrated that two weeks of resident time is a reasonable starting point for future tests and showed the importance of maintaining sufficient carbon supply to sustain suboxic conditions. Larger-scale field-tests are required to evaluate process kinetics and control at a wider range of temperatures and residence times.

Conclusions

Selenium management for the Grassy Mountain Coal Project requires that mine water capture and treatment considerations are integrated in the mine design. The conversion of mined-out open pits to anaerobic bioreactors for attenuation of selenium and nitrate is the key aspect of the proposed mine design and water management approach. The attenuation process is well established and proven at different scale but the hydraulic design of the backfilled pit and operational control of carbon dosing will have to be developed through phased field tests carried out concurrently with full-scale design.

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SELENIUM RELEASE FROM COAL MINES IN THE ELK VALLEY, AND TREATMENT R&D PLANS

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ABSTRACT

Teck Coal Limited operates five coal mines in the Elk River Valley in southeastern British Columbia. Selenium concentrations were found to be elevated in some mine-influenced waters in the area. The major sources of selenium are the large rock spoils present in the drainage area. Removal of selenium by water treatment is being researched to decrease loadings on the Elk River. The focus of the treatment program is biological reduction and volatilization methods, which are more effective for selenium removal in high flow, multiple discharge and low concentration scenarios typical at the sites. Bench-scale testing of active, passive and hybrid bioreactors is currently underway at Teck's Applied Research and Technology (ART) research centre in Trail, British Columbia. Six active bioreactors were operated using a variety of parameters for eight months, achieving up to 98% selenium removal. Mobilization experiments were also conducted in humidity cells to determine the potential for selenium to leach from sediment samples. Results indicated that selenium was being mobilized from sediment at some of the sites tested. Future testing will continue in the future using a variety of methods.

KEY WORDS: Water treatment, biological removal, sediments

INTRODUCTION

Selenium mobilization in coal operations occurs due to oxidative processes. The mean Elk River selenium concentration has been increasing over time downstream from Elk River Valley mines. The Elk Valley Selenium Task Force (EVSTF) is a multi-government agency/industry scientific team advising and overseeing selenium-related activities at the Teck's coal operations in British Columbia. These operations are located in the Elk River Valley, in southeastern British Columbia. Teck Coal Limited is owned by Teck Resources Ltd. As part of ongoing discussions with the EVSTF, Teck is proactively researching selenium removal methods (EVSTF, 2008). There are three management approaches for control of selenium: prevention of release, reported in the literature to be effective (Sobolowski, 2005); control of selenium in the environment; and, the third is water treatment (Chapman et al., 2009). Although all three approaches are being actively investigated by Teck, this paper is focused on research and development of water treatment alternatives and mobilization of selenium from settling pond sediments.

Selenium removal technologies have been reviewed (Gusek et al., 2008; NSMP, 2007; MSE, 2001). Microbial-based selenium removal technologies were identified as being applicable to the Elk Valley coal operations (Sobolowski, 2005). Microbial methods to decrease selenium concentrations in Elkview Operations water, investigated at ART on a laboratory scale, were effective in decreasing the selenium concentrations over a range of conditions that could be encountered in the field. Indigenous microbial selenate and selenite reducers were identified in Elkview Lagoon D sediments (Siddique, 2007). The current work evaluates active biological treatment methods to remove selenium from Teck Coal operations' streams.

STREAM IDENTIFICATION

Teck Coal has 5 coal operations in British Columbia and each operation exhibits complicated water drainage systems. The streams are generally characterized as exhibiting high flows and contain low concentrations of selenium. The main form of selenium in the streams is selenate, which is a difficult form of selenium to remove due to its higher oxidation state (Frankenberger et al., 1998).

The major sources of selenium from operations are the waste rock dumps present in the drainage area. Solution-based biological treatment methods include passive bioreactors, active bioreactors, hybrid systems, anaerobic and aerobic wetlands and combinations of these systems. Biological treatment methods were selected for evaluation due to their effectiveness, general ease of operation, and ability to concentrate the selenium into selenium-containing residues. Volatilization is another biologically based selenium removal method which is being investigated separately (Martin et al., 2008).

Elkview Operations' Bodie Creek was selected as the candidate stream to evaluate biological selenium removal based on the following key parameters:

- Stream flow;
- Stream selenium concentration and estimated loading;
- Stream location; and
- Availability of infrastructure for treatment evaluation on a larger scale.

SELENIUM REMOVAL

Selenium removal from Elkview Operations Bodie Creek water was evaluated using active biological treatment over a number of years on a laboratory scale. Selenium removal from Bodie Creek water was microbially mediated and occurred on a variety of support materials. The best selenium removal occurred with the reactor operating in an up-flow configuration. Ethanol was used as the nutrient in these investigations.

Experimental

Four 2-m columns and two 1-m columns (7.6 cm in diameter) were used in the experiments. The columns were constructed from clear PVC. The columns operated in an up-flow configuration and were filled with approximately 11 kg of support material. The fine coal rejects known as high frequency screen oversize (HFSO), had a particle size of ~1 mm and were used as the support material. Water from Bodie Creek was collected by Elkview personnel during the test program.

Each column was inoculated using indigenous microorganisms in a lactate medium before water treatment started. The ratio of chemical oxygen demand to sulphate concentration (COD/SO_4^{2-}) in the column feed was important for establishing reducing conditions in the columns. Column shutdown was mainly determined by plugging issues.

Solution parameters such as oxidation-reduction potential (ORP), pH, temperature and dissolved oxygen concentrations were measured on the column overflow solutions. Electrode potentials were calculated relative to a saturated silver chloride/silver electrode and converted to E_h. Solutions were also assayed weekly for dissolved selenium, sulphur, calcium, magnesium and barium. Sulphide concentrations were determined periodically with a Hach meter. The experimental setup is shown in Figure 1.

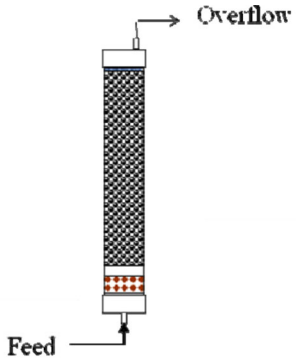


Figure 1. Column setup for up-flow experiments.

Column Operation

Six columns were operated for a maximum duration of 239 days. During this time period different operating strategies were conducted such as varying the operating temperature, feed rate and nutrient and sulphate addition rates. Table 1 illustrates the operating conditions for each of the columns.

Table 1. Operating conditions for columns.

Column	Support Material	Inoculation	Flow Rate $m^3/(m^2d)$	Column m	Operating Day
1	HFSO	Slow flow through	1.56	2	239
2	HFSO	Medium flow through	3.13	2	217
3	HFSO	Static (biosolids culture)	1.56 initial 6.26 final	2	159
4	HFSO	Static (biosolids culture)	1.56	2	138
5	HFSO biosolids /gravel layer	Static (lactate media)	1.56	1	62
6	HFSO layered with gravel	Static (biosolids culture)	1.56	1	166

Reducing conditions are required for optimum selenium removal. A convenient way to monitor reducing conditions in the columns is ORP. Figure 2 represents E_h measurements taken over the operating period for Columns 1 and 2. The E_h readings became more negative as reducing conditions were established in the columns. The spikes observed in Figure 2 can be attributed to operation upsets, or changes in operating parameters, such as flow rate or nutrient concentration.

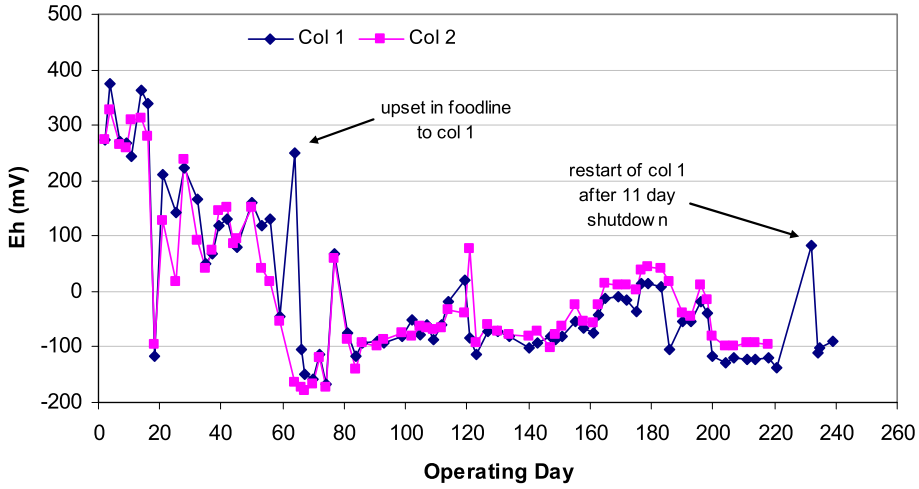


Figure 2. ORP in column overflow solutions during the operating period.

Selenium Removal

The feed and overflow selenium concentrations in Columns 1 and 2 are shown in Figure 3. Selenium concentrations in the Bodie Creek water ranged from 27 - 140 µg/L, averaging 61 µg/L. High selenium removals were generally obtained.

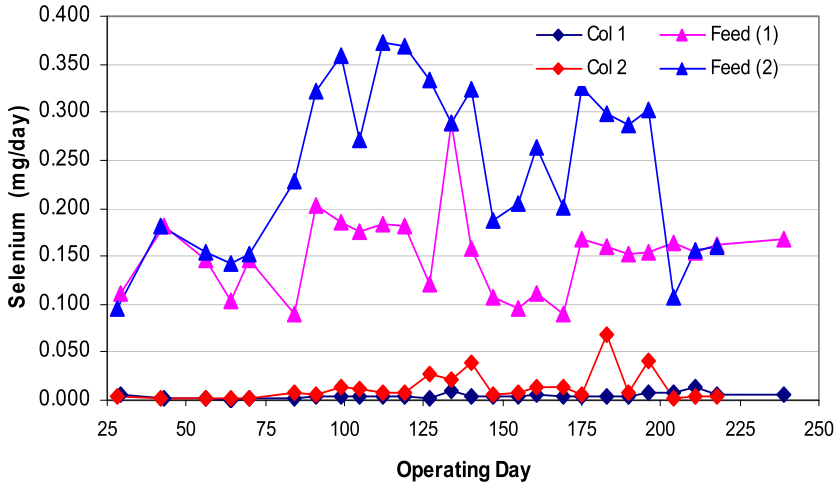


Figure 3. Selenium concentrations in column overflow during operating period.

Table 2 illustrates the effect of the flow rate on the selenium removal for Columns 1 – 4. Columns 5 and 6 plugged early and were decommissioned. The average selenium removal from the columns operating at a specific flow of 1.56 $m^3/(m^2d)$ was 97%. Increasing the specific flow to 3.13 $m^3/(m^2d)$ slightly decreased selenium removal to 94%. Column 3 was operated at 1.56 $m^3/(m^2d)$ until day 138 when the flow rate was increased to 6.26 $m^3/(m^2d)$, and additional sulphate was discontinued. The selenium removal for these two flow rates was 97% and 42%, respectively. While Columns 1 and 2 ran at 1.56 and 3.13 $m^3/(m^2d)$, the E_h measurements were similar (-100 mV). Increasing the flow rate to 6.26 $m^3/(m^2d)$ in Column 3 caused the E_h to rise dramatically.

Table 2. Comparison of selenium removal at different flow rates*.

Column	Test Descriptor	Flow Rate Range (m^3/m^2d)	Average Flow Rate (m^3/m^2d)	Average Selenium Removal (%)
1	5 x	0.06 – 2.3	1.2	97.1
2	10 x	0.06 – 3.7	2.2	93.7
3	5 x	0.88 – 2.6	1.4	97.6
	20 x	4.4 – 7.2	5.5	42.4
4	5 x	1.1 – 2.6	1.5	97.4

* Ethanol feed concentration 10 mmol/L.

After 142 days of operation, Column 2 showed signs of plugging. On day 200, the flow rate in this column was reduced from 3.13 m^3/m^2d to 1.56 m^3/m^2d. Plugging issues continued and the column was shut down on day 217.

Figure 4 represents the effects of changes in nutrient concentration on selenium and sulphate removals. When the feed ethanol concentration was decreased to 5 mM, selenium removal decreased slightly; however, sulphate removal decreased significantly. Improvement in the selenium removal selectivity was also observed when the specific feed flow rates were increased from 1.56 - 3.13 $m^3/(m^2d)$ to 6.26 $m^3/(m^2d)$. This result may reflect the relative rates of selenate and sulphate reduction under these conditions.

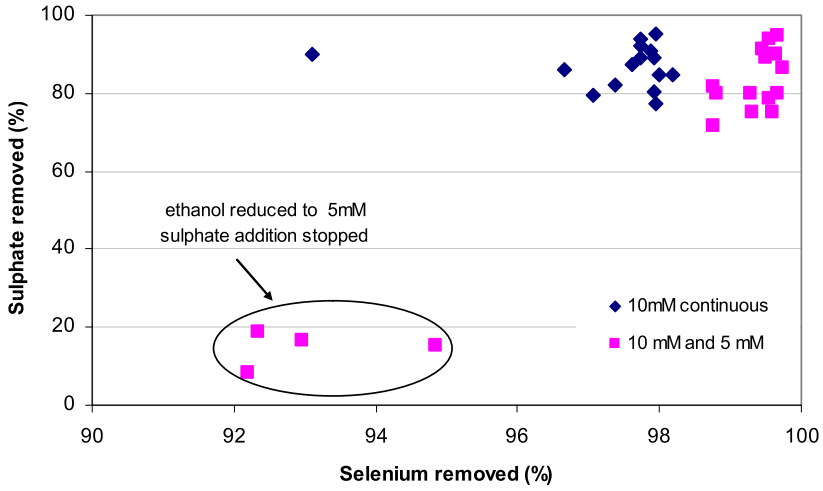


Figure 4. Effect of changing parameters on sulphate and selenium removal.

Post Mortem Analysis

A scanning electron microscope (SEM) investigation identified minerals present in the HFSO and from the decommissioned columns. These SEM micrographs are shown in Figure 5. Selenium was not detected by SEM.

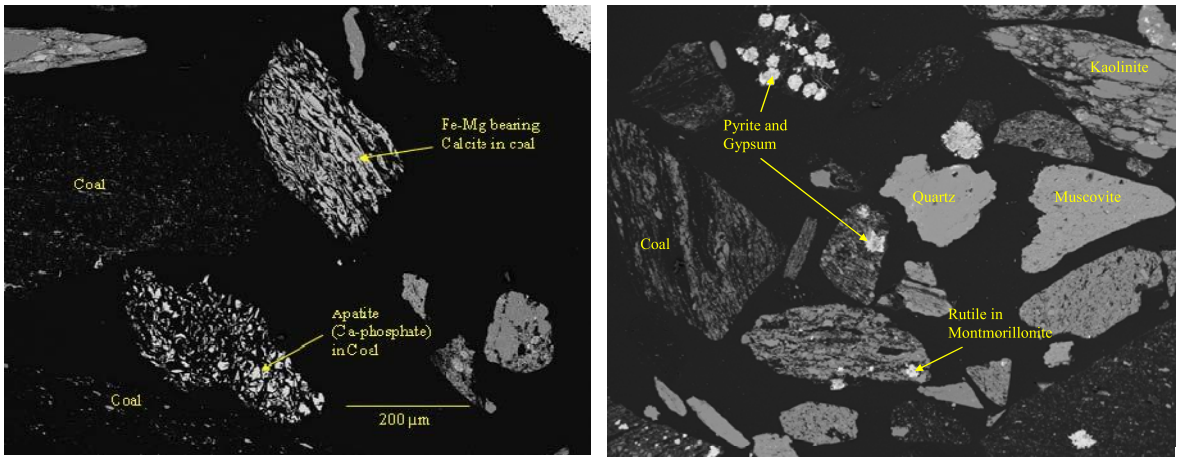


Figure 5. SEM study of support material before (left) and after (right) experiment.

A decrease in the pore volume of approximately 20% inhibited solution flow through the columns. The source of the plugging was largely inorganic, with pyrite, siderite, gypsum, goethite and elemental sulphur being identified as secondary minerals. Selenium was not taken up by the HFSO in the absence of micro-organisms.

SELENIUM MOBILIZATION

The ability of selenium to mobilize from decant sediments was investigated in laboratory-scale experiments. Sediments from decant ponds at Coal Mountain (Corbin Pond) and Elkview (Bodie Creek) Operations were investigated in this study. The experimental setup is shown in Figure 6.

Cells were set up using Büchner funnels. Irrigation of the sediments occurred via perforated tubing attached to the upper funnel with caulking. A filter paper was placed in the lower funnel with a 1.5-cm-thick layer of washed and weighed gravel on top. The gravel simulated coarse material in the waste rock dumps. A 1.5-cm-thick layer of weighed sediment was then placed on top of the gravel.

Water was recirculated to simulate percolation through many layers in a waste rock dump (Recirculation). The second leach test (No recirculation) was set up the same as the first except the water dispersed in the humidity cells originated from one common reservoir and was collected. The irrigation rate was based on local precipitation data for Sparwood, British Columbia. Selenium leaching results are presented in Figure 7.

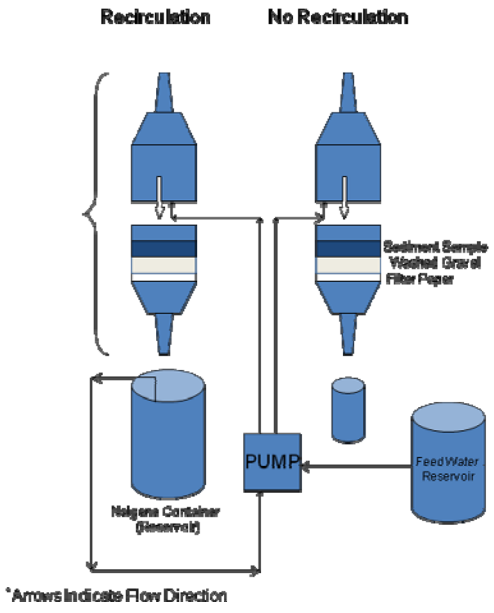


Figure 6. Leach test with recirculation (left) and no recirculation (right).

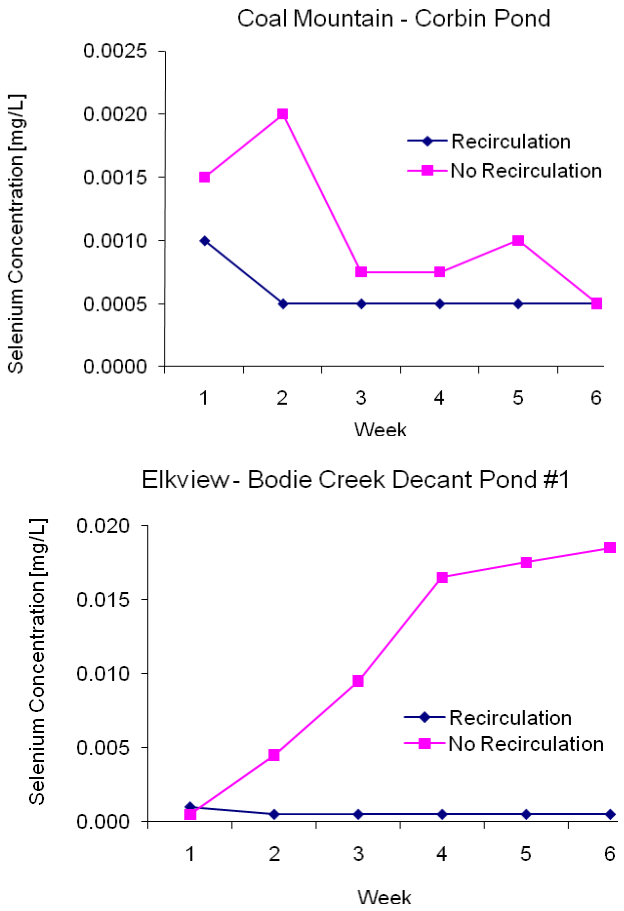


Figure 7. Results of leaching experiments from Corbin Pond (top), Bodie Creek (bottom).

The initial selenium concentrations in the Corbin Pond and Bodie Creek Decant sediments were 0.94 and 11.3 mg/kg dry weight, respectively. The Corbin Pond sediment samples were generally coarser (9.3 – 1000 µm) than the Bodie Creek Decant samples (19 – 29 µm). The leach test with solution recirculation showed no significant changes in the selenium concentration for Corbin Pond sediment and the Bodie Creek Decant Pond #1 sediment after the first week. In both solution recirculation tests, week 1 leachate selenium concentrations were 0.001 mg/L and were <0.001 mg/L in the remaining test weeks. These results indicate that solution recirculation inhibits selenium mobilization compared to tests without recirculation.

In tests with no recirculation, the selenium release from Corbin Pond sediment occurred via a flushing mechanism where selenium may be present in a soluble form. Selenium release from Bodie Creek Decant Pond #1 indicated a leaching process was occurring from the form of the curves in Figure 7. Over time this release would decrease as the selenium was depleted. Placement of the sediments in such a way to avoid direct release of selenium to the water shed is recommended.

CONCLUSIONS

The following conclusions were reached from this study:

- A target stream was identified for evaluating an active biological selenium removal system by considering loading. The criteria for identifying treatment technologies and streams have subsequently been extended to include all of Teck's British Columbian coal operations, a wider range of treatment options and streams for each operation.
- A laboratory-based active biological water treatment system successfully demonstrated selenium removal under a variety of conditions for up to 239 days of continuous operation. The ORP was an important control parameter for the selenium removal system. Selenium removal up to 98% was observed in these experiments.
- Plugging of the columns occurred as a result of inorganic solids buildup, impeding column permeability. A coarser support material is suggested for future studies. Some selectivity in selenium removal over sulphate removal was observed by limiting nutrient concentrations and increasing specific flow rates.
- Decant pond sediments released selenium from aerobic processes in laboratory-scale experiments. The selenium release occurred via flushing or from leaching.

FUTURE WORK

Biological treatment methods show promise for selenium removal at Teck's coal operations. The concepts require evaluation at a larger scale onsite and for an extended period of time. The use of locally available materials is desirable in the treatment systems. An integrated laboratory and field program is already underway to determine the feasibility of various treatment methods as part of a larger selenium study.

The current ART-based laboratory program is evaluating active and passive bioreactor systems in addition to chemical methods for selenium removal. Locally available materials are being used as the support/nutrient system. Water from two of Teck's coal operations will be tested to determine the general applicability of the methods. The laboratory experiments are on a 20-L scale. Experiments will be run to determine the influence of startup and operating variables on selenium removal.

ACKNOWLEDGEMENTS

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Column Tests of Selenium Biomineralization in Support of Saturated Rockfill Design

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Abstract Biological reduction of oxidized selenium to less mobile forms within mine waste rock can reduce the cost of protecting water quality. Batch and column studies of native microbial capacity to reduce Se in waste rock show that oxygen and nitrate inhibition is overcome via carbon addition. Biofilm in aerobic columns showed 50 to 99% nitrate reduction followed by 40 to 95% selenium removal; selenium was sequestered as selenite. Microaerophilic nitrate and selenate removal increased to 75 and 98%, with 25% sulfate removal. Suboxic denitrification and selenium reduction to elemental selenium was most rapid and efficient, as high as 99%.

Key words biological reduction of selenium, column tests, biomineralization.

Introduction

Enviromin, Inc. and the Center for Biofilm Engineering (CBE) at Montana State University have jointly conducted column studies of selenium and nitrate reduction in saturated rock fills (SRF) on behalf of Teck Resources Limited (Teck). Waste rock is produced during mining and can release selenium into the environment upon exposure to water and air. Selenium is recognized as an "essential toxin," as it is an essential nutrient which has potential to be toxic with increased concentration (Lenz and Lens, 2008). Saturated backfills have been identified as a priority research target for *in situ* reduction of selenium from mine-affected water at Teck operations.

The oxygen-dependent reduction of nitrate, selenium, and other electron acceptors common in mine waste are illustrated in the conceptual model shown in Figure 1. Nitrate from blasting during the mining process can potentially serve as an electron acceptor coupled to the oxidation of reduced iron sulfide minerals that contain selenium, and both oxygen and nitrate may inhibit selenium reduction by competing as electron acceptors.

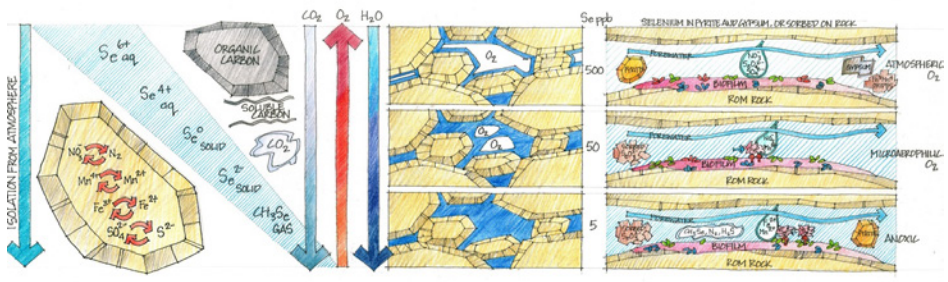


Figure 1 *Conceptual Model of Selenium Biogeochemistry for Waste Rock Deposits.*

Decreased solubility of Se resulting from incremental Se reduction. Elemental cycling of N, Mn, Fe, S, and C dominates the biogeochemistry. As sediment becomes progressively saturated with water and oxygen content decreases, and carbon dioxide accumulates. Shifts in the microbial ecology occur, as shown at right, with the mixed community of aerobic (red), facultative (green) and anaerobic (blue) microbes in the aerobic biofilm transitioning to a community of facultative and obligate anaerobes under anoxic conditions. Changes in solutes, pore gases, and minerals in equilibrium under progressively reduced conditions are illustrated. Selenium concentration is shown to change, as a rough approximation, by an order of magnitude between each condition shown.

Column-based rate experiments were used to explore biogeochemical strategies for decreasing selenium and nitrate release from waste rock facilities. Under realistic flow conditions within saturated fills, oxygen and growth substrate were varied to assess the rate and extent of selenium and nitrate reduction and the associated microbial activity (see Hwang et al. 2017, this volume). This work was conducted in support of pilot scale demonstration tests of this innovative *in situ* biological treatment technology (see Mayer and Yost 2017, this volume).

Methods

Six 3.7 L column reactors packed with waste rock were run in an upflow configuration under aerobic, microaerobic, and suboxic conditions, respectively; 18 columns were run in total. For each oxygen exposure condition, experiments were run in duplicate using three growth substrates: no-added carbon, glycerol, and methanol. Dissolved oxygen was controlled in the influent groundwater by sparging with nitrogen gas to achieve microaerophilic and suboxic conditions, respectively. Influent groundwater was amended to a concentration of 1.0 mg/L Se-SeO_4 (1.81 mg/L selenate) with NO_3-N between 1 and 10 mg/L depending upon the experiment.

Experiments were conducted until desired biogeochemical conditions were attained, generally within 60 days. Tests were designed to represent realistic conditions for multiple "stream tubes" inside saturated backfilled mine panels, as shown in Figure 2. These column experiments were conducted under darkness and were temperature-controlled at 10°C (+/- 1 ˚C), with an influent flow rate of 0.85 mL/min. These conditions were intended to simulate conditions relevant to the mine site.

Changes in various conditions including T (°C), pH, oxidation reduction potential (ORP, mV), concentrations of dissolved oxygen (DO), total organic carbon (TOC), dissolved (non-purgeable) organic carbon (NPOC), total inorganic carbon (TIC), total Se, selenate (SeO_4^{2-}), selenite (SeO_3^{2-}), nitrate (NO_3^-), nitrite (NO_2^-), sulfate (SO_4^{2-}), sulfide (S^{2-}) and dissolved metal(loid)s (As, Sb, Al, Ba, Be, Ca, Cd, Cr, Cu, Co, Fe, Mg, Na, Mn, Mo, K, Ni, Ag, Pb, U, V, Zn) were measured using relevant probe-based, ion chromatography and/or ICP-MS methods. Furthermore, periodic microbial cell counts were conducted. The microbial community and biomineralization was characterized in samples from each column; microbial community characterization results are presented by Hwang, et al. this volume.

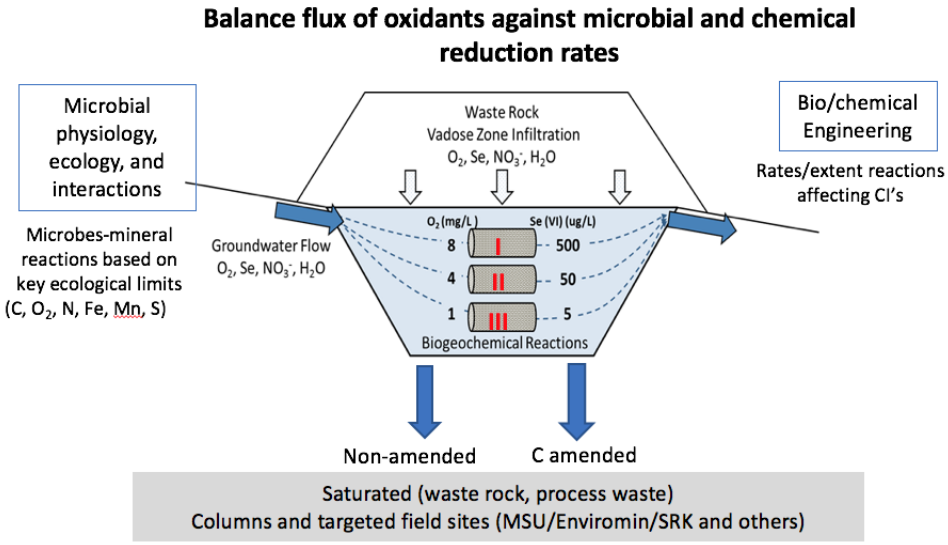


Figure 2 *Experimental Model of Saturated Fill Biogeochemistry*

Stream tubes as envisioned within a saturated fill environment, with oxygen conditions changing with depth as represented by the three phases of experimentation.

Results

Aerobic Column Tests

The aerobic biofilm in no–carbon control columns reduced less than 80% of nitrate and only 20% of selenium. In the carbon-amended columns, following a 20-day acclimation period, up to 99% of nitrate was reduced, with 40 and 95% selenium removal, despite the presence of moderate levels of oxygen. The methanol-amended column showed better nitrate and selenate removal than the glycerol-treated column. Consistent with the observed nitrate reduction during the aerobic tests, low nitrite concentrations were measured in the columns by day 54. Carbon was detected in outflow from the glycerol and methanol-treated columns, but was very low from the no-carbon control. The number of biological cells in the effluent increased when carbon was first introduced into the columns and then declined as the biofilm became established. No sulfate reduction was observed.

Microaerophilic Column Tests

The microaerobic biofilm in the no–carbon control columns was more efficient at nitrate and selenium reduction than under aerobic conditions: ultimately, as much as 95% of nitrate and 80% of selenate was removed after 30 days. In the carbon-amended columns, following a 21-day acclimation period at 10°C, up to 99% of nitrate was reduced with over 95% selenium removal. Nitrite was detected initially, and then intermittently following a period of denitrification.

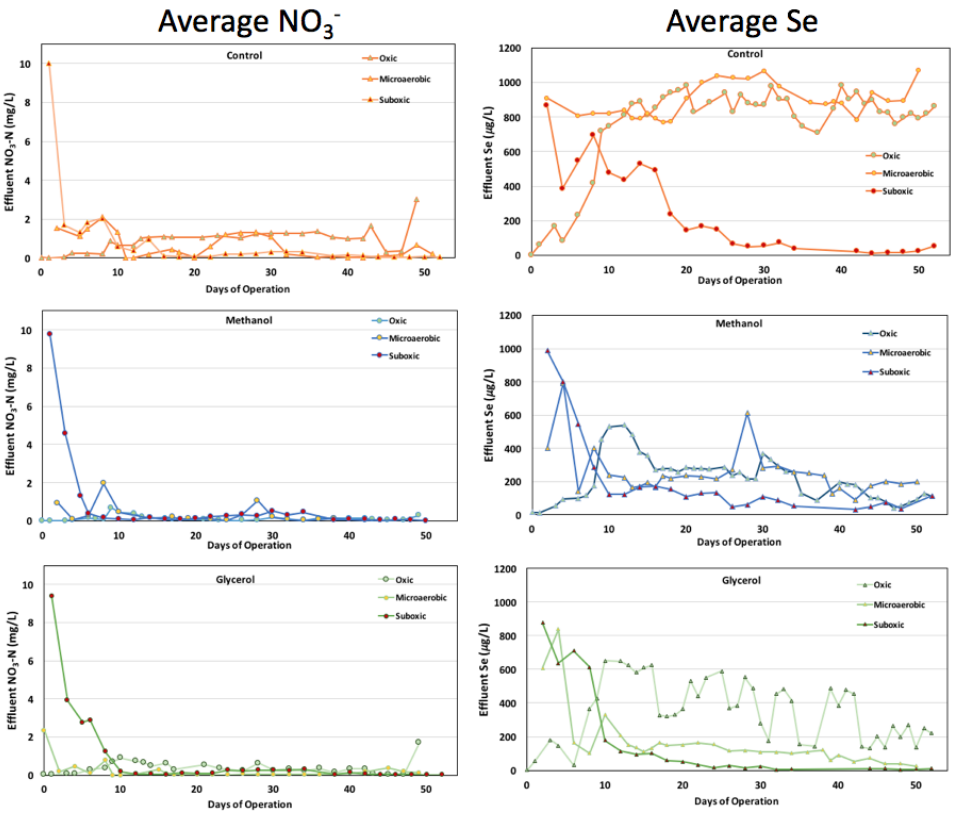


Figure 3 *Average nitrate and selenium for the three oxygen treatments and three carbon treatments*

Carbon was released by no-carbon control columns at low levels, while carbon was released by the glycerol and methanol columns at higher concentrations. None of the columns were carbon limited. Minor (up to 25%) sulfate reduction was observed and the no-carbon control columns showed an ability to release carbon extracted from carbonaceous rock when oxygen was low conditions. Selenite was detected in low concentrations following reduction of selenate.

Suboxic Column Tests

The suboxic biofilms in no-carbon control columns achieved nitrate and selenium reduction more slowly than in the glycerol-treated columns, but ultimately, both reduced most nitrate and removed more than 95% of selenate. As in the microaerobic columns, the glycerol-treated column more efficiently reduced nitrate and selenium to low concentrations than the methanol-treated column, which showed between 80-90% efficiency. Significantly more sulfate reduction was observed in Phase III, but little sulfide was measured; this may reflect the precipitation of sulfide minerals. Approximately equal masses of selenite and elemental selenium were detected following reduction of selenate.

Conclusions

This study characterized the conditions under which native microbial communities promote nitrate and selenium reduction/attenuation in saturated column flow reactors. Results are summarized in Figure 3. The microbial communities associated with biomineralization of N, Fe, Se and S have been identified and vary in rate and efficiency in response to changes in oxygen, nitrate, and carbon availability (see Hwang et al. this volume). These results were used to address the following two questions that inform the design and operation of pilot and full scale SRF facilities.

1. **How do varied dissolved oxygen levels influence selenium reduction rates?** As dissolved oxygen drops and becomes more consistent, nitrate and selenium reduction is initiated more rapidly and becomes more efficient in removing mass from solution. Review of Figure 3 shows that denitrification happens more readily than selenium reduction. Both processes were relatively noisier in the no-carbon control column, but could reach efficient removal at steady state for water with a 16-hour residence time under suboxic conditions, following a period of biofilm growth on the order of weeks. Reduction was more efficient in methanol-treated biofilms when oxygen was present, and in glycerol-treated biofilms when oxygen was low. Reducing conditions were established most quickly, and were most stable, when oxygen was low.

2. **Is carbon amendment necessary? Can coal from waste rocks provide enough carbon for selenium reduction?** Under suboxic conditions, no-carbon control columns were able to release carbon into solution, presumably through biological degradation of the carbonaceous waste rock. Under microaerophilic and suboxic conditions, the available native carbon appears to be sufficient to drive reduction with adequate residence time. This may not be true during upset conditions, however, such as seasonal spikes in oxygen or nitrate.

Acknowledgements

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PASSIVE AND SEMI-PASSIVE TREATMENT ALTERNATIVES FOR THE BIOREMEDIATION OF SELENIUM FROM MINE WATERS

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ABSTRACT

The bioremediation of selenium (Se) from mine waters using passive systems (those requiring negligible management) and semi-passive systems (those requiring active management to sustain desired conditions and processes) is reviewed. Examples of passive systems include natural wetlands, constructed surface-flow wetlands, constructed subsurface-flow wetlands and permeable reactive barriers (PRB). Examples of semi-passive systems, such as *in situ* pit lake treatment, require active management that may involve periodic amendments (*e.g.*, organic carbon, nutrients) to stimulate desired microbial mechanisms. In all cases, Se bioremediation relies primarily upon microbial and/or biological processes to remove Se from solution, including plant uptake, precipitation (*e.g.*, *in situ* formation of elemental Se), adsorption, microbial/algal assimilation and biological volatilization (*e.g.*, release of dimethyl selenide to atmosphere). Case studies that describe field-scale examples of passive and semi-passive bioremediation for Se are presented. Considerations for Se bioremediation in interior temperate climates (*e.g.* Elk River Valley region) as they relate to constructed/natural wetlands, pond environments (*e.g.*, sedimentation ponds), pit lakes and PRBs are discussed.

KEY WORDS: selenium, bioremediation, passive, semi-passive, mining

INTRODUCTION

Selenium (Se) is a naturally occurring metalloid that is widely distributed at low concentrations in crustal rocks, surface waters and groundwaters. However, anthropogenic activities such as irrigated agriculture, fossil fuel combustion, petroleum refining and mining operations can greatly increase Se loadings to the environment. The common occurrence of elevated Se concentrations in coal source rocks, for example, can greatly increase levels of Se in mining-influenced drainages over background levels, where the primary mode of Se input is through the weathering and leaching of exposed Se-bearing rocks (waste rock, pit walls, tailings, coarse coal reject, *etc*.). In aquatic settings, the major pathway for Se toxicity is through ingestion and associated Se accumulation in the tissues of reproductive egg-laying organisms (*e.g.*, fish, birds, amphibians). Toxicity is manifested as reproductive impairment due to maternal transfer resulting in juvenile abnormality or embryo death (Chapman *et al*., 2009).

Due to existing and potential environmental consequences of Se exposure to aquatic taxa in freshwater settings, considerable effort has been placed on the evaluation and development of active and passive treatment systems for Se removal. In particular, the potential for the passive removal of Se through

various forms of bioremediation has received considerable attention owing to the favourable cost implications and the ineffectiveness of traditional chemical precipitation methods for reducing Se to within environmentally-acceptable limits (Frankenberger *et al*., 2004).

In this paper, alternatives for the bioremediation of Se from mine waters using passive and semi-passive systems are reviewed. Case studies of field-scale treatment systems are described where data permit. Systems requiring extensive infrastructure, power and/or temperature control are not considered. The relevance of the various bioremediation alternatives to cold temperate climates (*e.g.*, interior Canada) is also discussed.

BACKGROUND

The speciation of Se in aquatic environments is highly dependent on reduction-oxidation (redox) potential, pH, ionic strength (salinity), biological/microbial interactions and kinetic limitations (rates of reactions). In particular, redox potential has been shown to present a dominant variable governing the speciation of Se in aquatic systems (Masscheleyn and Patrick, 1993; Zhang and Moore, 1996). In oxygenated surface waters at circumneutral pH, selenate (Se^{6+}) is predicted to dominate the Se species assemblage. At lower redox potentials, selenate is reduced to selenite (Se^{4+}) (Oremland *et al*., 1990). Selenite has a greater tendency for adsorption and therefore exhibits reduced mobility in comparison to selenate. In reducing environments, elemental Se (Se^{0}) and various selenides (Se^{2-}) become important, and their formation can present a dominant accumulation pathway in organic-rich sediments (Zhang and Moore, 1996). The formation of volatile methylated species such as dimethylselenide (DMse) by fungi, bacteria and algae and subsequent volatilization of gaseous Se to the atmosphere can be important mechanism of Se loss from aquatic environments (Hansen *et al*., 1998; Dungan and Frakenberger, 1999).

Passive and semi-passive treatment systems for the bioremediation of Se from waste waters rely upon various biogeochemical processes that are mediated by microbes (*e.g.*, bacteria) or plants (*e.g.*, algae, macrophytes). The mechanisms relevant to Se bioremediation in passive and semi-passive systems reflect processes that result in the removal dissolved Se from solution via adsorption, precipitation, biological uptake and volatilization, and include:

1. Microbially-mediated reduction of selenate (Se^{6+}) to selenite (Se^{4+}) in suboxic conditions followed by adsorption of selenite;
2. Precipitation of reduced Se species (elemental Se, selenides) through microbially-mediated reduction of Se oxyanions (selenate+selenite) in anoxic environments;
3. Microbial, fungal or biological methylation of Se to volatile methylated species (*e.g.*, DMSe) and release to the atmosphere (volatilization);
4. Uptake of Se oxyanions (selenate+selenite) into cells of microorganisms followed by assimilatory reduction to selenide and incorporation into metabolic machinery (*e.g.*, cellular proteins); and
5. Immobilization of Se through plant uptake.

TREATMENT ALTERNATIVES

In the following sections, descriptions are provided for the following passive and semi-passive bioremediation systems:

- Wetlands (natural and constructed surface-flow and subsurface-flow systems)
- Permeable reactive barriers
- *In situ* treatment of pit lakes/ponds; and
- *In situ* treatment of mine workings.

These emerging technologies have been selected based on their application at field scales, their success in removing Se from surface and/or groundwaters, and the availability of data in support of case study evaluation. In the context of this paper, wetlands (natural and constructed) and permeable reactive barriers (PRBs) are considered to represent passive systems for which minimal management and maintenance is required following initial commissioning. *In situ* Se removal in pit lakes, ponds and mine workings are considered semi-passive as these systems typically require on-going management (*e.g.*, fertilization or addition of organic amendments) to sustain desired processes in the long-term.

Wetlands: Wetland treatment systems offer a practical alternative for the bioremediation of Se due to the relatively-low costs with respect to construction, operation and maintenance. Removal through precipitation/adsorption of reduced species, immobilization into plant tissues, and release of volatile compounds to the atmosphere (volatilization) represent the dominant sinks for Se in wetland systems (Masscheleleyn and Patrick, 1993). The uptake of Se by plant roots is influenced by the chemical form and concentration of Se, soil redox conditions, pH of the rhizosphere, and the presence of competing ions such as nitrate, sulphate and phosphate The generation of volatile Se in sediments and plants can be bio-stimulated with the addition of organic amendments including saccharides, amino acids, and proteins (Losi and Frakenberger, 1997).

Wetlands can comprise surface-flow wetlands (natural or constructed) or subsurface-flow (SSF) constructed wetlands (Frakenberger *et al*., 2004). In contrast to surface-flow wetlands, SSF wetlands typically consist of engineered gravel beds that serve as a rooting medium for salt-tolerant emergent wetland plants such as cattails (Typha spp.) and bulrushes (Scirpus spp.) (Shardendu *et al*., 2003). In SSF systems, the influent stream flows through the gravel/root system where biogeochemical reactions within the plant root zone (rhizome) promote the removal of Se through a combination of Se uptake, *in situ* precipitation and volatilization (Figure 1).

An ecological risk associated with the use of surface-flow wetlands for Se bioremediation is the potential for increased transfer of Se into invertebrate and vertebrate food chains (Dungan and Frakenberger, 1999). However, deterrents such as barriers and noise can be used to reduce the attractiveness of wetland systems to wildlife. A primary advantage of SSF treatment is the capacity to minimize the potential for food-chain transfer of Se through physical isolation of the waste stream from biological receptors. Other limitations of wetland systems include their limited capacity to treat high-flow waste streams and seasonal

changes in performance in temperate climates associated with annual temperature fluctuations and plant growth/decay cycles (Lin and Terry, 2003).

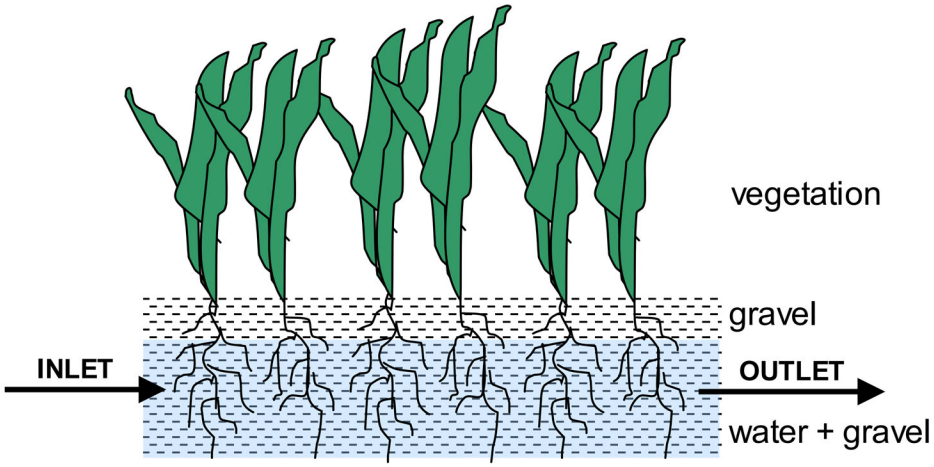


Figure 1. Conceptualized schematic of subsurface-flow wetland

Permeable Reactive Barriers: Permeable Reactive Barriers (PRBs) present a passive, *in situ* technology that has a high potential to treat shallow aquifers at a lower cost than traditional pump-and-treat methods (Blowes et al., 2000). In these systems, a permeable barrier is constructed to intercept a contaminated groundwater plume, with the barrier amended with one or more materials to create a reactive media for contaminant removal (Figure 2). Zero valent iron (ZVI) has proven to be an effective reactive material for the treatment of Se using PRBs, where ZVI facilitates the reduction and precipitation of Se as reduced forms, including elemental Se and Fe-selenides (Morrison et al., 2001). PRBs are most effective for the remediation of lower-flow and highly-concentrated waste streams which report to groundwater. PRBs are also more cost effective for well-constrained groundwater flows with relatively-small cross-sectional flow paths. With proper design and application, PRBs can perform to design standards for several decades. The major limitations of PRBs relate to their finite life span and potential to become clogged through precipitation of secondary minerals which can impede flow and performance (Blowes *et al*., 2000).

Pit Lakes/Ponds: Pit lakes are a common feature at closure for many mine sites and are often repositories for large volumes of mine-impacted water. Pit lakes offer viable opportunities for the bioremediation of Se given the tendency of these systems to develop suboxic conditions through either passive or active means. For Se bioremediation to be effective in pit lakes, suboxic conditions must be achieved to allow precipitation of reduced species (*e.g.*, elemental Se). Suboxic conditions are more easily sustained in stratified lakes due to the reduced influence of atmospheric interaction with pit bottom waters. The geometry and density characteristics of pit lakes often make them more conducive to lake stratification. Pit lakes differ from natural lakes in that they are often deep, steep sided, and sheltered from wind by pit walls. Further, given the saline features of pit wall runoff and other mine-related inputs that may enter the pit, pit lakes are often more saline than natural lakes. These features contribute to an increased tendency for seasonal and/or permanent stratification (meromixis). The depletion of oxygen and onset to Se/sulphate reduction in pit lakes can be accelerated through the addition of nutrients and/or

organic amendments (Martin *et al*., 2003). Such amendments have also been successful in promoting oxygen depletion and maintaining stratification in initially oxygenated pit lakes (Harrington *et al*., 2004; Harrington, 2002).

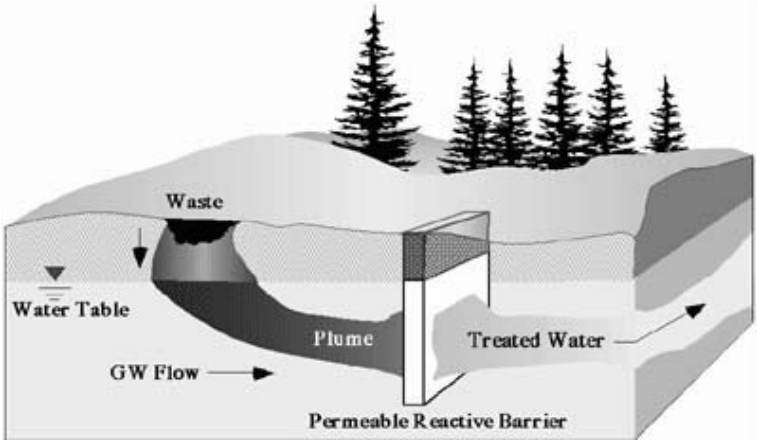


Figure 2: Schematic of permeable reactive barrier (from Bronstein, 2005)

The features described above for pit lakes can also apply to ponds, although suboxia is harder to sustain in such systems given their typically shallow water depths and tendency for wind-induced mixing. However, there is evidence to suggest that Se volatilization from pond environments can be effective in removing Se in the absence of anoxic conditions through the stimulation of volatilization by nutrient addition (Fan et al., 1998).

The main advantage of *in situ* pit lake treatment is the semi-passive feature and the ability to remediate large volumes of water at relatively low cost. The disadvantages include the generation of anoxic and potentially toxic waters that may require secondary treatment (*e.g.*, aeration and settlement) prior to discharge to receiving water courses.

Mine Workings: The methods described above for the *in situ* bioremediation of Se in pit lakes also have relevance to the *in situ* treatment of mine workings. The long residence times of waters in flooded underground settings present an ideal environment for the establishment of reducing conditions and removal of Se through reduction and precipitation mechanisms. Although no case studies for Se were available for review, the addition of organic carbon and nutrients to mine workings has been shown to promote conditions conducive to Se removal (Harrington, 2002).

CASE STUDIES

Chevron Surface Flow Wetland (San Pablo Bay, California): The Chevron Wetland is a 36 ha surface-flow constructed wetland that was commissioned to treat Se-rich oil refinery wastewaters (Hansen *et al*., 1998). The wetland comprises a combination of dense saltmarsh vegetation and open water. Se concentrations in the inflow of 20 to 30 µg/L decrease to <5 µg/L in the outflow, representing a loading reduction of ~89% (flow = 50 to 80 L/s) (Table 1). Mechanisms contributing to Se removal include adsorption/precipitation, plant uptake, and volatilization. Most of the Se removal has been attributed to immobilization in sediments and plant tissues, with volatilization estimates accounting for 10 to 30% of the Se removed (Hansen *et al*., 1998). The major disadvantage of surface flow wetlands in the increased potential risk for Se accumulation in organisms such as birds and fish. Indeed, development of the Chevron system resulted in an increase in Se body burdens in birds, leading to measures to reduce the attractiveness of the wetland to wildlife.

Benton Lake Wetland (Great Falls, Montana): Benton Lake is a shallow seasonal lake that was divided into six ponds through the construction of dikes to facilitate water management and habitat for waterfowl (Zhang and Moore, 1996). The system comprises a combination of perennial and seasonal wetlands, with water depths ranging from 0.5 to 1 m. Surface waters that enter the wetland system host elevated levels of dissolved Se (as selenate) in response to the weathering of Se-rich marine shales underlying the basin. Total dissolved Se concentrations decrease through the pond system from 26 to <1 µg/L (Table 1). Detailed analysis of Se partitioning demonstrated that Se removal to sediments (as elemental Se and organic-Se) could account for the bulk of Se removal (Zhang and Moore, 1996). Similar to the Chevron wetland, there have been concerns over increased Se transfer to waterbirds.

***In Situ* Pit Lake Treatment (Sweetwater Uranium Mine, Wyoming):** The Sweetwater Pit Lake, an oligotrophic lake located in Sweetwater County (Wyoming), was formed by the flooding of the Sweetwater open pit uranium mine following cessation of dewatering activities in 1983. The lake (4.5 million m^3) was treated by Kennecott Uranium Company with ~550 tons of sugars, fats, proteins, alcohols, phosphates and nitrates over a two month period in 1999 (Paulson *et al*., 2002; Harrington, 2002). Bacterial metabolization of the nutrient/carbon amendments promoted the development of suboxic conditions which led to the removal of dissolved Se from an initial concentration of 460 µg/L to values <10 µg/L. Removal is presumed to have occurred through adsorption/precipitation of reduced Se species (*e.g.*, elemental Se). The treatment process was efficient, requiring minimal equipment (a hydroseeder) at an estimated cost of <\$0.16/m^3. Phosphate addition maintains the growth of algae which provides a continuous source of organic carbon to maintain desired conditions in the water column.

***In Situ* Treatment of Backfilled Pit (Beal Mountain Mine, Montana):** Closure of the Beal Mountain Mine, located near Butte Montana, involved backfilling the open pit with wasterock (Harrington, 2002). Inputs of seepage, pit wall runoff and precipitation filled the voids of the backfilled pit. In order to ameliorate elevated levels of nitrate (~2 mg/L) and Se (42 to 47 µg/L) in pit waters, organic carbon was added to the pit during the filling period to allow the distribution of carbon throughout the wasterock pore spaces. Organic carbon was added at a rate sufficient to reduce Se levels to between 2 and 3 µg/L.

***In Situ* Pit Lake Treatment (Gilt Edge Mine Superfund Site):** The Gilt Edge Mine near Lead, South Dakota, was the site of *in situ* treatment of the Anchor Hill Pit Lake (Park *et al*., 2006; Harrington *et al*., 2004). Prior to treatment in 1991, the pit lake (235,000 m^3) was characterized by low pH (pH=3) and elevated concentrations of TDS, nitrate, sulphate and several trace elements, including Se (~20 μg/L).

Table 1. Case Study Summary for Passive and Semi-Passive Bioremediation Systems for Selenium

Project	Location	System Type	Treatment	Initial [Se] (μg/L)	Final [Se] (μg/L)	Flow Rate (L/s) or Volume	Reference
Chevron Marsh	San Francisco Bay, California	Constructed surface-flow wetland	Adsorption/precipitation, biological uptake by plants, and volatilization to the atmosphere.	20-30 μg/L	<5 μg/L	50-80 L/s	Hansen et al., 1998
Benton Marsh	Great Falls, Montana	Engineered natural system comprising perennial and seasonal wetlands	Adsorption/precipitation, biological uptake by plants, and volatilization to the atmosphere.	26 μg/L	0.7 μg/L	Flow not reported	Zhang and Moore, 1996
Sweetwater Pit	Sweetwater County, Wyoming	Pit lake	*In situ* removal through addition of nutrients and organic amendments	443 μg/L	<5 μg/L	4.5 million m^3	Paulson et. al., 2002
Anchor Hill Pit Lake	Gilt Edge Mine, South Dakota	Pit lake	Lime addition followed by i*n situ* removal through addition of nutrients and organic amendments.	20 μg/L	<1 μg/L	235,000 m^3	Park et al., 2006
Beal Mountain Mine Pit Lake	Butte, Montana	Back-filled pit lake	*In situ* removal through addition of organic carbon during pit filling	42-47 μg/L	2-3 μg/L	Volume not reported	Harrington, 2002
Monticello Mill Tailings Site	Monticello, Utah	Permeable reactive barrier	PRB using zero valent iron, in conjunction with impermeable funnel walls to funnel contaminated groundwater	18.2 μg/L	0.1 μg/L	0.3 to 0.6 L/s	Bronstein, 2005

Following lime addition to neutralize acidity, the lake was amended with various sources of organic carbon (methanol, molasses and wood chips), fertilizer (phosphoric acid) and further base additions (sodium hydroxide). Following complete neutralization of the water column and subsequent to organic/nutrient amendments, reducing conditions developed as indicated by the onset of sulphate reduction. Pronounced decreases in Se concentration occurred commensurately with the shift to reducing conditions to values <1 μg/L in 2004. For release to the environment, pit waters have been extracted from an intermediate depth, filtered to remove particulate metals, and pumped to a holding pond to allow removal of hydrogen sulphide prior to discharge to a local creek system.

Monticello Permeable Reactive Barrier (Monticello, Utah): A PRB system using zero-valent iron (ZVI) was commissioned in 1999 to remediate contaminated groundwater at a former uranium and vanadium ore-processing mill at Monticello, Utah (Carpenter *et al*., 2000; Bronstein, 2005). The remediation system includes a PRB used in conjunction with impermeable funnel walls to funnel contaminated ground water to the PRB for treatment. The barrier was built by driving steel sheet piling into the bedrock forming a rectangular box approximately 100 feet long by 8 feet wide. The native soils inside the box were replaced with ZVI and gravel packs upgradient and downgradient of the ZVI. The impermeable walls are composed of a bentonite and soil slurry mix. Water quality data for an array monitoring wells indicated that initial concentrations of Se (40 μg/L) were reduced to non-detectable levels for influent flows ranging from 0.3 to 0.6 L/s. Losses in PRB performance have occurred in response to a decrease in hydraulic conductivity associated with the precipitation carbonate and oxide minerals within and adjacent to the barrier.

SUMMARY

This paper demonstrates that, for certain environments, passive and/or semi-passive systems can present potentially cost-effective options for the bioremediation of Se. With regards to wetlands, surface-flow systems can afford significant Se removal for relatively low-flow applications. However, such systems have been shown to create a potential wildlife hazard primarily through increased Se transfer to waterbirds. In this regard, subsurface-flow wetlands offer considerable promise given that influent waters are physically isolated from the surface environment. Wetlands are also limited in cold climates that experience large seasonal flow and temperature fluctuations. *In situ* pit lake treatment for Se through fertilization and/or organic amendments is clearly a viable option to treat large volumes of water at relatively-low cost. The Sweetwater, Beal Mountain, and Anchor Hill pit lake case studies are all examples of Se bioremediation in cold-temperate interior climates where water temperatures are less than 4°C for several months of the year. Permeable reactive barriers also offer a viable strategy to treat Se in cold-temperate interior climates due to the perennial nature of groundwater flows and the maintenance of performance at low temperatures.

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In Situ Attenuation of Selenium in Coal Mine Flooded Pits

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ABSTRACT

Suboxia is a prerequisite for the bioremediation of selenium (Se), whereby Se is removed from solution as reduced species (*e.g.*, elemental Se). In this regard, flooded open pits offer suitable repositories for the bioremediation of Se given the tendency of these systems to develop suboxic conditions through either passive or active means. Specifically, the geometry of flooded pits and their water column density characteristics often make them conducive to permanent stratification (meromixis) and the development of bottom water suboxia. In order to assess the potential for Se bioremediation in a coal mine flooded pit in northern Canada, a combination of high resolution physical profiling (temperature, dissolved oxygen and conductivity) and water quality sampling was conducted. Vertical profiling revealed a stratified water column with respect to both temperature and salinity, with the pycnocline occurring at a depth of 5 m. Dissolved oxygen was absent below a depth of 20 m, suggesting that the water column stratification is permanent. Profiles of other redox-sensitive species (dissolved manganese and nitrate) further support the presence of bottom water anoxia below 20 m. The data for nitrate, for example, show evidence of denitrification immediately below the oxic-suboxic boundary. Dissolved Se shows evidence of attenuation in response to the vertical redox gradient in the water column, with surface values (12 to 20 µg/L) decreasing to <3 µg/L in the suboxic zone. Overall, the data reveal evidence of both denitrification and Se reduction, with Se being removed from solution presumably as either selenite (Se^{+4}) (via adsorption to settling particles) or as precipitation of elemental Se (Se^{0}) or selenide (Se^{2-}). The implications of the data with respect to mine water management and Se bioremediation are discussed.

Keywords: coal, mining, bioremediation, passive treatment

INTRODUCTION

For coal mine districts throughout North America, selenium (Se) is a water quality parameter of concern with respect to environmental compliance and the protection of aquatic resources. The common occurrence of elevated Se concentrations in coal source rocks (*e.g.*, wasterock, pit walls, tailings, coal reject, *etc.*), and leaching through natural weathering, can increase levels of Se in mining-influenced drainages to well over background levels. Due to potential environmental consequences aquatic taxa exposure to Se in mine-affected settings, considerable effort has been placed on the development and evaluation of active and passive treatment systems for Se removal (CH2MHILL, 2010, 2013). In particular, the potential for the passive removal of Se through various forms of bioremediation has received considerable attention due to the favourable cost implications and the ineffectiveness of traditional chemical precipitation methods for reducing Se to environmentally-acceptable limits (Frankenberger *et al.*, 2004).

Engineered passive and active treatment systems designed to remove Se from solution generally rely upon the development of suboxia. Under suboxic conditions, the potential for Se attenuation is enhanced by a suite of microbially-mediated processes that favour the reduction of selenate (Se^{+6}) and removal of dissolved Se from solution via adsorption and precipitation reactions. Such suboxic mechanisms include: 1) reduction of selenate (Se^{6+}) to selenite (Se^{4+}) followed by adsorption of selenite to particles; 2) precipitation of elemental Se (Se^{0}); 3) precipitation of Se as inorganic/organic selenides (Se^{2-}); and 4) co-precipitation of Se with reduced sulfur (Masscheleyn and Patrick, 1993). Suboxia is also required to reduce nitrate (through denitrification), the presence of which can inhibit Se reduction and hence its potential for attenuation (Oremland *et al.*, 1991).

Mine settings offer significant opportunities for the bioremediation of Se through the natural and/or engineered development of suboxia within mine facilities. Specifically, large-scale zones of suboxia may occur in pit lakes (Castro and Moore, 2000), within the pore spaces of saturated wasterock (Bianchin *et al.*, 2013), and in some cases, within unsaturated zones of large wasterock dumps (Kuo and Ritchie, 1999). Further, such suboxic zones have the potential to be incorporated into water management strategies designed to reduce Se loadings from mine operations.

In this paper, the potential utility of flooded open pits as bioremediation cells for Se is discussed through examination of water quality data from a mine in northern Canada. Mine pit lakes often differ from natural lakes in that they are typically deeper, more saline, and less susceptible to wind mixing (due to small fetch and topographic sheltering from pit walls). These features can lead to the development of permanent stratification (meromixis), resulting in the development of suboxic bottom waters. Specific objectives this study are as follows: 1) describe the physical and chemical limnological setting of the flooded pit; 2) delineate the biogeochemical processes governing the behaviour of Se and other mine-related parameters; and 3) discuss potential applications of flooded pits for Se bioremediation through passive and engineered methods.

ENVIRONMENTAL SETTING AND METHODOLOGY

The study site is situated at a closed coal mine in northern Canada at an elevation of ~1,500 m. The open pit was developed between ~1987 and ~1995 and partially backfilled with spoils from ~1995 to ~1998. Passive flooding of the pit began in 1998, reaching a static water level in 2002. The maximum water depth in the pit is 72 m, encompassing a total water volume of 2.35 million m^3. Due to the generally low total sulfur content (generally <1%) and high abundance of carbonate minerals in

host rocks, waste materials in the region are not acid generating. Environmental concerns relating to Se are typically associated with neutral to basic-pH leaching from subaerial (unsaturated) wasterock.

On July 31, 2013, the flooded pit was sampled through a combination of *in situ* profiling and water sample collection. *In situ* vertical profiling (20 cm vertical resolution) of conductivity, temperature, pH, dissolved oxygen (DO) and fluorescence was conducted over the deepest portion of the pit using a Sea-Bird Electronics™ conductivity-temperature-depth (CTD) profiler (SBE 19plus SEACAT Profiler, Bellevue, Washington). The CTD was configured with a WETLABS ECO Fluorometer™ to measure vertical variations in chlorophyll concentration in the water column (proxy for photosynthetic algal biomass). Water quality samples were collected at depths of 1, 2, 4, 6, 8, 10, 12, 15, 20, 30, 40, 50 and 60 m, and analyzed for physical parameters, anions, nutrients and total/dissolved trace elements. Trace element concentrations were determined via inductively-coupled plasma mass spectrometry (ICP-MS), while anions were analyzed via ion chromatography (Dionex).

RESULTS AND DISCUSSION

Water column physical structure

High resolution profiles of temperature and conductivity show the presence of a stratified water column in the flooded pit, with a pronounced thermocline observed between 3 and 6 m (Figure 1). The thermocline overlaps with a sharp gradient in salinity as revealed by the profile of specific conductivity. The combined effect of the temperature and salinity gradients result in a pronounced density gradient (pycnocline) that is spatially consistent with the temperature and conductivity gradients observed in the uppermost 6 m of the water column (Figure 1).

Salinity gradients in the flooded pit are dominantly governed by vertical variations in the concentrations of sulfate, calcium and alkalinity, all of which represent products of mine waste weathering (wasterock and pit walls) (Figure 2). Sulfate is liberated through the oxidation of reduced sulfur minerals (*e.g.* pyrite) while calcium and alkalinity represent the products of carbonate mineral dissolution which are abundant in the host Cretaceous sedimentary rocks. Sulfate concentrations in the water column (750 to 1,000 mg/L) are strongly elevated above background values, and illustrate the pronounced mine-related signature in pit waters. The range in sulfate concentration is comparable in magnitude to values observed in wasterock seepages in the region.

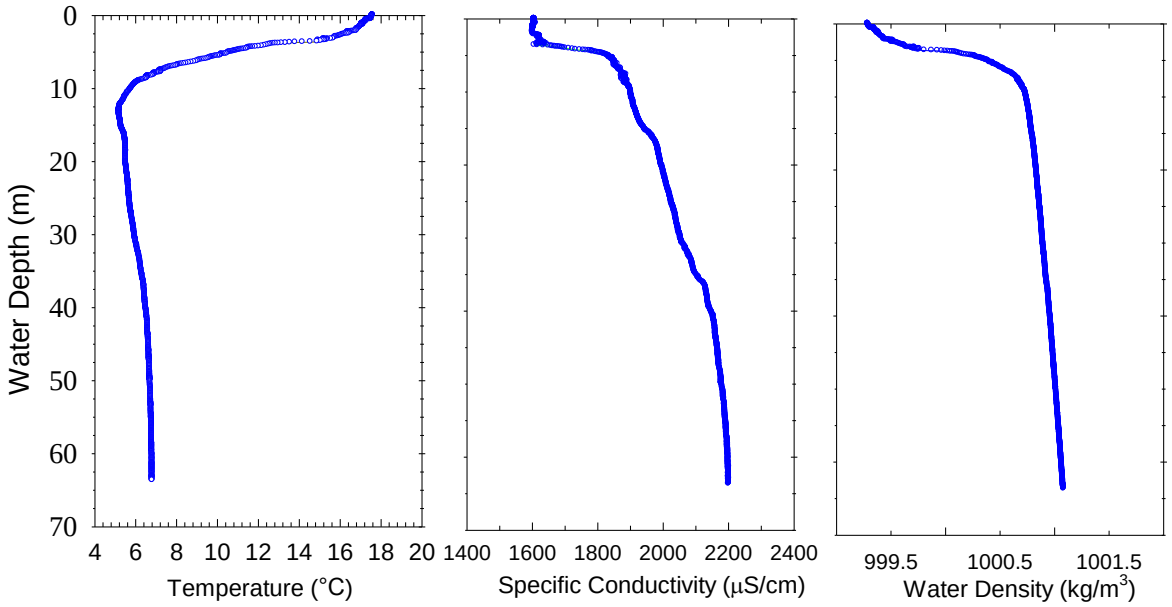
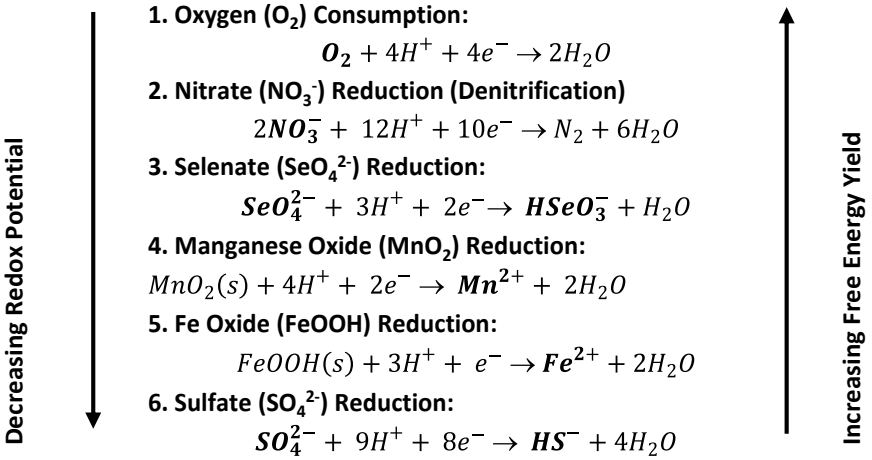


Figure 1 High vertical resolution (20 cm spacing) profiles of *in situ* temperature, specific conductivity and calculated water density in the flooded pit.

Redox conditions

Redox conditions have been shown to be the dominant variable governing Se speciation, precipitation/dissolution, sorption/desorption, methylation and volatilization in water and sediments (Masscheleyn and Patrick, 1993; Zhang and Moore, 1996). Accordingly, an understanding of redox conditions is essential to support interpretations of Se behavior. In natural systems, redox reactions are driven by the oxidation of organic matter, which can be defined by a series of microbially-mediated reactions (Table 1). In the presence of dissolved oxygen, aerobic bacteria will utilize O_2 as a terminal electron acceptor since this redox reaction affords the greatest energy yield. However, in systems where the rate of O_2 consumption exceeds the rate of re-supply, O_2 will become depleted and other secondary oxidants will be utilized by facultative anaerobic bacteria. These, in order of their free energy yield, are nitrate, manganese oxides, iron oxides, and sulfate (Table 1). In this sequence of redox reactions, selenate reduction occurs at a similar redox potential to that of nitrate.

Table 1 Oxidation/reduction reactions associated with the re-mineralization (oxidation) of organic matter. Parameters measured to elucidate redox conditions are highlighted in bold.



Water column redox conditions in the flooded pit were assessed through examination of various redox-sensitive indicators including dissolved oxygen (DO), nitrate, ammonia, dissolved Fe and dissolved Mn (Figure 2). Overall, the presence of lake stratification has a pronounced effect on water column redox conditions. DO levels show a progressive decline below the thermocline, from a maximum of 12 mg/L (at 5 m) to undetectable concentrations below a depth of 22 m. The absence of DO below 22 m provides strong evidence to indicate that the flooded pit is permanently stratified. If a mixing event had occurred in the previous months, some residual DO would be expected to persist in lake bottom waters.

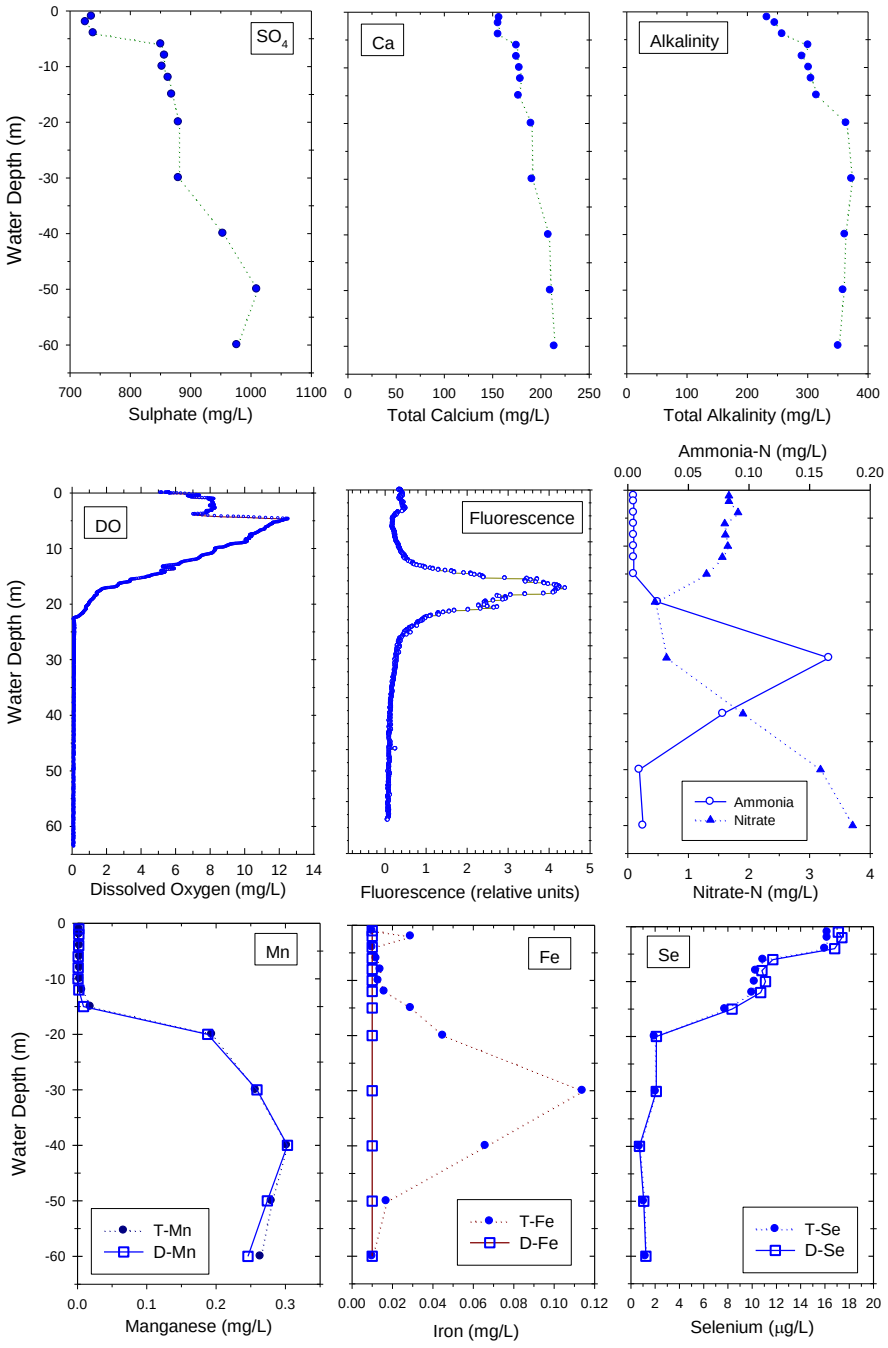


Figure 2 Vertical profiles of sulfate, total calcium, total alkalinity, dissolved oxygen, fluorscence, nitrate-N, ammonia-N, manganese, iron and selenium in the flooded pit. Data for fluorescence and dissolved oxgyen were collected via high vertical resolution *in situ* profiling.

Nitrate shows a pronounced mine-related signature in surface waters (1.6 mg/L), and reflects the input of residual nitrogen-based blasting residues. Below the oxic-suboxic boundary at 22 m, nitrate-N values decline to a minimum value of 0.5 mg/L at a depth of 20 m. The horizon of low

nitrate concentration is interpreted to result from denitrification (microbially-mediated nitrate reduction) in the suboxic zone below 20 m. Below the nitrate minimum, nitrate-N values progressively increase to a bottom water maximum of 3.7 mg/L, presumably reflecting the original mine-related signature established post-filling. Overall, the data suggest that the nitrate profile is in non-steady-state, whereby denitrification is progressively depleting the nitrate inventory in the suboxic zone below 20 m.

The occurrence of nitrate reduction near the oxic-suboxic boundary may in part be related to the peak in photosynthetic biomass (*e.g.*, algae) observed between 16 and 23 m, which will supply a source of organic detritus (and oxygen demand) to this portion of the water column. The magnitude of the fluorescence peak is indicative of oligotrophic conditions, which is common to pit lake environments. The influence of the autotrophic peak is also illustrated by the ammonia data, which show a concentration maximum in the upper portion of the suboxic zone (Figure 2). This ammonia peak is inferred to represent a product of organic matter remineralization. The presence of ammonia also provides additional evidence in support of suboxic conditions below water depths of 20 m, given the chemical instability of this species in the presence of DO.

Below the oxic-suboxic boundary at 22 m, dissolved Mn concentrations increase to a maximum of 0.3 mg/L. This is consistent with the reductive dissolution of Mn-oxides in the suboxic water column, which will liberate dissolved Mn^{2+} into solution. In contrast to Mn, dissolved Fe does not show any evidence of bottom water enrichment. Low levels of particulate Fe (as inferred from the total Fe profile) are evident; however, the data do not indicate the occurrence of Fe-oxide reductive dissolution. Collectively, the data for redox proxies are indicative of mildly suboxic conditions below 20 m, as inferred by the absence of DO, evidence of denitrification, presence of ammonia, and elevated levles of dissolved Mn. Indicators of more strongly reducing conditions, as would be revealed by Fe oxide reductive dissolution and/or sulfate reduction, are not observed.

Selenium

Profiles for dissolved and total Se are congruent, indicating that Se is present almost exclusively as dissolved species (Figure 2). Se shows evidence of attenuation in response to the vertical redox gradient in the water column, with surface values (12 to 20 µg/L) decreasing to <3 µg/L in the suboxic zone (Figure 2). The low Se values below the oxic-suboxic boundary, and the strong parallels between Se and DO, suggest that the behaviour and attenuation of Se is tied to vertical variations in redox conditions. Specifically, the data strongly suggest that the decrease in Se concentrations below 20 m reflects the removal of dissolved Se from solution as reduced Se phases, presumably as either selenite (Se^{+4}) (via adsorption to settling of particles) or as precipitation of elemental Se (Se^{0}) or selenide (Se^{2-}). The redox-controlled attenuation of Se is supported by the data for other redox proxies, which show evidence of both denitrification and Mn-oxide reductive dissolution. Specifically, the selenate/selenite redox couple occurs between nitrate reduction and Mn-oxide reduction (Table 1) Importantly, these data demonstrate that Se removal is achievable under mildly suboxic conditions in the presence of nitrate, which could be expected to hinder Se reduction.

The mechanism of Se attenuation described here is consistent with other forms of passive and engineered Se removal systems that rely on suboxic conditions, including passive wetland treatment (Martin *et al.*, 2011), passive removal in saturated wasterock (Bianchin *et al.*, 2013),

constructed permeable reactive barriers (Morrison *et al.*, 2001), and active biological treatment systems (CH2M HILL, 2010, 2013).

A conceptual model for Se bioremediation is shown in Figure 3. The required elements to support selenate reduction and removal from solution include: 1) a stratified water column, which allows the development of bottom water suboxia; and 2) a source of oxygen demand, which in this case is provided by *in situ* photosynthetic activity. The input of terrestrial organics via surface runoff likely also provides a source of organic carbon (and oxygen demand) to the system.

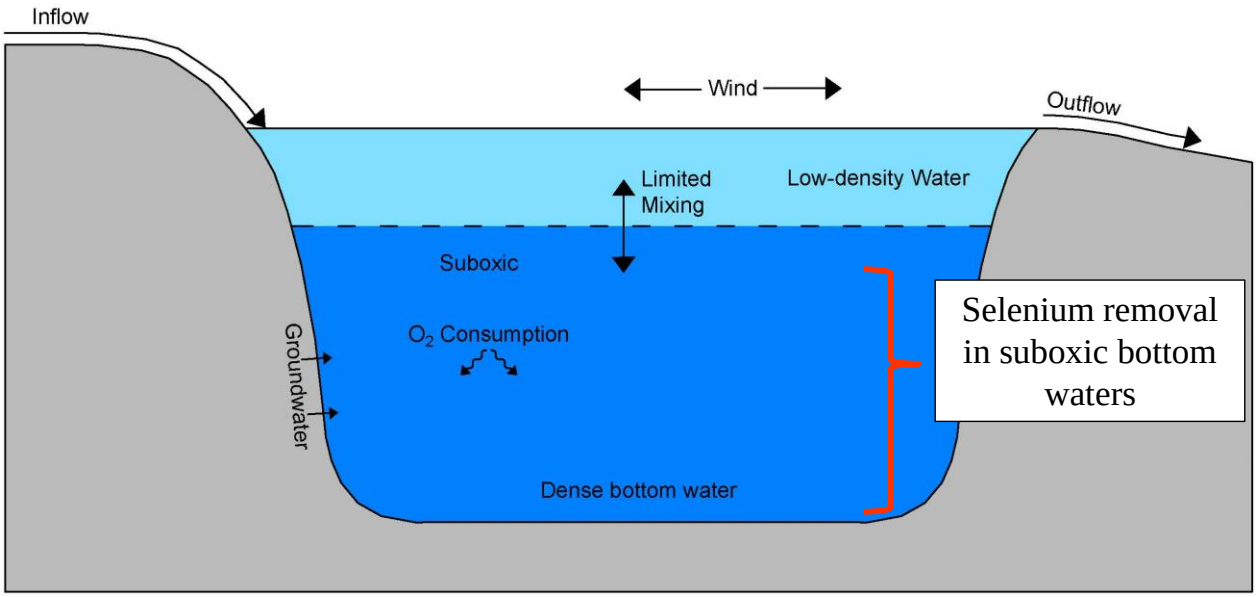


Figure 3. Conceptual model for selenium removal in a stratified flooded pit.

CONCLUSIONS AND IMPLICATIONS FOR MINE WATER MANAGEMENT

Overall, the data provided here illustrate the potential utility of flooded pits as *in situ* bioremediation cells for the removal of Se. The scale of Se removal can be illustrated by the volume of water in this system showing Se concentrations <5 µg/L, which equates to approximatly 1 million m^3 (below a depth of 20 m). There is also the potential to enhance rates of Se removal via the addition of organic amendments. Lake fertilization, for example, can provide an effective means to increase rates of *in situ* algal production and associated carbon generation (Dessouki *et al.*, 2005; Martin *et al.*, 2009). Such methods rely upon the well-established links between phosphorus limitation and algal growth (Schindler *et al.*, 1980). This form of amendment is very cost effective, given that only small additions of phosphorus can promote extensive carbon production. Alternatively, successful Se removal has been achieved via the direct addition of organic amendments to flooded pits (as liquid or solid forms) (Park *et al*., 2006).

Flooded pits that exhibit stratified and suboxic water columns also offer the potential to passively treat other site contact flows. This is illustrated in Figure 4 which shows a conceptual model depicting the injection of contact waters (*e.g.*, wasterock seepage) into the suboxic (bottom) zone of a flooded pit. Following mixing and Se attenuation in pit bottom waters, waters are then withdrawn from the pit for final discharge, which may require aerobic polishing prior to release to

receiving streams. The input of contact waters to the pit bottom will introduce DO, which has the potential to push the system to a less favourable redox regime (more oxic). In this regard, the addition of fertilizer and/or innoculum (*e.g.*, Se and nitrate reducing microbes) could be used to sustain suboxia and the desired redox state conducive to Se removal (also illustrated in Figure 4). This form of semi-passive treatment has been implemented at the Island Copper Mine, which uses a combination of ARD injection to bottom waters and surface water fertilization to promote more reducing conditions in the lower water column (Polling *et al.*, 2003).

With regards to mine water management, the data presented here also highlight the merits of maximizing saturated storage volumes in the design of mine waste facilities, which can passively, or through augmentation, form large-scale zones of suboxia. This requires consideration during mine planning (pit morphometry), potential use of in-pit berms to maximize in-pit water levels, mine waste management and water management.

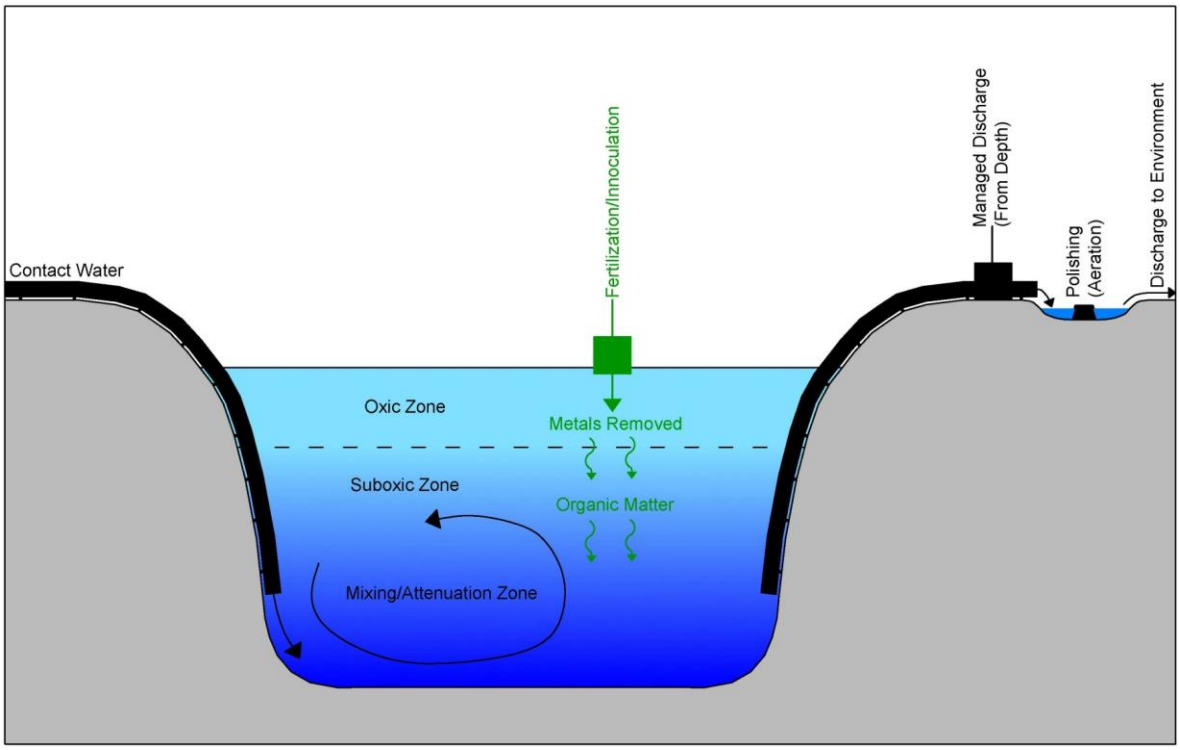


Figure 4. Conceptual model that desecribes a contact water injection system to pit bottom waters and associated removal in support of engineered Se removal system. Fertilization and polishing components

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Evaluation of Treatment Options to Reduce Water-Borne Selenium at Coal Mines in West-Central Alberta

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Microbial Technologies, Inc.



Evaluation of Treatment Options to Reduce Water-Borne Selenium at Coal Mines in West-Central Alberta

Report prepared for Alberta Environment
Water Research Users Group
Edmonton

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Executive Summary

Microbial Technologies, Inc. reviewed the environmental chemistry of selenium and technologies for its treatment at three mountain coal mines in West-Central Alberta. These mines have recently been shown to release selenium to adjacent water bodies, resulting in its uptake into the food chain.

Based on limited data from the Alberta mines, selenium is found in the dissolved form (mostly as selenate) in surface waters, a form that from a chemical perspective is relatively unreactive. Selanate can be reduced to selenite, a form more readily removed (chemically) from solution, or (biologically) to elemental selenium, an insoluble form. Currently, the expected duration of selenium release at the Alberta coal mines is not known.

Notwithstanding the advantages or disadvantages of treatment technologies, preventative measures such as submerging seleniferous sulphides or covering waste rock are recognized as an integral component of any management plan for selenium at coal mines in West-Central Alberta. These measures are not fully reviewed in this document. However, a manual of Best Management Practices for seleniferous mining wastes is currently being developed in Idaho and is expected to provide practical guidance with regards to such preventative measures.

Eleven technologies were reviewed in detail. These include physically-based technologies (reverse osmosis, nanofiltration, and ion exchange), chemically-based technologies (iron precipitation and catalyzed cementation), and biologically-based technologies (algal volatilization, biological treatment plant, in-situ treatment, Biopass and other passive treatment systems, treatment wetlands, and evaporation ponds). Several of these technologies have been tested at a pilot-scale or implemented as treatment facilities.

The above technologies varied considerably with regards to their ability to remove selenate from solution cost-effectively. Several of them could not meet a treatment objective of 5 µg/L. Treatment costs ranged from less than USD$1.00/1,000 gallons for in-situ treatment to over $10.00/1,000 gallons for reverse osmosis and iron precipitation. Some technologies employ very straightforward processes, with simple process flowsheets (e.g., in-situ treatment or constructed wetlands), whereas others rely on more complex processes (e.g., iron precipitation). In addition, some technologies are handicapped by the necessity to manage residues from treatment, such as brines or wash solutions for membrane filtration and ion exchange, or sludges resulting from iron precipitation.

These different technologies were evaluated using a scoring system based on nine separate factors relevant to coal mines in West-Central Alberta. Two technologies stood out from the others as being most suited: in-situ treatment and bioreactors (biological treatment plant). Four other technologies might possibly be appropriate to some of the sites if favoured by some site-specific factors: reverse osmosis, nanofiltration, the Biopass/passive treatment systems and treatment wetlands. The other technologies were deemed too underdeveloped or inappropriate for application at coal mines in West-Central Alberta.

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1 Introduction

Concerns about selenium (Se) toxicity were galvanized by its effects observed in the Kesterson Reservoir, San Joaquin Valley, California. Field studies in the early 1980's documented dramatic losses in migratory bird populations and specifically attributed to Se the decline in reproduction of waterfowl, shorebirds and other aquatic birds (1). One other case of Se ecotoxicity had already been documented earlier at Belews Lake, and more reservoirs exhibiting impacts from Se were identified later on, indicating that this was not an isolated incident. Se ecotoxicity in aquatic ecosystems was thus uncovered as a new ecological problem.

Although knowledge of Se poisoning of cattle had existed for some time (2), the striking finding following these new environmental disasters was that ecotoxicity occurred at very low Se concentrations. Little was known about how it acted at such low doses, and this prompted an accelerated program of investigation to understand its fate and behavior in aquatic ecosystems and its toxicological mode of action. Although much has since been learned about its ecotoxicity, there are still knowledge gaps, particularly for cold water environments - compared to warm water environments.

Monitoring data in the late1990's indicate that selenium concentrations have increased in surface waters downstream from mountain coal mines in West-Central Alberta (3). This is a problem that appears to be specific to coal mines in the upper McLeod and Smoky river basins. This study confirmed that selenium concentrations exceeded the Canadian and US-EPA water quality guidelines for the protection of freshwater aquatic life (i.e., 1 and 5 ug Se/L, respectively) in various streams and one end pit lake influenced by active coal mines. In contrast, selenium was usually below the most stringent guideline (i.e., Canadian or CCME) at the reference sites. Moreover, selenium in fish muscles and eggs was significantly more elevated at sites impacted by coal mines compared with reference sites (except for one reference site). This survey also showed selenium is elevated in fish tissues from sites downstream of the mines, compared to reference sites. Concurrent monitoring at the mines confirmed the above findings of elevated selenium in waters draining coal mines (4). Background or upstream Se concentrations in water bodies draining the mines averaged 0.7 µg/L (N=56) compared with 9.1 µg/L (N=126) at downstream sampling stations. Se concentrations in end pit lakes, rock dump springs, and settling pond effluents averaged 19.8, 115, and 42.7 µg/L, respectively, well above the water quality guidelines. Long-term temporal trends for selenium loadings or subsequent selenium concentrations in water bodies influenced by the mines is not currently known.

Based on available data, lowest selenium concentrations in streams occurred in the spring compared to summer and fall. Lower concentrations in spring may be due a dilution effect from snowmelt and runoff. Limited data for chemical speciation of selenium indicated that it was present mostly in the dissolved form (as selenate).

Elevated selenium in surface waters of western North America have been associated with various activities including irrigation of seleniferous soils, and at phosphate and coal mines in Idaho, Wyoming and British Columbia (e.g., 2, 3, 10). Geological sources particularily Cretaceous marine shales appear to be an important source of selenium in these areas. Elevated selenium in surface waters has also been associated with gold deposits and is occasionally a problem at gold mines. Gold mine effluents that contain selenium typically also contain other contaminant, such as ammonium, arsenic, cyanide, and nitrate (e.g., Zortman-Landusky Mines, Gilt Edge), and possibly antimony and mercury. This is important because the problems – and solutions – associated with selenium treatment for gold mine effluents may be different from those associated for coal mine effluents. Similarly, some refineries in the United States (e.g., Chevron's Richmond, CA refinery) produce process-affected water that contains selenium and are required to treat it prior to discharge. In this case, treatment solutions must account for the low concentration/high volumes scenario typical of refinery effluents. Finally, coal-burning power plants may

generate a selenium-contaminated leachate from uncovered coal ash landfills (e.g., Reliant Energy's W.A. Parish coal ash disposal area, TX), leachate that may require treatment. In each case, a unique solution needs to be developed to treat the contaminated water.

A number of treatment technologies have been developed to remove selenium from contaminated water. These include physical methods (e.g., ion-exchange, reverse-osmosis), chemical methods (e.g., ferric iron precipitation), and biological methods (e.g., bioreactors/treatment plants, treatment wetlands). All these technologies vary in their characteristics, such as treatment efficiency (i.e., percent removal), achievable final effluent concentrations, volumes of water that can be treated economically, temperature-sensitivity, etc. This variation presents some difficulties to compare these technologies and identify the most appropriate solution for coal mines in Alberta.

This document presents the current state-of-the-art on treatment technologies for reducing selenium levels in water. Its main objectives are to:

- Review scientific literature and obtain expert opinion on available treatment technologies to reduce selenium in water;
- Using similar criteria, evaluate the technical feasibility of each technology;
- Recommend treatment options that might be used to reduce selenium in surface water at Alberta mines.

It is expected that new developments on the horizon will amplify or add to this information, but that the fundamental knowledge presented herein will not change.

.

2 Selenium chemistry

Understanding the characteristics and reactions of selenium provides a context for the potential use and choice of treatment technologies presented in Section 4. Thus, Se chemistry will be briefly reviewed here.

2.1 Physical Properties

Selenium was first identified as an element in 1817 by Swedish chemists J.J. Berzelius and J.G. Gahn. Its atomic number is 34, mass is 78.96, melting point 271°C, boiling point 685°C, and density 4.26-4.79. Se is in Group VIA of the periodic table between sulfur and tellurium. Its electron distribution is similar to that of sulfur, a fact reflected by the similarities of their chemical properties. Like sulfur, selenium occurs in oxidation states II-, 0, II+, IV+, VI+, although the II+ oxidation state is not known to exist in nature. Se is considered a metalloid because it possesses both metallic properties (e.g., semi-conductor) and non-metallic properties (e.g., elemental Se is dull, without metallic shine).

Se is present in the environment in both inorganic and organic forms. The inorganic forms are elemental Se (Se°), selenite (Se[IV], SeO_3^{2-}), selenate (Se[VI], SeO_4^{2-}), and hydrogen selenide (Se[-II], H_2Se) (See Figure 2). The oxidized forms of Se exist as soluble oxyanions in aqueous environments, with selenate dominant in freshwater and selenite dominant in seawater. Neither of these anions react with cations (e.g., Ca, Mg) under normal ambient conditions, thus remaining soluble in most water bodies. Elemental Se is found in either an amorphous state (an easily identifiable crimson red form, see Figure 1) or in one of three crystalline states. Most stable is the gray, semi-metallic crystalline form which exhibits photoconductive properties and has various industrial uses.



Figure 1. Elemental selenium formed by bacterial reduction of selenate.

Reduced Se species include inorganic forms, such as hydrogen selenide (H_2Se), and organic forms such as volatile methylselenides and nonvolatile organic compounds. Methylated forms are volatile, sparingly soluble and comparatively non-toxic. The Henry's Law constant for dimethyl selenide, the most commonly volatilized species, has been reported as 0.058 (5) and 0.0879 (for both dimethyl selenide and dimethyl diselenide, 6). Most organic non-volatile organoselenides have not been characterized. These species have direct carbon-Se bonds and are biologically active as selenoamino acids and selenoproteins. Two of these compounds are selenocysteine and selenomethionine, which are highly toxic analogs of the sulfur-bearing amino acids cysteine and methionine.

Se is almost exclusively associated with sulfur in endogenic processes (those occurring inside the earth), but differences in melting and boiling points and in redox potentials mean that they follow different paths

in exogenic processes. The similarities in ionic radius (198 pm for Se vs. 184 pm for S) allow for ionic substitution of Se(II-) for sulfur in sulfur minerals. Mineral selenides are usually found in association with sulfur minerals such as chalcopyrite ($CuFeS_2$), pyrite (FeS_2), and galena (PbS), forming seleno-counterparts to these sulfur minerals, such as selenopyrite (SeFeS). Elemental Se can also react directly with reduced sulfur compounds to form insoluble selenosulphides, e.g., Se_2S_3.

Selenates and sulfates have similar colors, ease of crystallization and water solubility, but have different decomposition pathways. While sulfates decompose to give the metal oxide, sulfur dioxide and oxygen, the equivalent mineral selenates typically decompose to give the metal-selenite and oxygen. This results from the greater stability of salts in the selenite-selenate system. Selenides of heavy metals such as mercury, silver, copper and cadmium are highly insoluble, which may explain an association between selenite and decreased heavy metal toxicity.

In coal, Se is one of the most strongly enriched element, being present as an organoselenium compound, in solid solution with pyrite and other sulfides, and as lead selenide (7, 8). It is primarily associated with the organic constituents and micron-sized sulfides and selenides, but is highly variable as a result of the variability of its sources.

Se is used extensively in the production of glass, pigments, rubber, metal alloys, textiles, petroleum, and photoelectric applications. The use of Se-based pesticides has been curtailed largely due to their stability in soils and resultant contamination of food crops, and their toxicity to mammals and birds (2).

2.2 Chemical Properties and Reactions

The many possible oxidation states of Se make for a complex chemistry. Interactions are further complicated by biologically mediated oxidation-reduction reactions. Speciation in soil solution is governed by various physico-chemical factors expressed in terms of pH, dissociation constants, solubility products, and oxidation-reduction potentials (9).

2.2.1 *Oxidation/Reduction and Solubility*

Se speciation is highly influenced by reduction/oxidation (redox) chemistry. This is especially important because Se oxyanions (sele*nite*: Se(IV) and sele*nate*: Se(VI)) are highly soluble, while the reduced forms (elemental selenium: Se° and sele*nide*: Se(II-)) are insoluble. It is the solubility of the oxidized forms that allows for their mobility in the environment and their biological uptake. As with sulphur compounds, selenite is quite reactive and is more easily reduced to elemental Se. Most selenite salts are less soluble than the corresponding selenates. The extremely low solubility of ferric selenite $Fe_2(SeO_3)_3$ ($K_s = 2.0 \pm 1.7 \times 10^{-31}$), and of the basic ferric selenite $Fe_2(OH)_4SeO_3$ ($K_s = 10^{-61.7}$), is important to the environmental cycling of selenium, as well as providing a basis for treatment (10).

Figure 2 shows the areas of thermodynamic stability for the Se-H_2O system in relation to redox potential (Eh) and hydrogen ion potential (pH). Typical redox potentials for environmental media are in the following ranges: Surface water (pe 1 to 6); groundwater (pe -1 to 1); wetland sediments (pe -4 to 1).

These distributions assume that equilibrium is established, a condition that is rarely met. Thus, the reduction of selenate to selenite is thermodynamically favoured but this reaction is very slow (days) and is rarely complete. In contrast, selenite is reduced to insoluble forms in a matter of hours at low redox potential (11). In fact, selenate, selenite, and biselenite ($HSeO_3^{2-}$) are commonly found outside of their predicted zones of thermodynamic stability. Both H_2Se and HSe^- also occur but are comparatively uncommon.

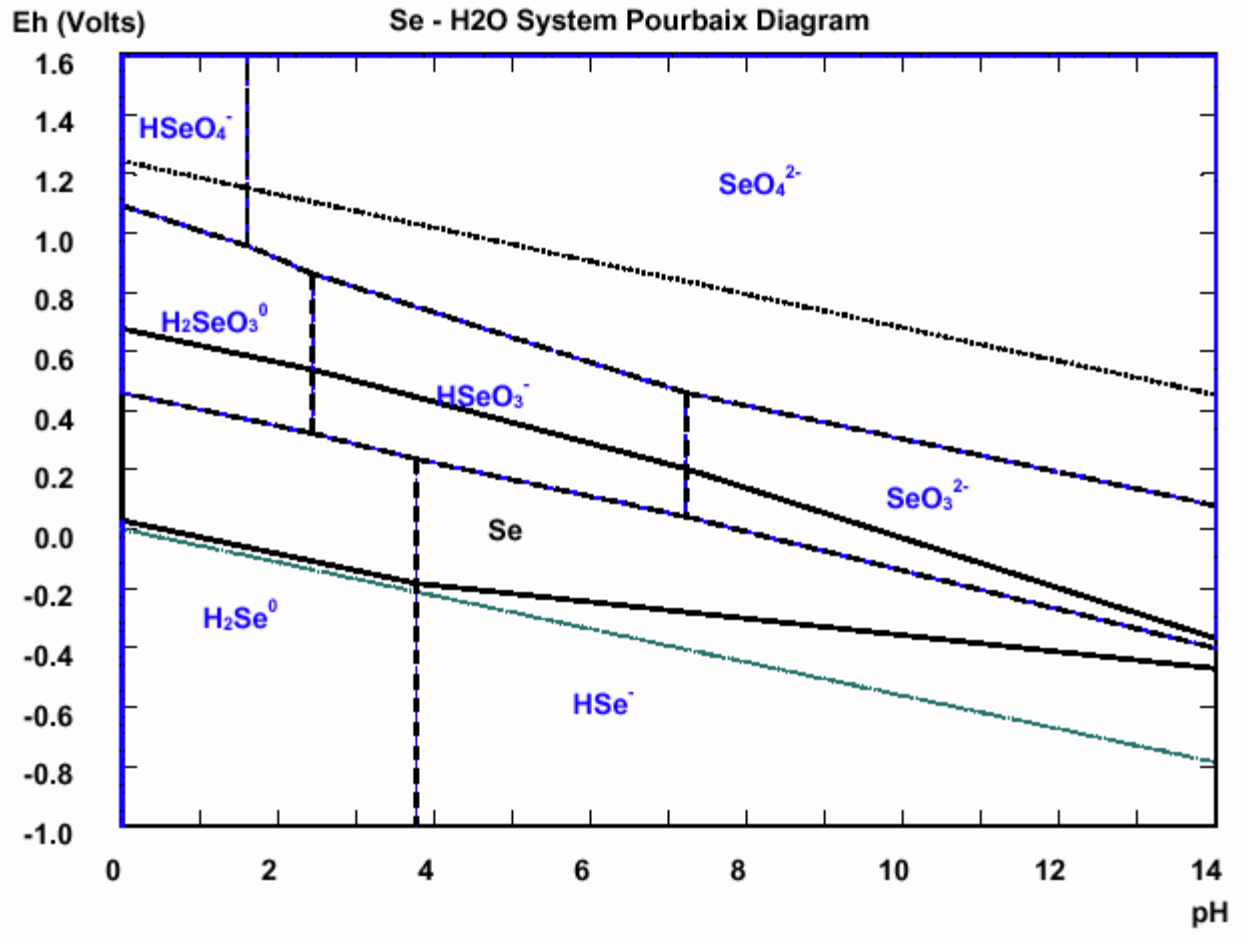


Figure 2. Eh-pH diagram for Se-H_2O system.

The transformation of selenate to selenite, while thermodynamically favoured, occurs slowly because the activation energy for this reaction is very high. ***The feasibility and/or economics of different treatment systems often revolves around this fact.*** Typically, chemically-based treatment processes require an initial reduction of selenate (stable) to selenite (reactive) using strong reductants (e.g., zinc powder). In contrast, microbes catalyze this reduction at ambient conditions, a strength of biologically-based processes.

Calculated reaction equilibria and constants at environmentally-relevant oxidized or moderately reduced conditions indicate that metal-selenite and metal-selenate minerals are too soluble to persist in soils and sediments (12). Under these redox conditions, Se solubility appears to be governed by an adsorption-type mechanism rather than precipitation/dissolution reactions. At low redox potentials, elemental Se or a metal selenide are predicted to limit Se solubility. Since hydrogen selenide (H_2Se) is a highly reactive species, it will be transformed into metal selenides such as FeSe and $FeSe_2$, or ionically substituted into metallic sulfide minerals such as chalcopyrite ($CuFeS_2$) and pyrite (FeS_2). Either elemental Se or these insoluble minerals could act as potential sinks for Se.

Naturally, as redox conditions change, reduced compounds could become sources of soluble selenium. Oxidation of elemental selenium and Se-containing pyrite was credited as a source of increased soluble Se concentrations in Kesterson Reservoir sediment suspensions (13). Similarly, the continued release of selenium in the British Columbia and Wyoming coal fields, and in the Idaho phosphate region, has been shown to arise from the oxidation of Se-containing pyrite (14, 15). The former examples are relevant to the Alberta foothill coal mines, because they likely share common geological origins, including

Cretaceous marine shales, which may have high Se concentrations (16). It suggests that selenium release may persist for decades, as long as the sulphide minerals are exposed to the atmosphere and allowed to weather.

2.2.2 *Methylation and Volatilization*

Dimethyl selenide (DMSe, $(CH_3)_2Se$) and dimethyl diselenide (DMDSe, $(CH3)_2Se_2$) are two volatile species of Se. In natural waters, the production of DMSe is proposed to involve enzymatic and nonenzymatic processes. Methylation is one way for organisms to eliminate excess Se, and aerobic and anaerobic bacteria and fungi capable of doing so have been reported (12). Se volatilization in plants also appears to be a detoxification mechanism and is correlated with tissue Se concentration. Threshold Se concentrations at which volatilization occurs, and rates of volatilization will vary with species for a given water chemistry. DMSe volatilizes rapidly due to its limited water solubility and high vapor pressure. Volatilization rates of Se from soils and plants are also affected by temperature, moisture, time, season, concentration of soluble Se, and microbiological activity. Addition of carbon, alkaline pH values, and oxidation to moderately reduced conditions stimulate biomethylation of Se (12).

Hydrogen selenide (H_2Se) is another volatile species. It may be produced and released in reduced environments, but it oxidizes quickly to elemental Se in the presence of oxygen.

2.2.3 *Other Reactions*

Complexation reactions can also occur with Se, and ion pairs such as $CaSeO_4^{\circ}$, $CaSeO_3^{\circ}$ together with the dissociated SeO_4^{2-} and $HSeO_3^{-}$ species are predicted to be thermodynamically dominant. However, unlike sulfates and sulfites, concentrations are rarely high enough to allow such associations in significant quantities.

Selenite adsorbs to surfaces far more than selenate. Sorption can be onto detritus, clays, Fe- and Mn-oxyhydroxides, or onto soils, and each is pH-dependent (12). Like phosphate and sulfate, the association of selenite with Fe- and Mn-oxyhydroxides is very strong and is described as a ligand exchange reaction, whereby –OH groups on the surface of the mineral are replaced (17). There is a treatment process that exploits this reaction for selenium removal.

An interesting abiotic transformation is the reduction of selenate to elemental Se in the presence of Fe(II,III) oxides known as Green Rust (GR). GRs were initially found as intermediate products of the reduction of iron oxides in aqueous systems, but have recently been found as minerals (i.e., compounds forming in a natural environment). Only in the past few years have the environmental occurrences and implications of GRs been considered. The catalyzation of the selenate redox reaction by GR may represent a pathway for Se cycling which had previously been considered to be mediated by microorganisms. The rapid oxidation of green rust has allowed its presence to be overlooked in the past, but recent studies give evidence of its presence in soils, sediments and porewaters. The reduction reaction can be described as follows:

$$HSeO_4^- + 4Fe_4^{II}Fe_2^{III}(OH)_{12}SO_4{\cdot}3H_2O \Leftrightarrow HSe^- + 8Fe_3O_4 + 4SO_4^{2-} + 8H^+ + 32H_2O$$

This may occur either through coprecipitation and reduction in GR interlayers, or by adsorption on the GR surface. Myeni et al (18) investigated this transformation and found that green rust catalyzed the reduction of selenate in anoxic conditions with pH>5.0. The degree of reduction varied with pH (greater at higher pH), the nature of the reaction (coprecipitation or adsorption), and the initial concentration of Fe(II). Synthetic green rusts have been developed for corrosion studies by oxidizing $Fe(OH)_2$, incorporating Cl^-, SO_4^{2-}, or CO_3^{2-} ions (19). Our understanding of this mechanism is still in its infancy, but investigation into the remedial possibilities for GR in wetlands is certainly warranted.

3 Source Control

The expected length of time for the release of selenium at the mountain coal mines in west-central Alberta is not known at this time. Thus, it is not known how long selenium levels will remain elevated or if selenium levels will increase over time. At the Alberta mines it is possible that selenium mobilisation due to mining activities or disturbance may be a long-term problem. This is expected to be the case at the Elk Valley River coal mines in Southeastern BC because selenium is associated with sulphide minerals (15), which may oxidize for decades. A similar problem exists at many metal mines, which may leach metals for decades after closure. These mines have developed a number of strategies to minimize or mitigate metal release from waste rock. Time and again, it has been shown that preventative measures are the most cost-effective way to mitigate impacts from contaminants leached from waste rock. These measures include preventing or minimizing sulphide oxidation (submerging sulphide minerals, covering waste rock with air or water impermeable soil covers) or managing the contaminants in place (e.g., using *in-situ* treatment, phytoremediation).

In Idaho, both coal and phosphorus mines contain highly seleniferous shales that represent long-term sources of selenium in the environment. Mining companies in that state have collaborated with the US Forest Service (USFS) and Bureau of Land Management (BLM) to develop Best Management Practices (BMP) that minimize the release of selenium from these materials. For example, shales with high Se are identified during mining and are returned to open pits, where they are covered with 8-10 feet chert (non-seleniferous), then capped with top soil, as a means of minimizing Se release (20). This and other BMP are currently being formalized and collated, and are expected to be available by the time this report is published[1].

Two of the most common preventative methods used to minimize Se release will be discussed briefly, since they form a component of the overall treatment solution at mine closure.

3.1 Submerging Sulphide Minerals

Submerging tailings containing sulphide minerals, or “subaqueous disposal”, is practiced at metal mines. The low dissolved oxygen concentrations in the water overlying submerged tailings keeps oxidative rates at a minimum. Furthermore, reducing conditions may develop at depth, near the surface of tailings, thereby halting oxidation altogether.

This approach was extensively studied by metal mining companies. One of the key reports from these studies (21) was that sulphides in tailings either did not release metals, released minor amounts of some metals (e.g., zinc), or release soluble metals (e.g., arsenic) originating from minerals that were oxidized during processing (milling). A companion study that reviewed effects from submerged tailings reported that there are no demonstrable aquatic impacts (22).

Another application of this method is the flooding of underground mines, where metal leaching rates decrease dramatically upon flooding. For instance, zinc concentrations in the Galkeno 900 adit discharge decreased gradually as the underground workings flooded after a concrete plug was installed in the adit (23).

[1] Further information should be available from the USFS, Soda Springs office, or the BLM, Pocatello, ID.

3.2 Soil Covers

In most circumstances, placing engineered soil covers on rock that releases selenium is likely to substantially decrease loadings.

Covers are constructed from natural or man-made materials that retard or divert the movement of water and oxygen into areas containing oxidizing rock[2]. Soil covers can achieve substantial reductions in water flow through piles, but generally do not completely stop sulphide oxidation. For instance, a cover placed over waste rock dumps at the former Rum Jungle Mine reduced sulphide oxidation rates by a factor of 2-3, based on 15 years of monitoring (24). These covers are typically designed by soil engineers, based on material availability, climate, anticipated life, treatment objectives and desired performance (25).

There is a great deal of information available on soil covers, but it will not be reviewed here because it is peripheral to the main focus of this document. Much of the research is published in proceedings from mining conferences, such as those of the International Conference on Acid Rock Drainage (ICARD) or the American Society for Surface Mining and Reclamation (ASSMR). Additional information is available from various research groups (e.g., Unsaturated Soils Group, Dept. Civil Engineering, University of Saskatchewan; The Australian Centre for Mining Environmental Research (http://www.acmer.com.au); consulting firms (e.g., O'Kane Consultants Inc. http://www.okane-consultants.com), etc.

[2] Plastic liners are rarely used because covering large volumes of waste with a liner is usually too expensive.

4 Treatment Systems

Although many different processes have been examined for the removal of selenium from surface waters contaminated by selenium, only a few engineered solutions have been shown to be successful on a commercial scale. In the past, the most widely used approach involved chemical co-precipitation with iron salts at an acidic pH. However, this process is only effective with selenite, and it will not consistently decrease Se concentrations to currently existing discharge criteria. Recent advances in membrane technology and biological processes have brought a new generation of treatment systems. These various systems are reviewed below.

Selenium treatment can be divided into physical, chemical, and biological processes, as shown in Table 1.

Table 1. Types of treatment systems available for selenium.

Physical	Chemical	Biological
Reverse Osmosis	Zinc or iron reduction	Volatilization
Nanofiltration	Iron precipitation	"In-situ" treatment
Ion Exchange	Cementation	Bioreactor
Deep Injection/ Evaporation		"Passive system", i.e., Biopass, Reactive Wall
		Treatment wetland

Reverse osmosis (RO), nanofiltration, and ion exchange remove selenium from an effluent by concentrating it into brines or wash solutions. The resulting concentrates must be disposed safely, either by deep-injection, evaporating the solutions, or other methods.

Chemical methods rely on the reactivity of selenite (Se(IV)), whether with iron or other reagent. Typically, a pre-treatment is required to chemically reduce Se(VI) to Se(IV), using (most commonly) elemental iron or zinc. Such a reduction of Se(VI) is not normally required for biological treatment, but other forms of pre-treatment may be required, such as removal of nitrate[3]. These different pre- and post-treatment steps add to the complexity of the system (its design, operation, etc) and they must be included in any calculation of treatment cost.

Technologies are commonly evaluated by comparing the cost for treating 1,000 gallons of mine water. This cost is either explicitly expressed as an operating cost, or is implied as an amortized capital cost + operating cost for a defined period (e.g., ten years).

When comparing different treatment systems, two factors must be kept in mind. First, the system eventually adopted may make sense for that mine or industry, but not elsewhere. Thus, at Lac Mineral's (now Barrick) Richmond Hill Mine, iron reduction followed by iron co-precipitation was selected partly because tanks used for the carbon-in-pulp gold extraction could be marshaled to this task. Similarly, the Biopass system developed at Homestake's (now Barrick) Santa Fe Mine made sense because the

[3] Bacteria that utilize nitrate to oxidize organic matter derive more energy than those that use selenate or selenite. This confers an advantage to them and allows them to outcompete selenate-reducing bacteria. In practice, nitrate will be removed before selenium in any biological treatment system.

drawdown water from the spent heap was to be released for a limited time, flows were limited, other contaminants (e.g., nitrate, mercury) were also treated in the system, and because lined, open ponds were available for this system. Economics greatly favoured these systems because these facilities were available, thereby reducing capital costs.

The only way to compare "apples with apples" is to evaluate side-by-side different technologies that treat the same water. Such an evaluation was conducted recently by the U.S. EPA, and its results will be reviewed.

A second factor to consider is the gap between technology development and adoption. Thus, nanofiltration is a very promising technology, but no one is willing to be the "test case" in the industry. Consequently, this technology sits on the shelf, waiting for someone to give it a try. However, this situation is changing in the U.S.A. because of the stringent regulatory requirements to treat selenium to very low concentrations.

4.1 Physical

Physical methods used for selenium removal include membrane filtration and ion exchange (electrostatic interactions) methods. Membrane filtration does not discriminate between selenate and selenite, but ion exchange does, being only effective on the latter. Thus, a pre-reduction step is required for treatment of selenate-containing water by ion exchange.

Adsorption onto activated carbon has not proven effective for selenium removal, at least in achieving the low concentrations (< 5 ug/L).

Generally, treatment systems based on these processes are expensive, due to the requirement for pre-treatment steps and post-treatment disposal of concentrated reject brines, as discussed below. This has limited their application at mine sites.

4.1.1 *Membrane Filtration*

Reverse osmosis (RO) and nanofiltration are two membrane filtration methods for treating contaminated water. RO is a widely used and tested technology, whereas nanofiltration is relatively new. Both technologies use a membrane that is semi-permeable, allowing the fluid that is being purified to pass through it, while rejecting the contaminants that remain. The membrane for nanofiltration is different from that used in RO, in being charged and having a hydrophobic reject layer, thereby selectively rejecting divalent salts while retaining monovalent salts. Most RO technology uses a process known as crossflow to allow the membrane to continually clean itself. As some of the fluid passes through the membrane the rest continues downstream, sweeping the rejected species away from the membrane.

Membrane filtration requires a driving force to push the fluid through the membrane, and the most common force is pressure from a pump. The higher the pressure, the larger the driving force. As the concentration of the fluid being rejected increases, the driving force required to continue concentrating the fluid increases. The pressure can reach 1,000 psi, and this requirement constitutes a high proportion of the operating cost. In this respect, nanofiltration is attractive because it operates at lower pressures, and therefore costs less to operate.

Their ability to meet acceptable discharge criteria depends on the characteristics of the mine water to be treated. It is generally agreed that complex or hard waters cannot be treated to below 10 ppb (26). Successful treatment requires a water softening plant to pre-treat mine water. In any event, this would normally be required to prevent excessive membrane fouling, as described below.

There are problems inherently associated with these technologies. Fundamentally, treatment is extended until constituents of concern (e.g., Se) reach the desired final concentrations. As solutes are being concentrated, some salts initially present at high concentrations may crystallize, thereby impairing function or damaging membranes. This is particularly true for hard waters containing high calcium and magnesium concentrations. In general, membrane life is expected to be 2-3 years, depending on the Total Dissolved Solids (TDS) of the water being treated.

In addition, the concentrated brine containing the rejected contaminant(s) must be dealt with safely and cost-effectively. This may require an evaporation facility to dispose of the brine, deep-injection, or some other method. These options can be expensive, depending on the volume of brine to be disposed.

Treatment costs are high, which has limited application of this technology at mines. Depending on necessary pre- and post-treatment requirements, operating costs can range from USD$4.7-71/1,000 gallon, with a median around USD$10-15/1,000 gallon. Capital costs can exceed USD$1 million for the RO unit alone, depending on volumes being treated.

At Lac Mineral's (now Barrick) Richmond Hill Mine, reverse osmosis was selected to treat mine water that is incompletely treated by iron reduction and precipitation (described below). The latter decreases Se concentrations from over 100 ppb to 12-22 ppb, whereas RO decreases it further to approximately 2 ppb. The RO unit is operated at 250 psi and up, which contributes substantially to the operating cost. Flows of 200 gpm are fed to the RO unit, and it produces a permeate at 100 gpm and a reject stream at 100 gpm. This brine, which is a Se concentrate, is cycled back to the iron treatment circuit. Given that selenium is produced from 52 acres (21 hectares) of leach pads, water treatment is expected to be required for at least 50 years.

A filtration pre-treatment is necessary to remove TSS. In addition, the operator is currently evaluating the need to remove calcium in a softening plant. Calcium concentrations in the feed have gradually increased to the present 450 ppm, causing gypsum to be deposited on membranes as salts become concentrated. The cost of this additional softening plant is compared against that of the shortened membrane life, which is presently replaced every 1-2 years at USD$30,000, instead of the normal 3 years.

During winter operation, water is heated to 15 ºC to prevent the cold-induced salt crystallization[4] on membranes. The heating cost is approximately $USD5,500/week, and depends on the weather[5] and propane costs.

The capital costs include purchase of a used RO unit at USD$750,000 (a new unit with the same capacity is approximately $1.2 million) and a multimedia pre-filtration unit at $200,000. Overall monthly operating costs are $50,000, or $10/1,000 gallon when the RO unit operates without trouble. The above issues are presently increasing treatment costs to $18/1,000 gallon. Some of these problems stem from changing water chemistry, some are caused by algal growth.

Nanofiltration is potentially less expensive than RO, due to its more selective nature and the lower pressures under which it operates. There are no examples of mines currently using this technology, although Newmont has evaluated its use at the closing Yanacocha Mine, in Peru to remove sulphate and thallium.

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[4] Concentrated salts are less soluble in the cold.

[5] South Dakota winters are comparable to Alberta winters.

The same issues of membrane fouling must be considered: pre-treatment for high TDS, addition of anti-scalants, anti-bacterial agents and Total Suspended Solids (TSS) removal may be necessary. These can add 10-20% to the operating cost of treatment.

Capital costs for a single-stage filtration unit are quoted at USD$2,000/gpm feed: a plant treating 500 gpm would cost $1 million (27).Additional pre-treatment may be 50% of the treatment plant cost, ranging from $300 - 1,000/gpm feed. Operating costs are quoted at approximately $0.50-0.60/1,000 gallons for a nanofiltration unit, with an additional $0.10-0.15/1,000 gallons for additional pre-treatment. This is much lower than operating costs for RO, but there are no operating nanofiltration units from which these costs could be verified. Additional maintenance costs include changing membranes every 2-3 years.

Development time is relatively short. Laboratory scoping studies can last two weeks, followed by a pilot campaign lasting one month, including mobilization and demobilization. System design can take one week, and ordering can take 20-24 weeks. Thus, a plant can be operational within half a year, assuming a fairly simple design. Additional delays will come from the requirement for, design and construction of pre- and post-treatment units.

4.1.2 *Ion Exchange*

Ion exchange is a reversible reaction wherein an ion (an atom or molecule that has lost or gained an electron and thus acquired an electrical charge) from solution is exchanged for a similarly charged ion attached to an immobile solid particle. These solid ion exchange particles are either naturally occurring inorganic zeolites or synthetically produced organic resins. Efforts to use zeolites for selenium removal have met with limited success. The synthetic organic resins are the predominant type used today because their characteristics can be tailored to specific applications.

Selenium removal is accomplished by using a strong base anion ion exchange resin. Se(VI) is extracted much more effectively than Se(IV). The extraction of Se(VI) is decreased by sulphate. Tailored resins show good selectivity for selenium in the presence of sulphate but only laboratory studies have been performed. Further laboratory studies (on mine waters) are required.

Once the capacity of the resin becomes exhausted, it must be regenerated with a strong acidic solution. As with RO and nanofiltration, the disposal of this solution adds to the overall cost of this technology.

Liquid ion exchange has been investigated on a pilot scale for treating gold heap leach solution effluents. The results were encouraging but the technology has been documented at only one site. Further laboratory and pilot test work need to be conducted.

4.2 Chemical

Several chemically-based treatment processes have been investigated, but only iron co-precipitation has met with success on a commercial scale. Precipitation with activated alumina has not met with success, though it has been tested extensively. Precipitation on lanthanum oxides looks promising, but has not yet been tried beyond the laboratory.

4.2.1 *Iron coprecipitation*

Ferrihydrite precipitation with concurrent adsorption of selenium onto the ferrihydrite surface is an USEPA-approved technology for treating selenium-bearing waters. For the coprecipitation to occur, ferric ion (Fe^{+3}) must be present in the water. The chemical reaction for ferrihydrite precipitation of selenium is:

$$Se^{+4} + FeCl_3 + 4H_2O \rightarrow Fe(OH)_3 \bullet Se^{+4} + 8H^+$$

Adsorption on ferrihydrite has been investigated by several researchers. Se(IV) is effectively removed at pH < 8. This technology is not very effective for Se(VI) except at high Fe/Se weight ratios and relatively low pH levels. Reduction of Se(VI) prior to adsorption is required for effective removal. The presence of other aqueous species may have a detrimental influence on the removal of Se(IV) and Se(VI).

In a review of this technology, Tidwell and co-workers (28) indicated that:

- Se(IV) is adsorbed much more effectively than Se(VI);
- Se(IV) adsorption is a function of type of oxyhydroxide present (amorphous ferrihydrite is best, crystalline FeOOH is considerably less effective);
- The initial concentration of Se(IV) in solution is very important (the higher the Se(IV) concentration the more effective the adsorption);
- The best pH for effective Se(IV) adsorption is 4-6 (85-90% removal), adsorption decreases slowly until about 7 (80-85% removal), then decreases drastically to about (20-40% removal)

In early studies on selenium treatment, Merrill and co-workers (29) reported an optimum pH of 6.5 for Se(IV) removal and that the optimum iron dosage was 14 mg/L for a water initially containing 40-60 µg Se/L. The effluent selenium concentration resulting from the treatment of 33 gpm in a continuous pilot facility was < 10 µg/L. The process treatment created 2.1-3.1 kg sludge/kg iron added. The estimated cost of processing 26 million gallons/day (for arsenic, heavy metals and selenium removal) would be USD$ 0.50/1000 gallons. This estimate, which seems very optimistic, is based on a flowsheet consisting of ferric chloride addition to form ferrihydrite, rapid mixing, polymer addition for agglomeration, clarification, sludge thickening and dewatering, and disposal of dewatered sludge in a municipal landfill.

The effect of other anions on the adsorption of selenium has been investigated (30). Certain anions were found to preferentially adsorb onto ferric oxyhydroxide. The order of adsorption at pH 7 was found to be phosphate > silicate = As(V) > bicarbonate/carbonate > Se(IV) > oxalate > fluoride = Se(VI) > sulphate. The order of adsorption at the lower pH used in treatment plants may be different.

The long term aging stability of adsorbed/co-precipitated selenium remains to be demonstrated. Adsorbed Se may be released when amorphous iron oxide crystallizes to the more thermodynamically stable phases of goethite (FeOOH) or hematite (Fe_2O_3).

At Lac Mineral's Richmond Hill Mine, a selenium treatment system was developed in 1994, based on a process using elemental iron to reduce selenate to selenite, followed by ferric sulphate precipitation at pH 4.5, with a copper sulphate catalyst. The resulting slurry is sent to a thickener to produce a peanut-butter-like sludge that is stored in a sludge pond.

The treatment process needed three years to be optimized. Even so, the best that could be achieved is effluent Se concentrations of 12-22 ppb, which is unacceptable for direct discharge to the environment. The treatment system is now used in conjunction with an RO treatment, which together produces an acceptable effluent.

A treatment plant was developed at FMC's (now Meridian) Dry Valley Mine for selenium removal (31). The process used zinc powder as a reductant, converting all the selenium to selenite, followed by iron salt precipitation at acidic pH. A similar plant was designed at a Homestake mine, where (elemental) iron powder and ferrous sulphate were used as reductants and ferric chloride was used to form ferric

hydroxide, which co-precipitates selenite. Again, the reaction was carried out at ~pH 4.5 and requires tight pH control (+/- 0.2 pH units).

Although capital and operating costs could not be found for both operations, their design and operation is comparable to the treatment plant for molybdenum removal at Noranda's former Brenda Mine. That treatment plant operates under very similar conditions and removes molybdenum through the same process (Figure 3), although it has been rated at 2,000-4,000 gpm. It is designed to operate for over 100 years, and reportedly costed over CDN$10 million when it was built in 1998 (32).

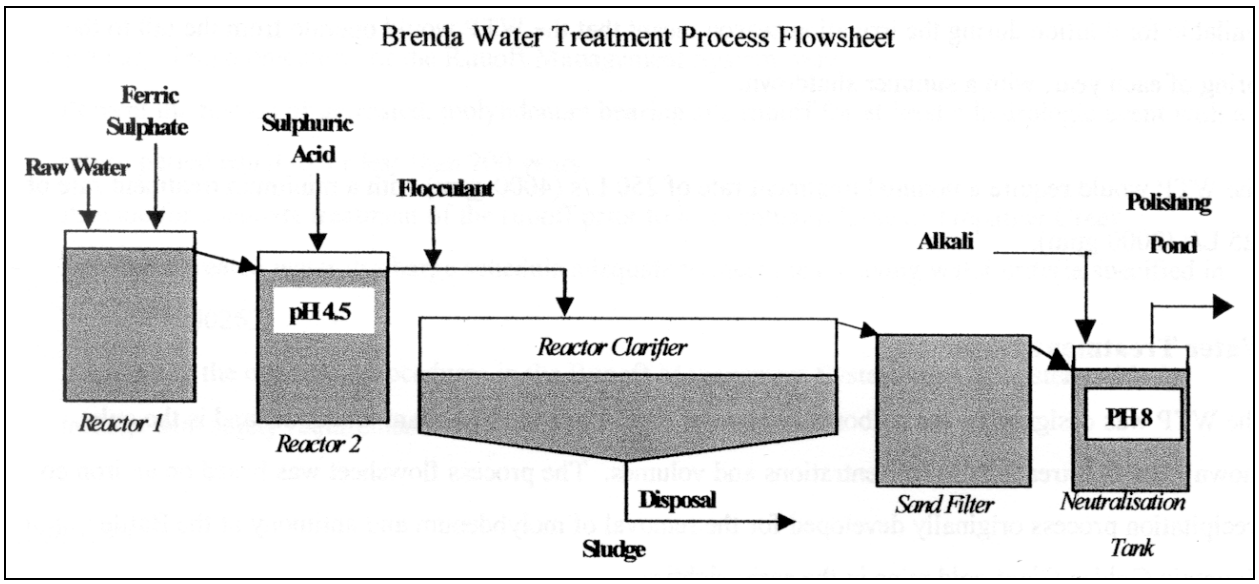


Figure 3. Process flowsheet for the Brenda water treatment plant.

Another chemical process, called catalyzed cementation has been developed by Dr. Larry Tidwell, Montana State University, to remove arsenic, metals and metalloids such as thallium and selenium from water. The term catalyzed cementation describes the process's ability to remove contaminants from solution by cementation (adsorption) onto the iron surface. Catalyzed cementation is expected to treat and remove selenium from solution regardless of its valence state (+6 or +4). To optimize the cementation process, proprietary catalysts are added to increase the removal efficiency of the process[6]. Laboratory tests have shown that selenium concentrations are decreased to below 50 ppb.

This process was tested in a US EPA-sponsored demonstration project at Kennecott Utah Copper Corporation's (KUCC) Garfield Wetlands-Kessler Springs site (33). This demonstration project was established to compare three different technologies side-by-side, thereby collecting comparable performance and cost information.. The site provides water with uniformly high selenium concentrations of 1,600 ppb Se, mostly as Se(VI).

During the test, flows were maintained at 1 gpm. In this process mine water receives iron powder, a proprietary catalyst, and its pH is carefully adjusted to allow for selenate reduction. The iron is recovered for re-use, the solution is pH-adjusted again, another reagent is added, and the cementation reaction is carried out. The suspended solids are thickened and the supernatant is discharged. The entire process is shown in Figure 4.

[6] Terry Mudder indicates that small amounts of copper aid in the adsorption of selenium onto ferrihydrite. This, or another metal, may be the proprietary catalyst.

The catalyzed cementation process could not at first consistently meet the target of 50 ppb Se in the pilot test. However, modification of treatment conditions produced a more acceptable effluent (Figure 5 and Table 2). Additional investigations in the laboratory further improved the treatment process, producing an effluent with selenium concentrations below 5 ppb.

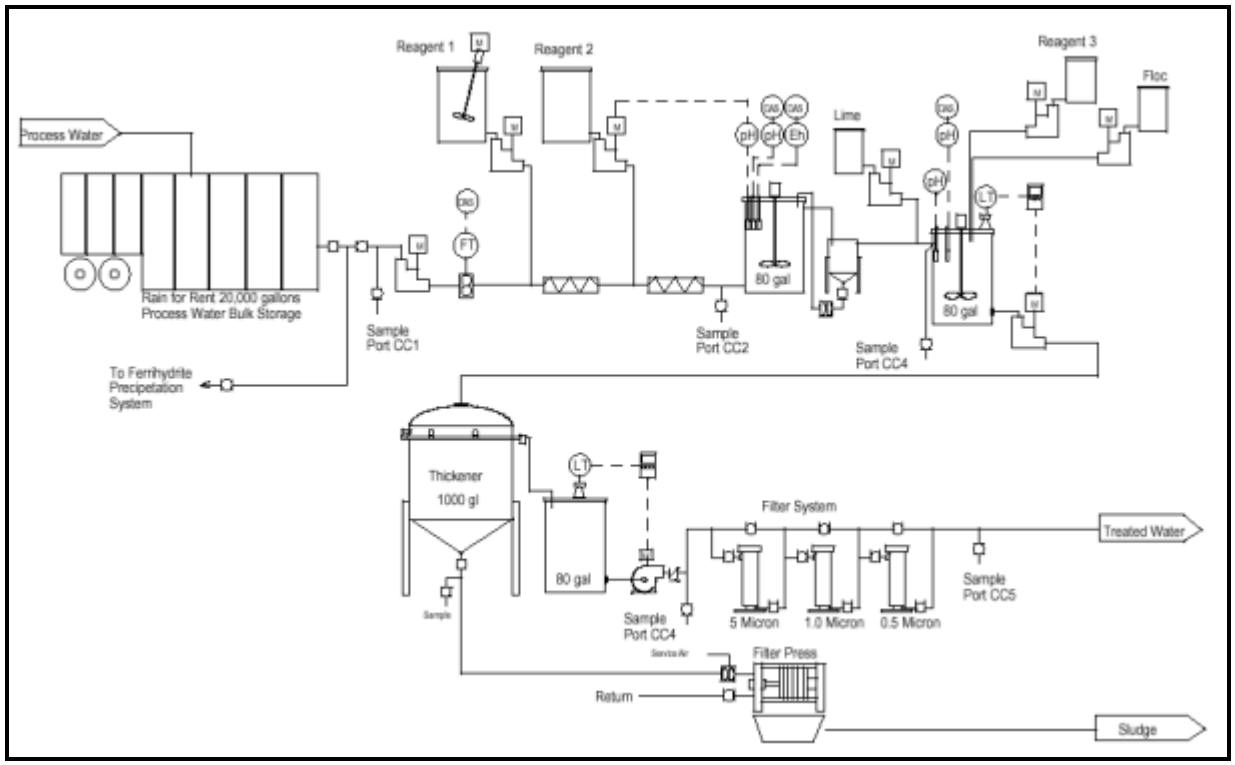


Figure 4. Flowsheet for catalyzed cementation process.

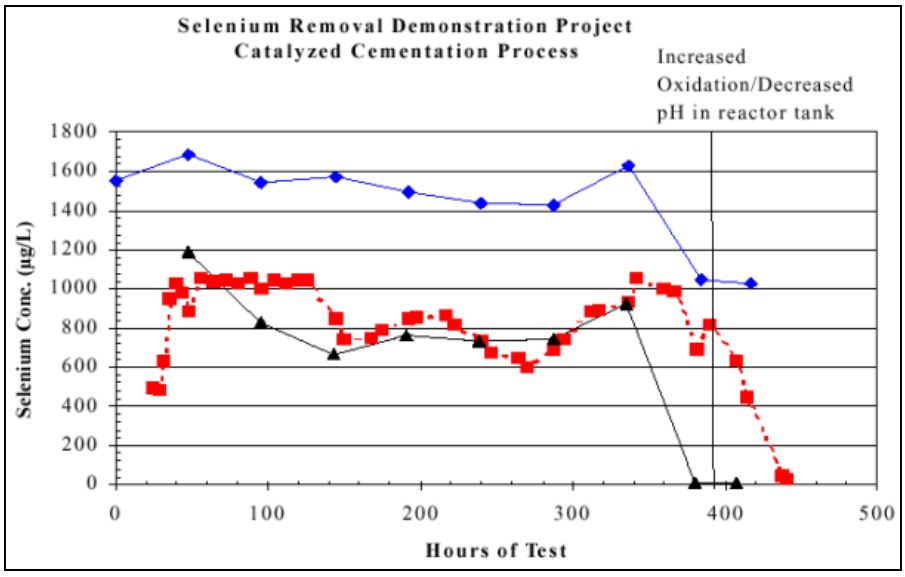


Figure 5. Treatment performance of the catalyzed cementation process at Kennecott.

Table 2. Mean effluent Se concentrations from catalyzed cementation pilot plant.

Treatment Condition	Mean Selenium Effluent Concentration (µg/L) ± Standard Deviation (n = sample size)	Minimum Selenium Effluent Concentration (µg/L)
Catalyzed Cementation	834 µg/L ± 204 (n = 42)	193 µg/L
Catalyzed Cementation with Increased Oxidation/Decreased pH in the reactor tank	35 µg/L (n = 2)	26 µg/L
Additional Testing of Catalyzed Cementation at MSE	3 µg/L 1 ± 4.4 (n = 5)	<1 µg/L

In many respects, catalyzed cementation is very similar to the above conventional iron precipitation technologies. For this reason, the cost comparison with a biological selenium removal technology is instructive. The capital costs for a treatment plant rated at 300 gpm, utilizing some tanks available on site, is calculated to be $1,083,285. Annual operating costs are calculated to be $1,165,358, of which a substantial proportion is accounted by the proprietary catalyst. The treatment cost, amortized over ten years, is calculated to be USD$8.17/1,000 gallons. As will be shown below, this is substantially more than that for biological treatment.

Another iron-based process has been developed at the University of Idaho (34). The process has been piloted and licensed to a company (Bluewater Technologies). Although treatment times are very rapid (10 minutes for low TDS water), final selenium concentrations are still remain higher than acceptable, at a reported 47 ppb. While promising, this technology still requires more development time before it can be evaluated properly for commercial application.

4.3 Biological

Treatment by biologically-based processes relies on the activity of a small group of bacteria that reduce selenate to selenite, then to elemental selenium (Figure 6 and Figure 7). Typically, these bacteria are found in anaerobic sediments, where they use selenium anions to oxidize organic matter. Different bacterial species will form either the red amorphous or the gray metallic form[7]. This may be important since these mineral forms may have different stabilities or susceptibility to oxidation.

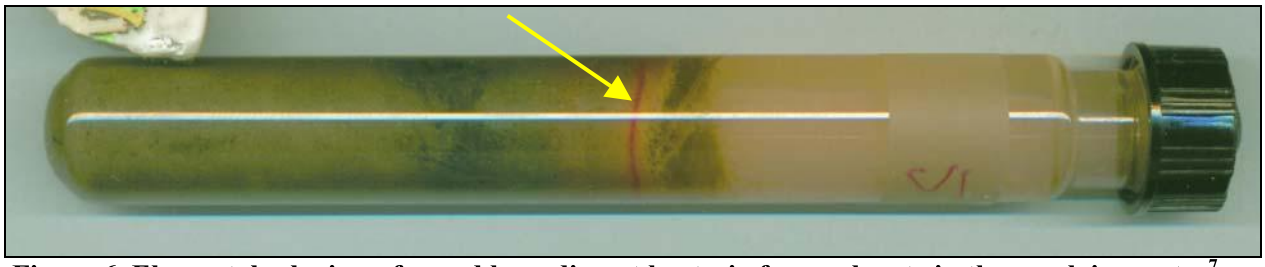


Figure 6. Elemental selenium, formed by sediment bacteria from selenate in the overlying water[7].

[7] André Sobolewski, Microbial Technologies, Inc. Unpublished observation..

Many factors affect their activity, including dissolved oxygen and nitrate concentrations (both are antagonists), temperature, pH, etc. Although it may be beneficial to identify the bacterial species used in a treatment process, this is not always necessary, since it is usually sufficient to identify the conditions that favour maximum activity.

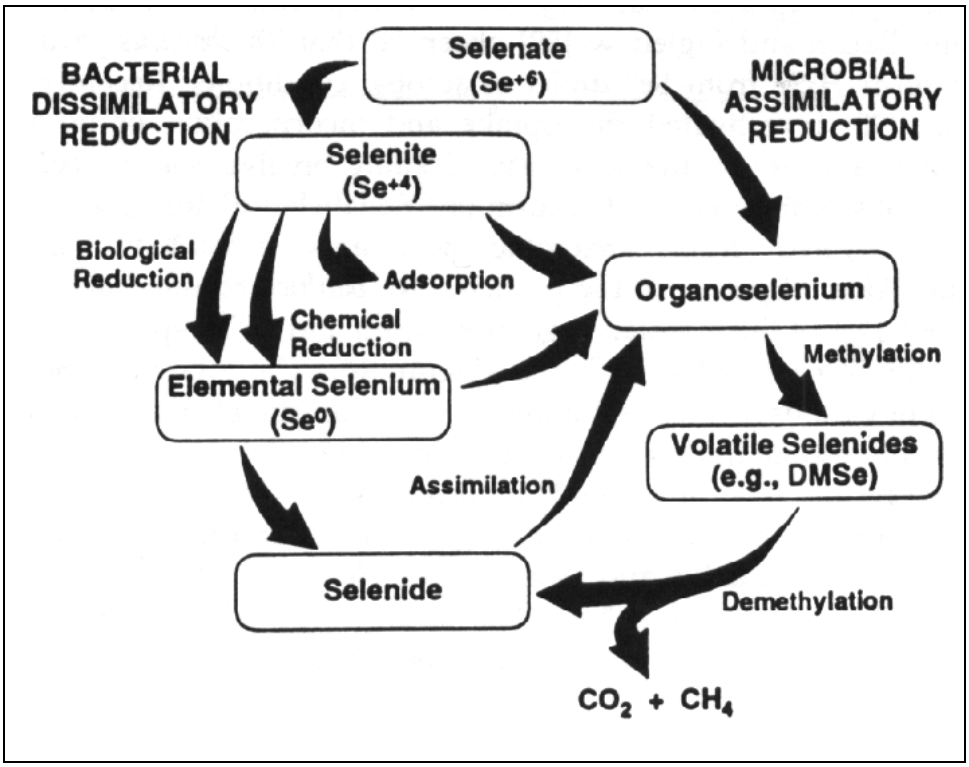


Figure 7. Selenium cycle in anoxic environments. Taken from 35.

The key to successful treatment system design lies in matching bacterial activity (i.e., selenium reduction rate) to the selenium loading rate for a given wastewater stream. This depends principally on the achievable bacterial biomass (more bacteria = higher activity), the supply of nutrients, and temperature.

4.3.1 *Selenium Volatilization*

Frankenberger and Karlson (36) attempted the remediation of sediments from both the Peck and the Kesterson ponds in the West San Joaquin Valley in California. The sediments were amended to stimulate bacterial volatilization of selenium. The Peck pond was bioremediated from a mean of 11.4 mg Se/kg sediment to the goal of 4 mg in 2.6 years. The Kesterson pond was not remediated to the 4 mg goal from 47.8 mg after 8 years, using the same techniques. The results can be explained by examining the distribution of selenium species in these sediments. For Peck the Se distribution was 6.6% Se(VI), 67.6% Se(IV), 18.4% Se(0), 7.3% Se(II-). For Kesterson, it was 5.2% Se(VI), 9.1% Se(IV), 58.0% Se(0), 27.7% Se(II-). Thus, the difference in Se(0) and Se(II-) distributions (25.7% vs. 86%) would suggest that most of the Se in Kesterson sediments was unavailable to microbial volatilization.

4.3.2 *Bioreactors*

Bioreactors are engineered structures that hold selected microbes for wastewater treatment. There are two different types of systems: active systems, essentially conventional treatment plants, in which operational parameters (pH, oxygen concentration, retention time, etc) are tightly controlled, and

passive systems, in which operator intervention is minimal. Both types of bioreactors have been designed for Se removal, as described below.

4.3.2.1 Active Systems

The efforts of the early 1990's to develop bioreactors for treatment of Se in agricultural drainage were reviewed (37). These reactors were mostly small laboratory-scale systems based on anaerobic bacteria that reduce Se oxyanions to elemental Se via the reactions:

$$\text{Se (IV+VI)} + \text{organic carbon} \rightarrow \text{Se (IV)} \rightarrow \text{Se (0)}$$

One of the systems was based on the known selenate reducer *Thauera selenatis*, originally isolated from agricultural drainage (38), whereas the others were seeded with undefined cultures. The reactors utilized either acetate or methanol as carbon sources (methanol being cheaper), and ammonium sulfate as a supplementary nitrogen source. Most of this organic carbon was consumed by bacteria respiring on nitrate (which is abundant in agricultural drainage), outcompeting the selenium-reducing bacteria.

Several reactor configurations were tested, including upflow anaerobic sludge blanket reactors (UASBR), fluidized bed reactors, sequential batch reactors, packed-bed reactors, and slow sand filters (SSF). The latter were found necessary under most configurations because they retained elemental selenium released by treatment bioreactors. Without the SSF, Se concentrations in reactor effluents were typically 30-60 μg/L, whereas they reached 15-30 μg/L with the SSF. These removal rates were achieved with retention times in the order of 10-30 hours. The removal rates were temperature-sensitive.

A common problem identified in most reactors was the formation of calcium carbonate and the potential for plugging. This results directly from the high calcium concentrations present in agricultural drainage and the production of bicarbonate during anaerobic bacteria respiration on nitrate or selenate. Although this makes these treatment systems inherently problematic, it was anticipated that these problems would be addressed during planned pilot tests.

The UASBR pilot plant campaign conducted over a two-year period identified a number of problems. The development of stable biomass took approximately 6 months. This biomass remained stable thereafter, despite variability in sludge volumes retained in the bioreactor. Approximately 90% of Se was removed during the campaign, with influent Se concentrations of 500 μg/L being reduced to 50 μg/L in the discharge. However, this level of treatment was not consistently attained, as effluent Se concentrations occasionally rose over 200 μg/L. This was due to the temperature-sensitivity of the process, as removal rates reached 88% at 15°C, but declined to 35% at 7°C. A partial solution was to insulate reactor tanks for the full-scale treatment system.

Costs were estimated for a full-scale treatment system based on the results from the pilot plant campaign. Operating costs were driven by the relatively high methanol consumption rate, being estimated at USD$1.00-1.30/1,000 gal. The total estimated costs, based on the pilot plant campaign, were USD$1.23-1.48/1,000 gal for a 10 Mgal/day plant, amortized over 20 years. Of course, these costs were derived from the treatment of agricultural drainage and are expected to be different for other types of water.

A number of treatment plants have been constructed and operated at mine sites in the past five years.

At Goldcorp's former Wharf Resources Mine, in Leads, SD, a biological treatment plant has been operated for two years. Mine water containing approximately 30 ppm nitrate (NO_3^-),15 ppb Se (as Se(VI)), and 70 ppb arsenic is collected in a French drain underlying barren rock. Flows are seasonal,

ranging from 40-300 gallons per minute (gpm). All these contaminants are removed during treatment, with NO_3^- decreasing to <1 ppm, Se to < 5 ppb, and As to < 1 ppb.

The plant is operated year-round, with no water heating (except to keep pipes from freezing). Water temperatures range from 1.5-4.0 ºC during the winter, to 15 ºC during the summer. The rate of bacterial activity decreases somewhat during winter operation, which is compensated with the addition of more nutrient. Problems develop when excessive nutrients are added, as the oxidation-reduction potential decreases to very low levels, causing nitrate to be reduced to ammonia. Otherwise, the system requires little maintenance, and has no scaling or odour (from hydrogen sulphide) problems, though it is checked regularly for sliming or other potential issues.

The overall capital cost for the treatment plant was somewhat under USD$1 million, and annual operating costs are USD$40-60,000. The plant made some use of tanks existing on the property, as well as constructing new tanks. The biggest capital cost item was the purchase of activated carbon as support matrix for the bacteria. A total of 800,000 lbs (362 metric tons) of activated carbon was purchased at USD$0.37/lb.

The system was first tested in the laboratory on a bench-scale, followed by a pilot campaign (Summer 2001) that lasted one month. Design, procurement and construction followed through Fall and Winter 2001/2002. The plant was operational in March 2002. The bacterial inoculum was grown in 3-4 weeks, and does not constitute a significant time constrain.

Overall, this treatment plant functions very well, though contaminant loadings are fairly light.

At the former Zortman-Landusky gold mine, in Montana, the acidic water collected from leach pads is treated biologically before discharge by land application. The neutralized influent to the treatment plant contains approximately 200 ppm NO_3^-, 500-700 ppb Se (as Se(VI)), and 300-400 ppb Total cyanide. The effluent contains <10 ppm NO_3^-, 100 ppb Se, and 200 Total cyanide. While this water does not meet state discharge criteria, it is sufficiently treated to allow for its disposal by land application.

The treatment plant consists of 3 x 250,000 gallon insulated (outdoor) tanks filled with activated carbon. It has treated flows of 75-300 gpm year-round for the past two years. Water temperatures vary seasonally, from approximately 1-15 ºC, without affecting treatment performance.

The capital cost for the treatment plant was USD$3 million, for which the highest cost item is the activated carbon (39). Operating costs are somewhat less than USD$250,000/year, and are broken down as follows (Table 3).

Table 3. Operating costs for Zortman-Landusky treatment plant.

Item	Annual Cost
Bacterial nutrients	$100,000
Labour	$43,000
Reagent (lime, etc)	$35,000
Maintenance	$25,000
Power	$15,000
Laboratory analysis	$14,000
Filtration	$10,000
Total	$240,000

A biological treatment system, comparable to the above systems, was tested at Kennecott Utah Copper Corporation's (KUCC) Garfield Wetlands-Kessler Springs site (33). The site provides water with uniformly high selenium concentrations of 1,600 ppb Se, mostly as Se(VI).

The treatment system comprises a series of tanks (total 500 gallon) that contain activated carbon seeded with selected bacteria. The tanks are fed groundwater (temperature = 13 ºC) at a rate of 1 gpm and a nutrient solution. The discharge flows through a slow sand filter to remove elemental selenium produced in the tanks. Treatment performance was excellent at all times (Table 4 and Figure 8). Selenium removal was complete, even with a 5.5 hours retention time.

Table 4. Mean effluent Se concentrations from biological treatment pilot plant.

Residence Time	Mean Selenium Effluent Concentration (µg/L) ±Standard Deviation (n = sample size)	Minimum Selenium Effluent Concentration (µg/L)
12 hrs (Series 1)	8.8 µg/L ±10.2 (n = 17)	<2 µg/L
11 hr (Series 2)	4.9 µg/ L ±4.9 (n = 16)	<2 µg/L
8 hr (Series 3)	<2 µg/L ±2.6 (n = 12)	<2 µg/L
5.5 hr (Series 2)	<2 µg/L ±2.1 (n = 26)	<2 µg/L

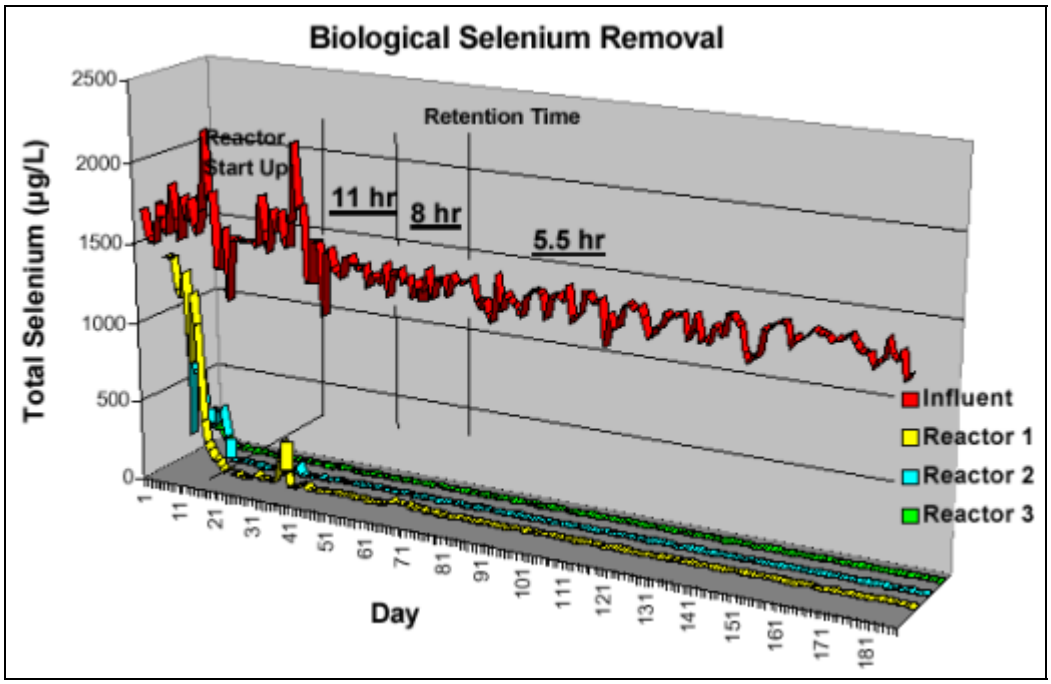


Figure 8. Treatment performance of the biological treatment process at Kennecott.

An economic analysis was carried out to calculate the cost of a full-scale treatment plant receiving 300 gpm of the above groundwater that contains 1,600 ppb selenium (mostly as selenate). The capital costs for such a treatment plant, utilizing some tanks available on site, is calculated to be $603,999. As with the above systems, the bulk of this cost comes from the activated carbon. Annual operating costs are calculated to be $135,029. The treatment cost, amortized over ten years, is calculated to be

USD$1.32/1,000 gallons, a fraction of the catalyzed cementation treatment process. This cost is roughly in line with the costs for the above biological treatment plants.

4.3.2.2 In-Situ Remediation

In-situ remediation involves the treatment of selenium in groundwater through stimulation of bacterial activity. In one typical application, aquifer sediments are sampled for the presence of selenium-reducing bacteria (See Section 4.3) and, if present, they are stimulated by addition of nutrient solutions (40). The reduction of selenate and selenite produces elemental selenium, which is retained in the subsurface.

This approach is been carried out in full-scale at Homestake Mining Co.'s Grants New Mexico Reclamation Project (41). Se present in a groundwater plume at 50-100 µg/L is being decreased through the action of bacteria to <5 µg/L. This process is very cost-effective, at less than USD$1.00/1,000 gallons, due to low capital costs. However, this approach may not be applicable everywhere, due to different aquifer characteristics. Moreover, the potential remobilization of elemental selenium retained in the subsurface has not been conclusively ruled out.

4.3.2.3 Passive System

The Biopass system was developed in the early 1990's for passive treatment of drainage from a reclaimed cyanide heap leach facility at Homestake Mining Company's Santa Fe Mine, in Mineral County, Nevada (42). This system relies on the flow of mine water through decaying organic matter (Figure 9). The system is designed to treat weak acid dissociable (WAD) cyanide (CN), nitrate (NO_3), mercury (Hg), and selenium (Se).

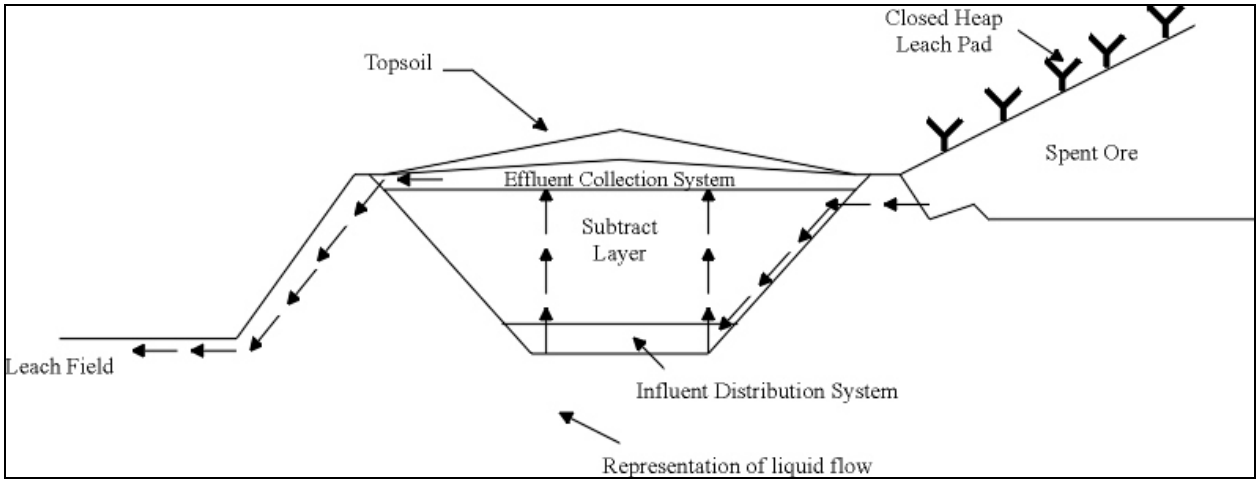


Figure 9. Schematic diagram of the Biopass system.

The Biopass system was constructed in an emptied double geomembrane lined solution pond and consisted of, from the bottom upward: a seepage collection (influent) layer comprised of gravel and perforated pipe, a substrate layer comprised of spent ore gravel and composted cow manure mixture, an effluent collection layer comprised of gravel and perforated pipe, a geotextile cushion, a geomembrane liner, and a vegetative soil cover. Treated solution flows by gravity through a buried pipeline from the effluent layer to a leach field where it is aerobically treated. Anaerobic bacteria in the substrate layer reduce selenium oxyanions to insoluble elemental selenium and form insoluble mercury sulfides. They also remove sulfate from the effluent. Other microorganisms biodegrade cyanide and remove nitrate from the water.

The Biopass system is designed to be sealed and operated passively. As a consequence, living organisms are not exposed to the fixed selenium and metals. However, these contaminants must be prevented from re-oxidizing in the future, or the system must be sealed off to prevent the discharge of re-oxidized contaminants.

Careful attention must be paid to two key considerations in the system design:

- Sizing of organic substrate mass and treatment retention times.
- Design and placement of the substrate layer to minimize consolidation and maintain permeability.

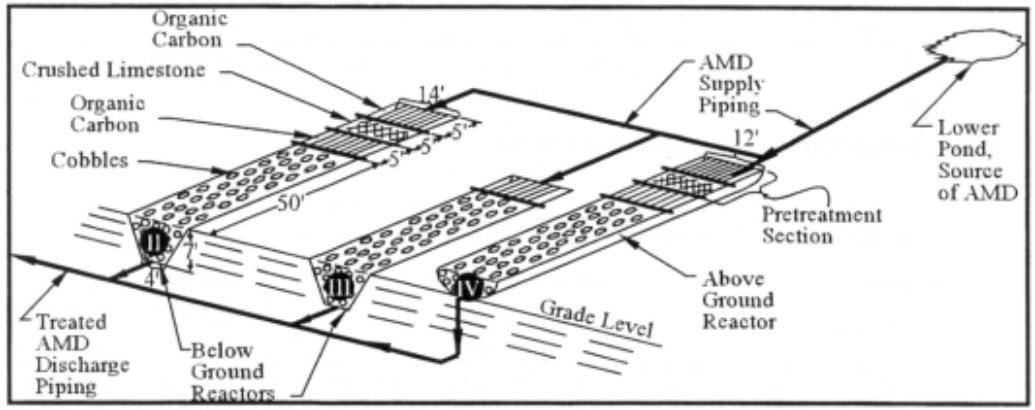
The required mass of organic matter is calculated on the basis of the anticipated sulfate load requiring treatment. A predicted sulfate load is calculated using the average annual flow rates, summed over a 20 year period with two 100 year 24-hour storm events, and an average sulfate concentration of 2,000 mg/L. The mass of organic substrate is determined assuming a conservative ratio of volatile suspended solids that will be consumed per pound of sulfate. Results to date indicate that every contaminant of concern is removed sufficiently for the effluent to meet mandated discharge criteria.

No cost information is available on this treatment system.

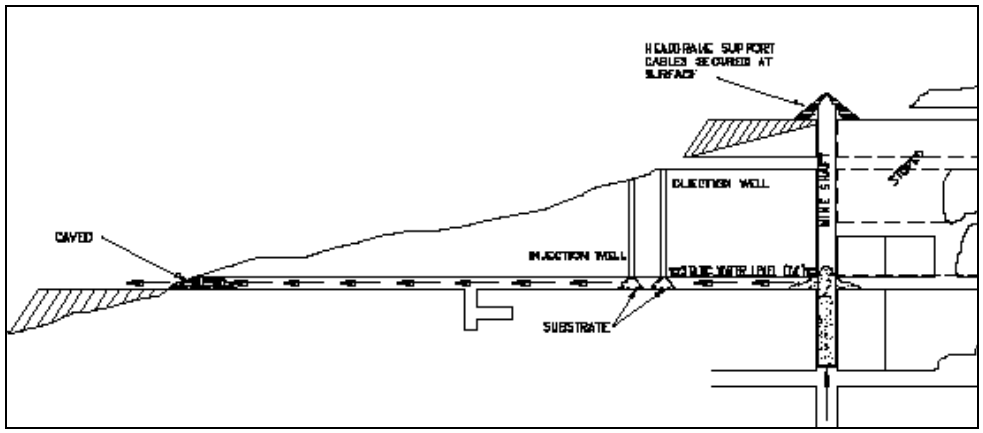
The Biopass system is a particular design of a general class of passive treatment systems that has been developed in the past 5-10 years. Such systems that have been used at other mine sites, though they were not designed to treat selenium-contaminated waters (See examples in Figure 10).

In general, they are very compact systems, a distinct benefit in certain settings. The majority of designs rely on the organic matter placed in them to feed the bacteria that provide treatment. Typical materials include alfalfa, manure, mushroom compost, sawdust, straw, etc. The benefit of this design is that organic matter is usually abundant and inexpensive. Its decomposition produces the anaerobic environment required by SRB, nitrate- and selenium-reducers.

The main drawback of this approach is that this material often offers poor or deteriorating system hydraulic, due to gradual decomposition, compaction, sliming, accumulated metals, etc. For that reason, most current designs are best suited for modest flows. Potentially, they represent a “walk-away” scenario, or an inexpensive solution for abandoned mines, specially since some of them have been shown to operate at low temperature.







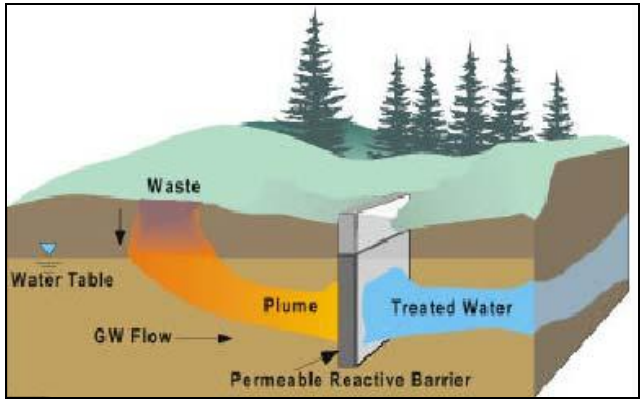


Figure 10. Examples of different bioreactors. Top: aboveground reactors; bottom: underground reactors.

4.3.3 *Treatment Wetlands*

ChevronTexaco's (Chevron's) Richmond, CA refinery, one of the largest on the West Coast, produces a contaminated effluent when selenium is stripped from crude oil during the refining process. The resulting wastewater passes through an oil-water separator, oxidation ponds, and ultimately through restored wetlands which remove Se (43). The 3x30-acre cells (called "passes") wetland system (Figure 11) receives flows of 1,000 gallons per minute (gpm) containing 10-30 ppb (predominantly selenite), a mass loading of 156 ± 13 g/day. Se concentrations are reduced by 60-70% at the outlet on Pass 1 and attain < 5 ppb dissolved Se at the outlet of the wetland complex.

Most of the dissolved Se is retained in the wetland sediments, where it has built up to concentrations of 3-8 mg/dry kg (44). A significant portion of the Se, estimated at 10-30%, is transformed to volatile selenides, which are lost from the system (44). Rates of volatilization in the wetland vary over two orders of magnitude and are a function of time of year and plant coverage (Table 5).

Table 5. Volatilization rates in Chevron's treatment wetlands.

Site	Volatilization Rate µg Se/m^2/day
Vegetated - Rabbitfoot grass	190 ± 150
Vegetated - Cattails	180 ± 100
Vegetated – Saltmarsh bulrush	150 ± 40
Vegetated – Saltgrass	80 ± 40
Vegetated – Brass buttons	60 ± 30
Unvegetated – Inlet channel	170 ± 30
Unvegetated – Fungal mat	110 ± 60
Unvegetated – Algal puddle	50 ± 20
Unvegetated – Uncovered sediments	20 ± 10

The wetland has attracted considerable attention because of its abundance of bird life. The marsh is home to black-necked stilts, Canada geese, Savannah sparrows, endangered California clapper rails, as well as grey foxes, raccoons, skunks, muskrats, mice and moles. Some of the latter carnivores were actively trapped to increase egg survival, thus enhancing bird populations. The National Audubon Society, National Geographic Magazine and the California Department of Fish and Game view it as a role model illustrating how a refinery turned land used to treat industrial effluents back into native habitat. Planted near the mouth of San Pablo Bay in Richmond in the late '80s, the restored wetland grows typical California marsh plants including salt marsh bulrush, cattail and rabbitfoot grass.

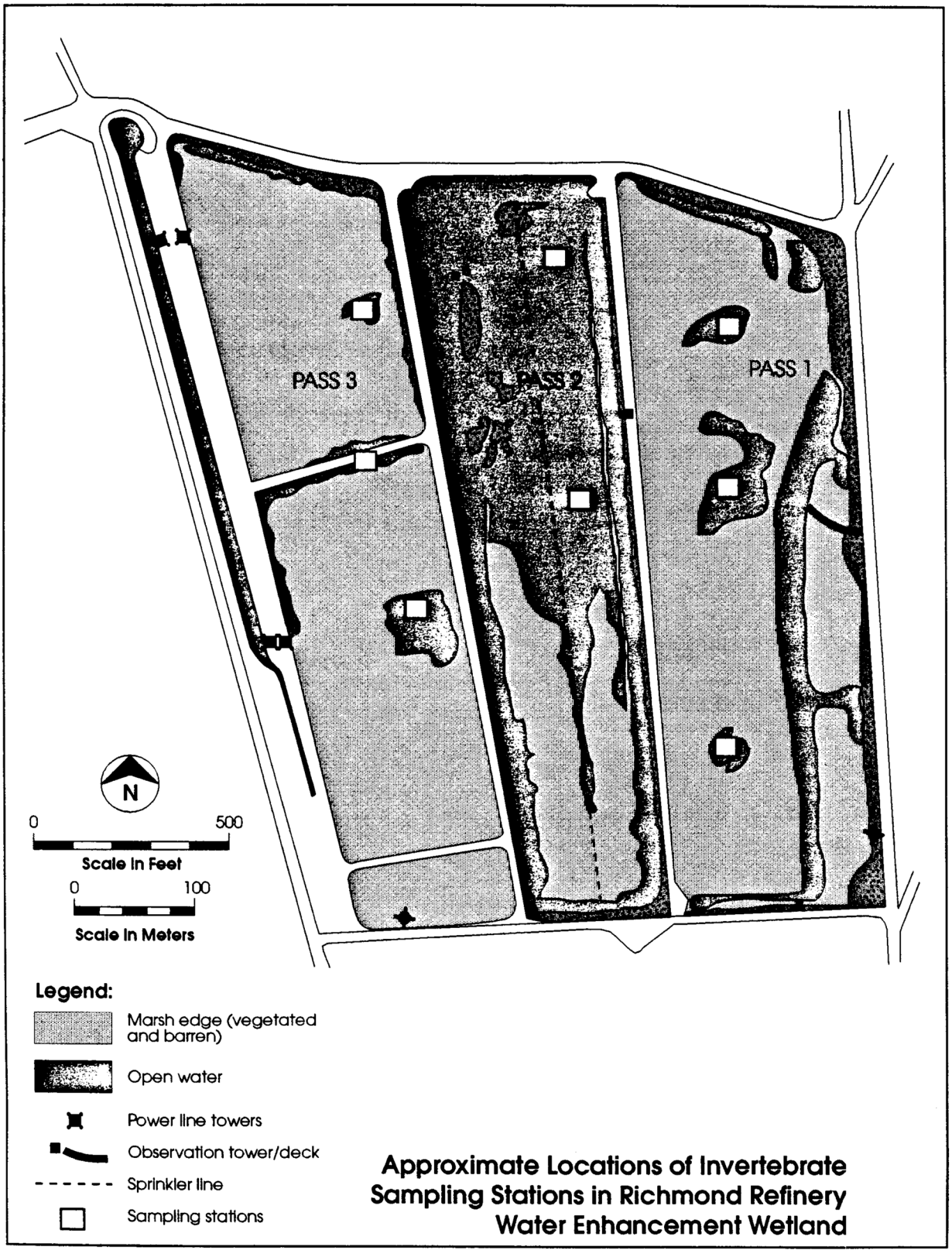


Figure 11. Layout of the Chevron refinery wetland treatment system. Taken from 45.

Se is taken up by organisms living in the wetlands. Se concentrations reach 31.0 µg/dry g in midge larvae (*Chironomus* species), 17.3 µg/dry g in water boatmen and 12.8 µg/dry g in snails (45). These concentrations are twice those predicted from invertebrates living in Tulare Basin evaporation ponds, apparently reflecting the fact that selenate is found in these ponds. Interestingly, tissue Se concentrations do not reflect ambient dissolved Se concentrations, but correlate with the average Se concentrations from the previous 2-3 weeks.

The U.S. Fish and Wildlife Service is concerned that Se is accumulating in the wetlands and causing toxic effects. Se concentrations in black-neck stilt eggs average (geometric mean) 20.4 µg/dry g, a concentration predicted to result in non-viability and/or embryonic deformations (45). These concentrations have increased the rate of deformities in young birds to an estimated 10-30%, whereas the rate of deformities is expected to be less than 1% (46).

To mitigate impacts of Se toxicity on bird populations, Chevron modified the treatment wetland by densely planting the first two passes and modifying their shoreline, both to deter bird usage. These passes was further altered to remain continually submerged, thereby improving treatment performance and preventing accidental drying out of sediments and release of accumulated selenium. Finally, the last pass was modified to enhance bird usage. The result of these modifications is that treatment efficiency is maintained, while selenium content in bird eggs decreased dramatically (47).

Unfortunately, no cost information is available for this system. However, the author's experience suggests that such a system would cost between $1-3 million to design and construct (depending on topography, soils, flow control structures, etc), and approximately $100,000/year to operate (including monitoring costs) and maintain. Such a system could accept up to 2,000 gpm (454 m^3/hr), removing 80-95% of input Se, depending on flows. Operation in a Northern climate would be seasonal, with water stored in an impoundment or reservoir during the winter.

4.3.4 *Natural Attenuation in Evaporation Ponds*

Microalgae and submerged aquatic plants can volatilize significant quantities of selenium from the water column. This ability has been exploited in California to remove Se from contaminated agricultural drainage. Drainage entering the Hacienda Evaporation Basin of the Tulare Lake Drainage District, Corcoran, CA, shows a progressive decrease in Se concentrations despite becoming more concentrated due to water evaporation. Rates of volatilization from planktonic algae for selenium concentrations of 1 µg/g are 220 ng/hour (48). These rates are achieved when conditions in the pond are favorable for plant growth and activity, which include slightly alkaline pH, clear water, non-limiting nutrient (i.e., nitrogen and phosphorus) concentrations, etc. Nevertheless, a retention time of approximately 80 days is sufficient to remove Se completely from agricultural drainage.

Unfortunately, these evaporation basins have caused reproductive impacts to avocets feeding and nesting at these sites. The operators of these basins have modified the design and management of the basins to discourage shorebird use and nesting (49). Modified designs include: greater water depths, steep banks with 3:1 slopes, no islands or windbreaks, level bottoms, and plastic lined or "stacked" rip-rap banks for erosion control. Management strategies include rapid filling and drawdowns of the ponds, intensive hazing during the pre-breeding and breeding seasons, vegetation control on the banks and ponds, and clean, smooth, scraped dikes and banks. Hazing efforts include: propane cannons, cracker shells, bird bombs, mylar flagging, airboat, and vehicles. Other management strategies include modifying sites adjacent to the basin that attracted birds to the basin area or providing a freshwater mitigation wetland adjacent to the evaporation basin. These mitigation efforts have succeeded in reducing bird use and, consequently, Se-induced reproductive failures.

5 Discussion

The chemical properties of selenium help explain several aspects of selenium treatment. Thus, the relatively greater reactivity of selenite (Se(IV)) compared with selenate (Se(VI)) (similarly to the greater reactivity of sulphite compared with sulphate) explains why iron precipitation will readily remove selenite from solution but not selenate.

Any of the technologies reviewed above could be used at the coal mines in West-Central Alberta, but they may not all be well suited. To compare their relative suitability, these technologies are assessed using the criteria listed below[8].

1. Achievable discharge concentrations (12 points)
2. Cost-effectiveness (12 points)
3. Treatment for selenate (8 points)
4. Operational constraints (i.e., land area or power requirement, temperature-dependence, by-product disposal, etc) (8 points)
5. Operational experience, reliability of the technology (6 points)
6. Post-treatment management (Brine disposal, sludge storage/management) (6 points)
7. Maturity of the technology (bench-, pilot-, or full-scale experience) (6 points)
8. Volumes of water that can be treated (4 points)
9. Development time (2 points)

The highest score is given when a criterion is completely met (e.g., effluent Se is 5 µg/L or less) or a technology is best suited (e.g., most cost-effective, requires no post-treatment management of residues). Each technology is assigned points for each criterion, and the technology with the highest score is recommended as that best suited for the coal mines in West-Central Alberta. Operational constraints are factored in Item 4, arising mainly from the long, cold winters and limited availability of flat areas existing at these coal mines. In some cases, professional judgment was applied when there was little or no information to evaluate a technology under a specific criterion.

The results of this evaluation are presented in Table 6. It must be borne in mind that this is a generic evaluation conducted without site-specific information. There may be circumstances at a mine that favour one option over another.

[8] The rationale for the scores assigned to each criterion is as follows. Costs and achievable discharge concentrations are the most important selection criteria by companies and government, respectively. Selenate treatability is important, but a chemical reduction step to selenite, which adds operational complexity and costs, can be used if selenate treatment is poor. Operational experience, post-treatment management, and maturity of the technology are somewhat less important – they are not make-or-break factors – but they are still quite significant in evaluating a technology. Some technologies can only handle limited flows, which handicaps them and should be considered in this evaluation. Finally, a minor issue is the time it takes to develop a technology for a site: development times of two month are preferred over two years.

Table 6. Evaluation of selenium treatment technologies for suitability to Alberta coal mines.

	Achievable[1] discharge [Se]	Cost-effectiveness	Selenate treatability	Operational constraints[3]	Experience, reliability	Post Manag't	Maturity	Water Volume	Dev't Time	**Total Score**
Maximum Points[2]	**12**	**12**	**8**	**8**	**6**	**6**	**6**	**4**	**2**	**64**
Reverse Osmosis	12	2	7	7	6	2	6	2	2	**46**
Nanofiltration	12	6	8	7	5	2	2	2	2	**46**
Ion exchange	8	2	3	8	3	1	1	2	2	**30**
Iron precipitation	3	4	2	7	5	2	5	4	1	**33**
Catalyzed cementation	3	2	3	6	1	3	2	2	1	**23**
Algal volatilization	5	12	6	3	2	6	2	3	1	**40**
Biological treatment plant	12	8	8	7	5	5	5	2	1	**53**
In-situ	12	12	8	5	3	5	2	4	1	**52**
Biopass system	10	10	8	3	4	4	2	2	1	**44**
Treatment wetlands	10	10	8	2	4	4	3	3	1	**45**
Evaporation ponds	6	12	6	2	2	3	2	3	1	**37**

[1] Headings correspond to categories identified in Page 27.
[2] Maximum possible score for each category.
[3] See discussion on Page 27.

Two technologies stand out from the others: In-situ treatment and Bioreactors (biological treatment plant). Both technologies score well with regards to effluent selenium concentrations and cost-effectiveness. Unlike filtration methods, treatment wetlands or evaporation ponds, these technologies can also operate in cold climates without heating. These two technologies appear to be most suitable for coal mines in West-Central Alberta. The fact that biological treatment systems have been favoured in the past five years undoubtedly reflects the above results.

Several consultants have indicated during the interviews that In-situ treatment is the method of choice *if applicable at a site*. As such, it is one of the technologies to consider first. Its applicability is dependent on favourable subsurface conditions.

Bioreactors have proved to be more reliable than expected in treating selenium, as well as a number of other contaminants. Another unexpected characteristic is their apparently good treatment efficiency at cold temperatures (e.g., 2-4 ºC). There are now four biological treatment plants that remove selenium in the USA, suggesting that this technology is becoming more mature. Note that they are located in Western states (e.g., South Dakota, Montana), where winters are comparable with those of West-Central Alberta.

Four other technologies form a second group in the ranking: reverse osmosis, nanofiltration, the Biopass/passive treatment systems and treatment wetlands. These technologies might possibly be appropriate to some of the sites if favoured by some site-specific factors, e.g., suitable land is available for treatment wetland or inexpensive equipment or other factor reduces the cost for RO treatment. Passive technologies, such as the Biopass system or treatment wetlands, might be favoured over others if several dispersed small flows require treatment, if they contribute significant loadings of selenium to receiving waters, and if their continued collection after mine closure proves onerous.

Treatment plants using iron precipitation could be suitable for waters containing low selenite concentrations. However, this does not seem to be the case for the coal mines where selenium speciation has been investigated.

The remaining technologies are too underdeveloped or inappropriate for application in West-Central Alberta.

It should be noted that preventative measures will always be preferred over treatment systems, at least for long-lasting contaminant leaching. Presently, there is not enough information to determine if Se release is a short-term or long-term problem in West-Central Alberta. This is an important issue that should be evaluated since evidence from other mines suggests that it might be a long-term problem. The most common preventative measures were only briefly described above and were not evaluated. However, there is a substantial body of literature that addresses such reclamation techniques, one of which was mentioned earlier[1].

In summary, this evaluation concludes that the two best treatment technologies are in-situ treatment and bioreactors (biological treatment plant), because they can remove selenium down to acceptable levels cost-effectively, even during cold winters comparable to those in West-Central Alberta. Four other technologies – reverse osmosis, nanofiltration, the Biopass/passive treatment systems and treatment wetlands – merit consideration and may be appropriate in certain circumstances at West-Central Alberta coal mines. Notwithstanding the advantages or disadvantages of each technology, preventative measures to minimize selenium release should be implemented as an integral component of any management plan at these mines.

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Appendix I

Topics used for questions during study

Topics used for questions during study

1. Characteristics of the water to be treated
    a. Selenium concentrations; selenite vs selenate
    b. Other constituents, such as nitrate, sulphate, or TDS that might affect treatment performance
    c. Other contaminants for which treatment is required
    d. Flows
2. Description of the treatment system
    a. Necessary pre-treatment
    b. Selenium removal process
    c. Post-treatment
    d. Treatment performance/discharge criteria
    e. Seasonal vs year-round treatment
3. Years of operation
4. Operational issues
    a. Stability of performance
    b. Seasonal/temperature effects, if relevant
    c. Maintenance issues
5. Costs
    a. Capital
    b. Any savings from using available equipment
    c. Operational cost, broken down, if possible
6. Time required for system development

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Passive Treatment of Mine Impacted Water In Cold Climates: A Review

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Executive summary

In this review, we evaluate the challenges encountered and the adaptations required for the successful treatment of mine-impacted waters in cold climates with Passive Treatment Systems (PTSs). Engineered PTSs are modeled on natural wetlands, which have been shown to effectively treat water with high metal concentrations through natural attenuation. PTSs include constructed wetlands, bioreactors, and hybrid systems. Some of the challenges associated with implementing cold climate PTSs include cold temperatures, remote locations and limited access in winter, which can lead to freezing pipes and surface water, variable seasonal flow, and low productivity of microbial and macrophytic communities. Many adaptations have been implemented to address these cold climate challenges including burial of pipes to avoid hydraulic failure, insulation to avoid freezing surface waters, bypasses and overflows to maintain constant flow, summer establishment of microbial and macrophytic communities and the addition of liquid carbon sources to offset reduced organic matter decomposition in cold temperatures. While further investigation and development is necessary to fully understand the factors affecting cold climate PTSs, with sufficient research and planning PTSs can be successfully implemented in cold climates.

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1. BACKGROUND

Passive treatment of mine impacted water has become increasingly common over the last 30 years. While natural attenuation of contaminants in wetlands, bogs and swamps has been well documented (McGregor, 2002; Sobolewski, 1997), recent advances in the design and construction of engineered passive treatment systems (PTSs) has resulted in more efficient contaminant removal (USEPA 2014; INAP 2010; Mays & Edwards, 2001; MEND 1996). PTSs consist of constructed wetlands (CWs), bioreactors, or some combination and/or variation on both of these components. Other types of PTSs exist, such as in-pit or in-pond treatment systems, but these are more specialized and will not be reviewed here.

Natural wetlands provide important information about the processes that drive PTSs, as well as, acting as water treatment systems in their own right. Natural wetlands and bogs have been removing contaminants from water for centuries (Gusek, 2008). From cupriferous and uraniferous bogs (Sobolewski, 2013) to bog iron ore deposits (Gusek, 2008), many examples of natural attenuation of metals in wetlands exist (e.g., Boyle, 1995; Wieder and Lang, 1982). Numerous studies have found evidence of metal retention in natural wetlands from natural and anthropogenic sources (Table 1). Natural wetlands can also give us an indication of the potential for the long-term performance of CWs. A wetland in Ireland has been assimilating metal-laden water from an abandoned Pb/Zn mine for over 120 years without interference (Sheoran and Sheoran, 2006). A natural wetland receiving drainage high in Fe, Zn and Mn from an iron ore mine in the Rocky Mountains was found to retain metals at a rate of 90%, 65% and 25%, respectively (August et al, 2002). The wetland received mine drainage for over a century and had accumulated large amounts of metal oxides and sulfides. This likely resulted in a decrease in efficiency overtime, as at the time of the study the wetland was found to be a sink for all metals during the winter, but then became a source for Zn and Mn during the summer when flows were higher. Similarly, a fen in Northern Manitoba treating Ni mine drainage was found to remove 96% of the Ni (Hambley, 1996). While higher levels of Ni were observed in the effluent in the spring and after heavy rains, sequential extractions of the soils indicated that 97% of the Ni captured by the fen would be unlikely to be remobilized. In another natural wetland receiving drainage from an abandoned Pb/Zn mine in Ireland, retention of 95% of Zn and 65% of As was observed (Beining and Otte, 1997). The wetland has been receiving mine drainage for over a century and is estimated to have reached only 30% of its capacity. A wetland receiving coal mining drainage high in Se removed 83% of the inflowing metal concentration (from 364 mg/L to 22mg/L) and selenium-reducing bacteria and SRB were found at high levels (Baldwin and Hodaly, 2003). Finally, a natural wetland established below the Silver King mine in Elsa, Yukon, was shown to completely remove Zn from mine drainage during winter months, even when temperatures decreased below -40°C (Sobolewski, 2003a). Evidence of sulfide generation was uncovered during this study, indicating that SRB were active and could account for metal removal.

Natural wetlands have been treating mine-impacted water in cold climates since mining activity began and while several studies indicate their efficacy and longevity, their effectiveness over long time periods and the effects of seasonal variation on efficiency still remains poorly documented. Understanding the effects of changes in water flow through the seasons would better inform PTS designers to adapt their own systems for cold climates. Natural wetlands also help to inform the scale necessary for treatment wetlands. The longevity of natural wetlands, particularly in cold climates, indicates that a well-designed PTS may last for decades to centuries.

Table 1: Natural wetlands shown to ameliorate mine drainage (Sobolewski, 1999, p.26).

Wetlands that only partly improve mine water quality

Mine	Location	Dominant plant Species	Acidic Drainage	Water quality parameter	Ref.
Abandoned tin, zinc mines	St Hilary Mining District, West Cornwall, U. K	*Juncus effusus, Phragmites australis*	No	Cu yes, Zn no	Brown, 1997
Carbonate mine	Montana	*Carex rostrata*	Yes	Al no, Fe yes, Pb yes	Dollhopf *et al.*, 1988
Coal mines	Eastern United States	*Typha, Scirpus* spp.	Yes	pH, Al, Fe, Mn	Kleinmann, 1996
Coal mine	Mpumalanga mining district, South Africa	*Typha,* spp.	Yes	pH, Al, Fe, Mn	Limpitlaw and Bloem, 1996
Dunka Mine	Minnesota, United States	Peat bogs	Yes	Cu, Ni	Eger *et al.*, 1994
Equity silver	British Columbia, Canada	Sedges	Yes	Cu	Mehling, 1985
Mt. Washington Mine	British Columbia, Canada	*Eriophorum angustifolium*	Yes	Cu, Al	Coombes, 1998
Natural wetlands at 35 coal mines	Pennsylvania, USA	*Mainly Typha,* spp., others also noted	Yes	pH, Al, Fe, Mn	Stark, 1990
Ranger Mine	Jabiru, Australia	*Eleocharis sphacelata Typha* species	No	U	Jones *et al.*, 1996
St. Kevin Gulch	Colorado, USA		Yes	Fe yes, Zn no	Walton-Day, 1994
Unnamed coal mine	Ohio, USA	*Sphagnum* spp.	Yes	pH, Fe, Mn	Huntsman, Solch and Porter, 1978
Tug Fork coal mine	West Virginia, U.S.A.	*Sphagnum* spp.	Yes	pH, Fe, Mn	Wieder and Lang, 1982

Wetlands which improve mine water quality to full environmental compliance

Mine	Location	Dominant plant Species	Acidic Drainage	Water quality parameter	Ref.
Abandoned Lead/ Zinc mines	Glendalough, County Wicklow, Ireland	*Molinia caerulea, Juncus acutiflorus*	Yes	As, Cd (?), Pb (?), Zn	Beining and Otte, 1996
Birchtree Mine	Manitoba, Canada	*Agrostis, Carex* spp. *Typha latifolia*	No	Ni	Hambley, 1996
Cluff Lake, Rabbit Lake	Saskatchewan, Canada	*Carex* species *Sphagnum* moss	No	U	TAEM, 1995; Sinclair, 1996
Con Mine	Northwest Territories, Canada	*Carex* species *Sphagnum* moss	No	CN^-, As	Ball, 1993
Hilton Mine	Mt. Isa, Queensland, Australia	Reeds, algae	No	Fe, Mn, Tl, Zn	Jones and Chapman, 1995
Pacific Mine	Utah, USA	?	No	Cd, Pb, Zn	Lidstone and Anderson, 1993
Quirke Mine	Ontario, Canada	*Typha latifolia*	Some	Fe, Ra-226	Davé, 1993
Silver Queen	British Columbia, Canada	Sedges	No	Zn	Higgs, 1996
Star Lake, Jolu	Saskatchewan, Canada	*Carex* species *Sphagnum* moss	No	CN^-, Cu	Gormely *et al.*, 1990
Tom's Gully Gold Mine	Darwin, Australia	*Melaleuca, Typha domingensis*	No	As, Co, Cu, Fe, Pb, Mn, Ni, Zn	Noller, Woods and Ross, 1994
United Keno Hill Mines	Yukon Territories, Canada	*Carex* species *Sphagnum* moss	No	Fe, Mn, Pb, Ag, Zn	Boyle, 1965
Woodcutter's Mine	Darwin, Australia	*Typha* species	No	Cd, Mn, Pb, Zn	Noller, Woods and Ross, 1994

In Yukon, Canada, effluent from hard rock mines can have neutral or acidic pH and be high in a suite of heavy metals, depending on the local geology (Nordin, 2010). Contaminated mine drainage

often requires treatment prior to discharge to the receiving environment. Yukon mines have expressed interest in implementing PTSs to treat contaminated drainage and in some cases have already begun research to develop such systems (i.e. Minto Mine, Casino Mine, Faro Mine, United Keno Hill Mine, Brewery Creek, Eagle Gold and Wolverine Mine). There are distinct advantages to PTSs in remote locations with limited access and power. Passive systems should ideally be able to function for decades with no power (Gusek & Wildeman, 2002). While most systems are not truly "walk-away" scenarios, they are generally lower maintenance than active systems (Johnson & Hallberg, 2005).

Some of the challenges facing PTSs in cold climates include hydraulic failure due to freezing in winter, reduced microbial activity, and increased water flows during spring melt. Many adaptations have been developed to overcome these challenges such as insulating and/or burying PTSs, maintaining constant flows through the use of bypasses and overflows, and providing carbon sources to feed bacteria during times of slower organic matter decomposition. There have been varying degrees of success, but hurdles have been overcome and many advances have been made in the use of PTSs in cold climates.

With the proliferation of PTSs around the world and the growing interest in Yukon, it is necessary to synthesize some of the successes and failures of PTSs, particularly in a northern context. This review aims to summarize many of the PTSs that have been used to treat mine-impacted water and address some of the challenges and future research directions associated with implementing these systems in cold climates. This review focusses primarily on PTSs for the treatment of mine-impacted water, although systems that treat other types of effluent are discussed where relevant cold climate adaptations have been used.

2. PASSIVE TREATMENT SYSTEMS

PTSs are generally defined as water treatment systems that require little or no maintenance once installed (Johnson & Hallberg, 2005). This is contrasted with active treatment systems (treatment plants), which use mechanical devices operated by workers and require continual flow control, reagent input, sludge/residual removal and power. More specifically PTSs can be described as water treatment systems that sequentially remove contaminants using biological or geochemical processes (Gusek & Wildeman, 2002). They are typically designed to last for decades and be less costly over the long term than active treatment systems. However, they can also require much more space and may be constrained by site limitations, such as topography (Johnson & Hallberg, 2005).

PTSs capitalize on natural attenuation processes that naturally occur in wetlands. Wetlands generally have an aerobic zone where plants thrive and oxidative conditions dominate. Below this is an anaerobic zone where reductive processes dominate and sulfate-reducing bacteria (SRB) thrive (Gusek, 2002). In each zone, different reactions occur that precipitate different contaminants. In the aerobic zone, hydroxide and oxide precipitation occurs and in the anaerobic zone sulfide and carbonate precipitation is catalyzed by microorganisms. Some contaminants like chromium, selenium or uranium are retained by reductive immobilization in these anaerobic environments. Filtration and adsorption by detritus are also important processes occurring in both zones. PTSs promote these processes by using organic materials as substrates for microbial activity, as well as, local native plant species as the living wetland layer. The chosen substrate is often waste material that can be obtained at low cost.

Additionally, organic material such as wood chips or sawdust can often be obtained on-site or nearby, reducing or eliminating transport costs (Gusek, 2002).

Metal removal in PTSs can be divided into abiotic or biotic processes. Technologies that rely on abiotic processes include anoxic limestone drains (ALDs), open limestone channels, diversion drains, vertical flow limestone drains and others. All these systems rely on limestone to neutralize acid drainage and remove aluminum and iron. They are often used in combination with other biotic passive treatments. For example, successive alkalinity producing systems (SAPS) or vertical flow limestone drains rely on the percolation of acidic water through a layer of compost, where the carbon dioxide produced by its microbial decomposition greatly enhances limestone dissolution (Kepler & McCleary, 1994). These systems are used to treat waters with high acidity, aluminum or ferric iron, which cannot be treated by other limestone-based PTSs.

Systems that rely on biotic processes can be divided into aerobic and anaerobic systems. Aerobic wetlands rely on oxidative processes to remove metals (primarily iron) and are most often constructed to treat mine water that has net alkalinity (Hedin et. al., 1994, Johnson & Hallberg, 2005). Anaerobic wetlands, or bioreactors, are used to treat neutral, metal rich water by reductive processes. They are typically applied at base and precious metal mines to remove metals that were originally present as sulphides and were released during the mining process (Sobolewski, 1999). Constructed wetlands and bioreactors are further detailed in Section **Error! Reference source not found.** and **Error! Reference source not found.** below.

The technology behind PTSs has evolved considerably over the last 20 years. A landmark development was the publication of an Information Circular by the former US Bureau of Mines (Hedin et al, 1994). This document presented for the first time design criteria that were field-validated, along with a decision-making flow chart that identified the different types of treatment required for different types of mine waters. The information circular focused on acid drainage from abandoned coal mines in Eastern Appalachia, where the authors had gained their experience. More recently, Gusek (2008) expanded this flow chart by including additional forms of treatment that were predominantly developed for abandoned base and precious mines in Western USA and Canada. This chart presents the multitude of PTS components and possible configurations available for industry and those involved in reclamation (Figure 1).

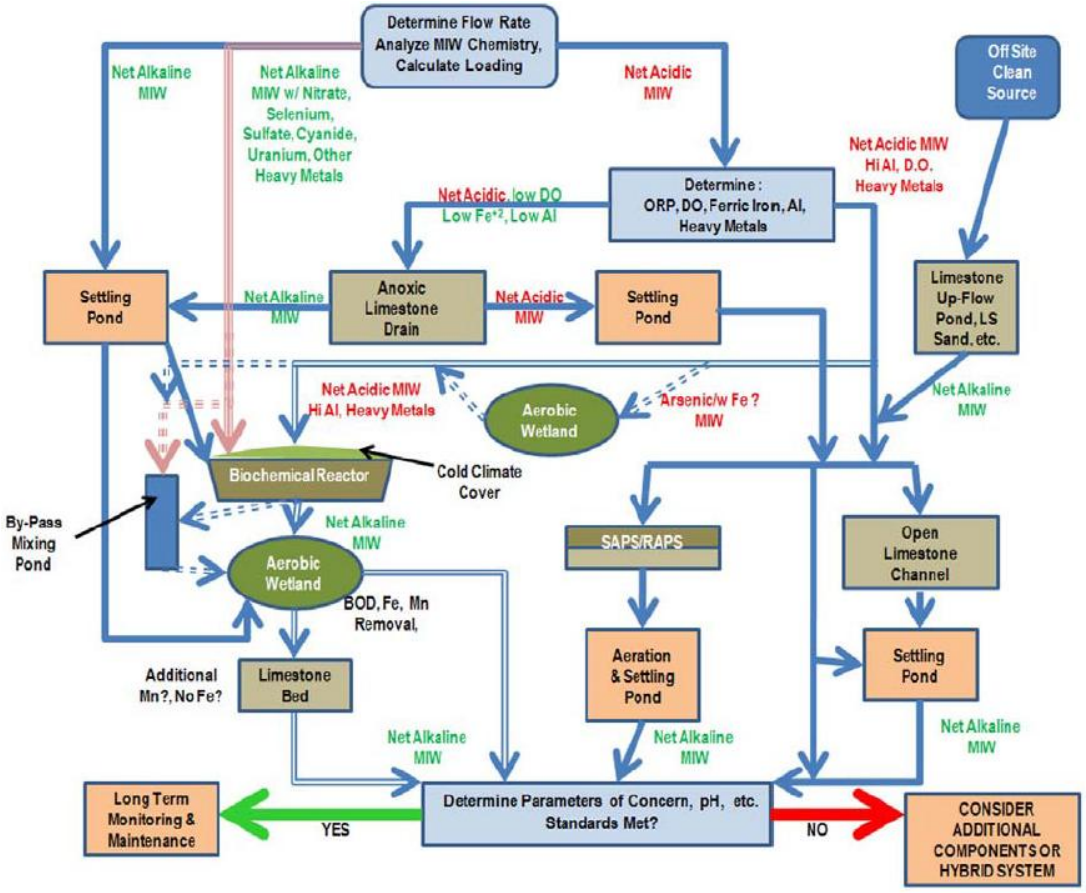


Figure 1: Flow chart for selecting PTS based on water chemistry and flow (adapted from Hedin et al, 1994 by Gusek, 2008, p. 4).

2.1. Constructed wetlands

Constructed wetlands (CWs) are defined as engineered wetlands that use natural processes associated with vegetation, soil and microbes to treat contaminated water (Mander & Jenssen, 2003). The basic processes that operate in CWs include nutrient uptake, bacterial degradation, filtration, oxidation, precipitation, sedimentation and adsorption (Sheoran & Sheoran, 2006). The characteristics of wetlands that contribute to their effectiveness in treating contaminated water include: high productivity, microbial diversity, organic matter accumulation, high reactive surface area and slow water flow (Sobolewski, 1999). It is these characteristics that designers seek to emulate when creating CWs, and many CWs are more efficient at removing metals than natural wetlands (Sheoran & Sheoran, 2006). CWs are used all over the world for treating various types of effluent. They have been used extensively in cold climates for municipal wastewater treatment (Mander & Jenssen, 2003) and in several northern settings for mine drainage (Nyquist & Greger, 2009; Sobolewski 1996a; Sobolewski 1996b; Duncan, 2002; Goulet & Pick, 2001).

Surface flow wetlands often consist of an excavated pond lined with an impermeable substrate, such as clay or geotextile and are filled with porous materials like peat (Eger & Eger, 1991), or sand (Nyquist & Greger, 2009), then fertilized (Sobolewski, 1996b) and planted with local wetland plants (Figure 2a). Sub-surface flow wetlands are similarly constructed but attempt to direct the flow through the root zone of the plants (Figure 2b). In both cases, the wetland bed is gently sloped so that water flows by gravity.

In Europe, sub-surface flow CWs are most often used to treat municipal wastewater (Galletti et al, 2010; Hiley, 2003; Vyzamal & Krasa, 2003), whereas in North America, they are most often used to treat mine drainage. Native wetland plants are generally chosen based on their ease of propagation and transplantation, water depth tolerance, root structure, and metal accumulation properties. Many studies have assessed the role of plants in CWs and most have found that plants uptake only a small fraction of the metals sequestered by a CW with most of the metal retention occurring in the roots (Noller et al, 1994; Sobolewski, 1999; August et al, 2002; Deng et al, 2004; Galletti et al, 2010; Mitsch & Wise, 1998; Nyquist & Greger, 2009; Taylor & Crowder, 1983; Vyzamal & Krasa, 2003; Ye et al, 2001) or on the surface of belowground biomass in a metal-rich plaque layer (Weis & Weis, 2004). It has been hypothesized that low translocation of metals from roots to shoots is a strategy of metal-tolerant plants (Taylor & Crowder, 1983; Deng et al, 2004). Metal uptake in plants varies considerably depending on the plant species, contaminants being treated, and the pH of water and sediment (Weis & Weis, 2004).

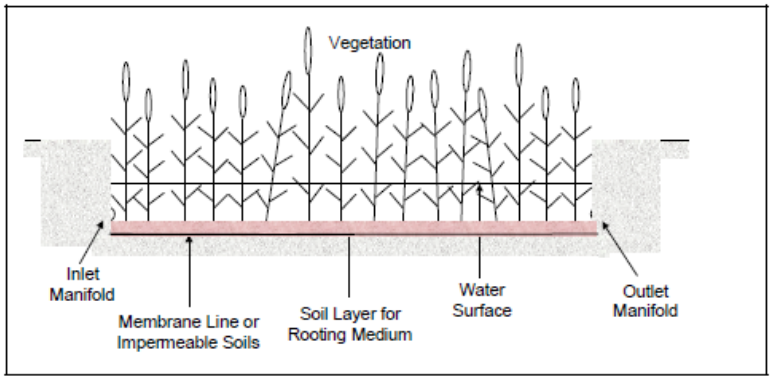


Figure 2a: Surface flow wetland (adapted from a drawing by SC Reed from EPA, 2000a, p. 1).

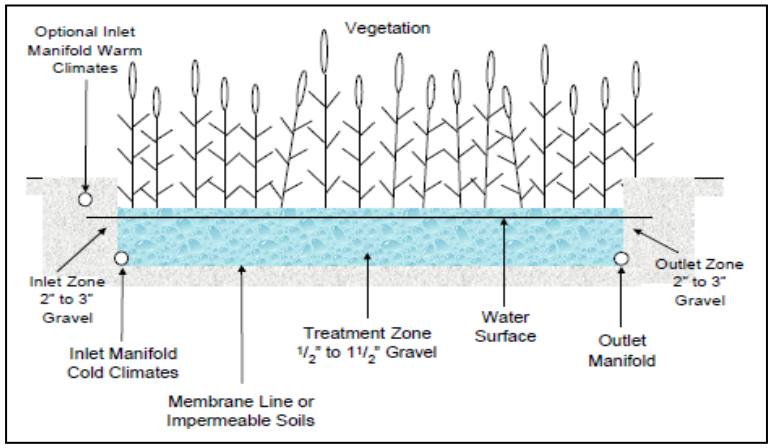


Figure 2b: Sub-surface flow wetland (adapted from a drawing by SC Reed from EPA, 2000b, p. 1).

2.2. Bioreactors

Bioreactors (or anaerobic wetlands) are PTSs that are contained in an excavation, pond, tank or even a mine shaft. It is filled with a solid reactive mixture made up of sand, gravel, compost, manure, wood chips, sawdust, or other organic material from nearby sources (Figure 3) (Schmidtova & Baldwin, 2011). The most effective reactive mixture generally contains an organic carbon source, a bacterial inoculum, a solid porous medium, a nitrogen source and a neutralizing agent (Zagury & Neculita, 2007). As mine water percolates vertically or horizontally through the substrate material, decomposing organic matter provides nutrients that fuel the activity of sulfate reducing bacteria (SRB) and other microorganisms that provide treatment (Hashim et al, 2011). The SRB then produce bicarbonates, which increases the pH while reducing sulphates to sulphides, which in turn precipitate with metals to form highly insoluble metal sulphides (Zagury & Neculita, 2007). Some bioreactors also rely on other anaerobic bacteria to remove nitrate (Reinsel, 1998) or selenium (Pahler et. al., 2007).

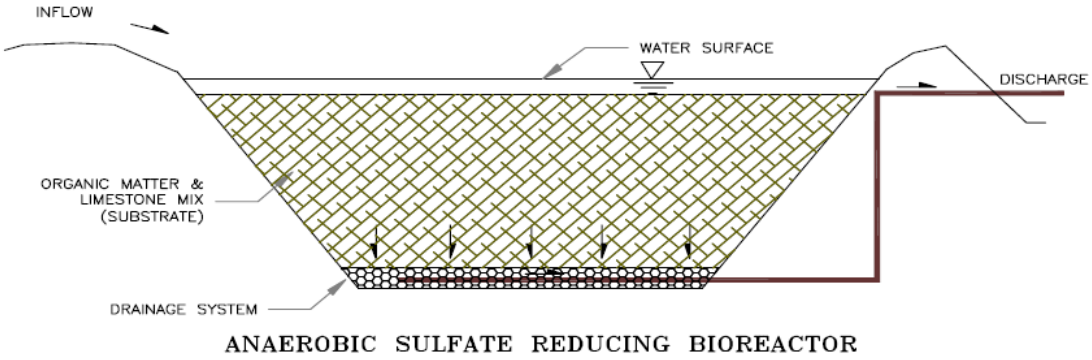


Figure 3: Typical bioreactor design (Gusek, 2002, p. 3).

Bioreactors can be used in combination with other PTS components such as limestone pretreatment to increase pH, constructed wetlands and aerobic cells (Figure 4). Bioreactors have been used at numerous mine sites in cold climates with limited access and power (Duncan et al, 2002; Ettner, 2007; Kuyucak, et al, 2006; Nordwick et al, 2007; Sobolewksi, 2010; Zagury & Neculita, 2007) due to low construction and operating costs (Schmidtova & Baldwin, 2011) and their ability to work year-round in sub-zero temperatures (Kuyucak et al, 2006).

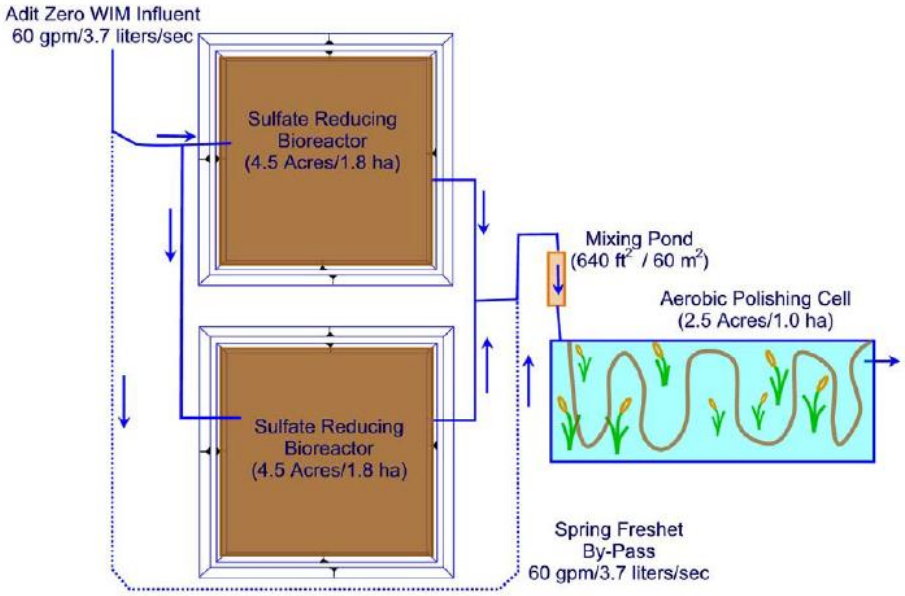


Figure 4: Hypothetical hybrid system with bioreactor and aerobic wetland components (Gusek & Conroy, 2007, p. 265).

2.3. Pilot and full scale PTSs

Many PTSs are currently being employed to treat contaminants in northern and/or cold climate environments (Table 2). While many lab and bench scale experiments are documented in the literature, our focus is only on those that have reached pilot and full scale implementation. For the purposes of this review, full scale passive treatment projects are defined as those that are constructed on-site to deal with a large portion of the effluent being produced. Pilot scale projects are experimental PTSs and are generally implemented on-site to increase the likelihood of successful full scale design (Gusek, 2002). An overview of pilot and full scale PTSs studies is provided in Table 2 including the metal removal rates observed. Note that this survey is not fully comprehensive and only reflective of the available literature, as there are PTSs that have operated for years, but have never been documented.

Table 2: Overview of Pilot and Full Scale Passive Treatment Systems

Passive Treatment Type	Components	Target Contamination	Location	Scale	Duration	Removal rates	Reference
Bioreactor	Bioreactor cell	Zn, Fe, Mn, Ni, Cd, Cu,	United Keno Hill Mine, Yukon, Canada	Pilot scale	2 years	Zn (98-99%), Mn (99%), Sb (80%), As (58-80%)	Alexco, 2012
CW	HSSF wetland & aerobic polishing cell	Cu, Zn, Pb, Fe	Clear Creek/Central City, Colorado, USA.	Pilot scale	n/a	Cu (99%), Zn (98%), Pb (94%), Fe (86%)	Banks et al, 1997
CW	Aerobic wetland and permeable reactive barrier	Fe, Mn, Al, Ni	Northumberland, UK	Full scale	2 years (ongoing)	Fe (99%), Mn (66%), Ni (83%), Al (80%)*	Batty & Younger, 2004
Bioreactor	BCR, aerobic polishing cell, aeration cell	Se, Tl, Zn	Montana, USA	Pilot scale	4 months (ongoing)	Se & Tl (99.5%), Zn (97%)	Blumenstein & Gusek, 2008
CW	3 different wetlands constructed in duplicate	Cu, Fe, S, Se	Minto Mine, Yukon, Canada	Pilot scale	1 year (ongoing)	Cu (89%), Se (26%)	Contango Stategies, 2013
Hybrid	ALDs, sedimentation ponds, CW, SAPS	Fe	Howe Bridge SAPS, Pennsylvania, USA	Full scale	7 years	Fe (50-69%)	Demchak et al, 2001
Bioreactor	SAPS, settling pond, SAPS	Fe, Al	Filson SAPS, Pennsylvania, USA	Full scale	4 years	Fe (90%), Al (20-50%)	Demchak et al, 2001
Bioreactor	Holding pond, SAPS	Fe, Al	Sommerville SAPS, Pennsylvania, USA	Full scale	3 years	Al (30%), Fe (increased)	Demchak et al, 2001
Bioreactor	SAPS, settling pond	Fe, Al	McKinley SAPS, Pennsylvania, USA	Full scale	2 years	Fe (92%), Al (25-90%)	Demchak et al, 2001
Hybrid	2 vertical upflow anaerobic bioreactors, 3 HSSF wetlands, sand filter, holding pond	As, Zn, Cd	Teck Metals Smelter, Trail, BC, Canada	Full scale	5 years (ongoing)	91% to 100% net removal efficiency	Duncan et al. 2002; Duncan, 2010
CW	5 surface flow wetland systems	Ni	Dunka Mine, Minnesota, USA	Small scale	18 years (ongoing)	Ni (30-90%)	Eger et al, 1991; Eger & Eger, 2005; Eger & Beatty, 2013
Bioreactor	Pretreatment pond, 2 bioreactors, settling pond, flushing pond & aeration channel	Al, Cu, Fe, Ni, Se, Zn	Leviathan Mine, California, USA	Full scale	2 years (ongoing)	Al (99%), Cu (99%), Fe (95%), Ni (86%), Zn (98%), Se (20%)	EPA, 2005
Bioreactor	Vertical flow cell, limestone drain, settling pond	Fe, Al, Mn	Indiana County, Pennsylvania, USA	Full scale	7 years	Al (Up to 90%)	Eppley & Gusek, 2009

Cold climate PTSs are highlighted in grey.

*calculated based on available published data. ALD=anoxic limestone drain, BCR=biochemical reactor, CW=constructed wetland, HSSF=horizontal subsurface flow wetland, SAPS=successive alkalinity producing system.

Table 2 (continued): Overview of Pilot and Full Scale Passive Treatment Systems

Passive Treatment Type	Components	Target Contamination	Location	Scale	Duration	Removal rates	Reference
Bioreactor	Limestone drain, 4 anaerobic basins	Cu, Zn, Cd, Pb, Cr, Ni	Kongens Mine, Norway	Pilot scale to full scale	4 years (ongoing)	Cu (85%), Zn (48%), Cd (98%), Pb (82%), Cr (71%), Ni (24%)	Ettner, 2007
Bioreactor	4 anaerobic basins	Ni. Al, Cu, Cd, Zn, Cr	Titania mine, Norway	Pilot scale to full scale	8 years (ongoing)	Ni (35-98%), Al (98%), Cu (98%), Cd (98%), Zn (99%), Cr (64%)	Ettner, 1999
CW	2 HSSF wetlands	Cu, Ni, Zn	Ferrara, Italy	Pilot scale	1 year	Cu (3.4-9%), Ni (25-35%), Zn (26%)	Galletti et al, 2010
CW	Surge pond, 4 sub-surface flow anaerobic cells, 2 aerobic polishing cells	Fe, Zn, Mn, Cd, Cu, Zn, As	Butte, Montana, USA	Pilot scale	2 years	Fe (37%), Zn (99%), Mn (45%), Cu (97%), Cd (99%), As (-38%)*	Gammons et al, 2000
CW	Liming circuit, free water ponds & permeable treatment walls	Fe, Zn, Mn, Cd, Cu, Zn, As	Butte, Montana, USA	Pilot scale	2 years	Fe (99%), Zn (99%), Mn (99%), Cu (97%), Cd (97%), As (53%)	Gammons et al, 2000
Bioreactor	Biofilter	As	Wood Cadillac Mine, Quebec, Canada	Full scale	7 years	As (81%)	Germain & Cyr, 2003; Tasse et al, 2003; Libeiro, 2007
CW	Surface flow wetland	Fe, Mn	Kanata, Ontario	Full scale	2 years (ongoing)	Fe (15-31%), Mn (23-49%)	Goulet & Pick, 2001
CW	CW with permeable barriers	Cu, Zn, Cd, Pb, Ni, Cb, Fe, Mn, As	Curilo, Bulgaria	Full scale	10 years	n/a	Groudev et al, 2008
Bioreactor	Settling basin, 2 anaerobic bioreactors, rock filter & aeration pond	Pb, Zn, Cd, Cu	West Fork, Missouri, USA	Full scale	4 years (est. 30 yr lifetime)	Pb (90%), Zn (80%), Cd (>33%), Cu (>78%)*	Gusek et al, 2000
Bioreactor	Vertical flow BCR, mixing basin, flow dispersion zone	Fe, Al, Cu, Zn, Cd, Mn	Golinsky Mine, California, USA	Full scale	6 years (ongoing)	Zn (~80%), Fe (~99%), Cu (~97%)*	Gusek et al, 2011

Cold climate PTSs are highlighted in grey.

*calculated based on available published data. ALD=anoxic limestone drain, BCR=biochemical reactor, CW=constructed wetland, HSSF=horizontal subsurface flow wetland, SAPS=successive alkalinity producing system.

Table 2 (continued): Overview of Pilot and Full Scale Passive Treatment Systems

Passive Treatment Type	Components	Target Contamination	Location	Scale	Duration	Removal rates	Reference
Hybrid	Vertical flow BCR, mixing pond, vegetated aerobic polishing cell	Fe, Cu, Zn, Cd	Iron King/Copper Chief Mine, Arizona, USA	Full scale	3 years (ongoing)	Al (50%), Cu (93%), Zn (96%), Cd (>89%), Mn (20%)*	Gusek et al, 2013
Hybrid	2 anaerobic bioreactors & aerobic surface flow wetland	Fe, Zn, Cu, Cd, Al	Haile Gold Mine, South Carolina, USA	Full scale	5 years (ongoing)	Fe (85%), Zn (80-100%), Cu (53%), Cd (94%), Al (97%)*	Gusek & Schneider, 2010
CW	6 connected ponds & CW	Fe	Marchand PTS, Pennsylvania, USA	Full scale	7 years (ongoing)	Fe (99%)	Hedin, 2013
CW	2 cell CW	Fe, Al	Quaking Houses, UK	Full scale	1 year (est. 15-20 yr life)	Fe (45%), Al (63%)	Jarvis & Younger, 1999
Bioreactor	Collection ditch, anaerobic cell, oxidation pond & limestone drain	Ni, Cu, Zn, Fe, Al, Mn	Cadillac Molybdenite Mine, N.Quebec, Canada	Full scale	2 years (ongoing)	Al (78%), Cu (97%), Fe (99%), Mn (40%), Ni (98%), Zn (99%)*	Kuyucak,2006
CW	HSSF wetland	Ni, Al, Cu, Pb, Zn, Cr, Fe, Mn	Flanders, Belgium	Full scale	3 years (ongoing)	Ni (49%), Al (93%), Cu (90%), Pb (53%), Zn (87%), Cr (66%), Fe (-50%), Mn (-103)	Lesage et al, 2007
CW	Surface flow wetland	Cr, Ni, Zn	Bahco metallurgical plant, Argentina	Full scale	2 years (ongoing)	Cr (86%), Ni (67%), Zn (95%)	Maine et al. 2006
CW	4 cell CW	Fe, Mn, As	Jackson County, Alabama, USA	Full scale	15 years	Fe (98%), Mn (79%), As (100%)	Mays & Edwards, 2001
CW	3 cell CW	Fe, Mn, Zn, Cd, B, As, Pb	Stevenson, Alabama, USA	Full scale	14 years	Fe (97%), Mn (47%), Zn (33%), Cd (100%), B (52%), As (99%), Pb (26%)	Mays & Edwards, 2001
CW	6 CW cells & 2 anaerobic cells	Fe, Al	Ohio, USA	Pilot scale	>1 year	Fe (84%), Al (36%)	Misch & Wise, 1998
Hybrid	Oxidation pond, surface flow wetlands, vertical flow bioreactors, re-aeration ponds, limestone beds & polishing pond	Fe, Zn, Pb, Cd, As, Ni	Mayer Ranch PTS, Oklahoma, USA	Full scale	4 years (ongoing)	Fe (99%), Zn (99%), Ni (96%)*	Nairn, 2013

Cold climate PTSs are highlighted in grey.

*calculated based on available published data. ALD=anoxic limestone drain, BCR=biochemical reactor, CW=constructed wetland, HSSF=horizontal subsurface flow wetland, SAPS=successive alkalinity producing system.

Table 2 (continued): Overview of Pilot and Full Scale Passive Treatment Systems

Passive Treatment Type	Components	Target Contamination	Location	Scale	Duration	Removal rates	Reference
Bioreactor	Subsurface bioreactor	Fe, Al, As, Zn, Mn, Cd, Cu	Lilly/Orphan Boy Mine, Montana, USA	Full scale	11 years	Fe (65%), Zn (99%), Al (>99%), Mn (75%), As (96%), Cd (>98%), Cu (>99%)*	Nordwick et al, 2006
Bioreactor	Pretreatment, above & below ground bioreactors	Fe, Al, Mn, As, Cd, Cu	Calliope Mine, Butte, Montana, USA	Full scale	3 years	Fe (99%), Al (99%), Mn (32%), As (0%), Cd (19%), Cu (98%)*	Nordwick et al, 2006
Bioreactor	Anaerobic reactor, passive alkalinity addition, anaerobic reactor, passive aeration, aerobic reactor	Fe, Zn, Mn, Al, As, Cd, Cu	Surething Mine, Montana, USA	Pilot scale	Ongoing	Mn (99%) & As (92%)	Nordwick et al, 2006
CW	4 surface flow wetlands	Fe, Zn, Cu, Cd	Kristineberg mine, Sweden	Pilot scale	1 year	Cu (36-57%)	Nyquist & Greger, 2009
CW	Horizontal flow wetland, cascade filters	Mn, Cu, Zn, Cd, Pb, Cr	Sewage Processing Plant, Przywidz, Poland	Full scale	2 years (ongoing)	Pb (60%), Cu (57%), Zn (50%), Cd (67%), Mn (75%)*	Obarska-Pempkowiak & Klimkowska, 1999
CW	Sedimentation pond, aerobic cells, anaerobic cells	Zn, Mo	Antamina Mine, Peru	Full scale	9 years (ongoing)	Zn (51%), Mo (65%)	Plewes et al, 2009
Bioreactor	Vertical flow BCR	Se	Grand Junction, Colorado, USA	Pilot scale	1 year	Se (98%)	Rutkowski et al, 2010
CW	2 CWs (1 large & 1 small)	Cu	Bell Copper Mine, Smither BC, Canada	Pilot scale	2 years	Cu (40-98%)	Sobolewski et al, 1994
CW	CW	Zn	United Keno Hill Mine, Yukon, Canada	Pilot scale	4 months	Zn (90%)	Sobolewski, 1996b
Bioreactor	5 anaerobic cells	Al, Fe, Cd, Cu, Zn	Tulsequah Chief Mine, BC, Canada	Pilot & Full scale	4 years	Al (92%), Fe (97%), Cd (46%), Cu (80%), Zn (32%)*	Sobolewski, 2010.
Bioreactor	2 parallel bioreactors	Se	Smoky River coal mine, BC, Canada	Pilot scale	1 year	Se (97%)	Sobolewski, 2010.
CW	Surface flow wetland	Cu	Campbell Mine, Ontario, Canada	Full scale	14 years	Cu (90-95%)	Sobolewski, pers comm.

Cold climate PTSs are highlighted in grey.

*calculated based on available published data. ALD=anoxic limestone drain, BCR=biochemical reactor, CW=constructed wetland, HSSF=horizontal subsurface flow wetland, SAPS=successive alkalinity producing system.

Table 2 (continued): Overview of Pilot and Full Scale Passive Treatment Systems

Passive Treatment Type	Components	Target Contamination	Location	Scale	Duration	Removal rates	Reference
Hybrid	Fixed film aerobic reactor, biological trickle filter	Al, Fe, Mn, Sr, Zn	Merrick Landfill, North Bay, Ontario, Canada	Pilot scale	1 year	Al (80%), Fe (96%), Mn (87%), Sr (41%), Zn (60%)*	Speer et al, 2012
Hybrid	Fixed film aerobic reactor, sand & gravel CW	Al, Fe, Mn, Sr, Zn	Merrick Landfill, North Bay, Ontario, Canada	Pilot scale	1 year	Al (80%), Fe (95%), Mn (60%), Sr (41%), Zn (60%)*	Speer et al, 2012
CW	Pretreatment basin, aeration cascade, limestone channel & 2 wetlands	Fe, Mn, Zn, As	Jales mining site, North Portugal	Full scale	6 years (ongoing)	n/a	Valente et al, 2012
CW	2 parallel sub-surface horizontal flow CWs	Mn, Al, Cu, Zn	Prague, Czech Republic	Full scale	3 years (ongoing)	Mn (80.9%), Al (>82.3%), Cu (>91.1%), Zn (>97.5%)	Vyzamal & Krasa, 2003
Bioreactor	5 BCRs	Fe, Al	Tab Simco coal mine, Illinois, USA	Pilot scale	4 months	Fe (56%), Al (95%)	Walters et al, 2013
CW	Vegetated wetland and stabilization pond	Pb, Zn, Cd	Pb/Zn mine, China	Full scale	16 years (ongoing)	Cd (94%), Pb (99%), Zn (97%)	Yang et al, 2006
CW	4 wetland cells	Fe, Mn, Co, Ni	Springdale, Pennsylvania, USA	Full scale	2 years (ongoing)	Fe (94%), Mn (98%), Co (96%), Ni (63%)	Ye et al, 2001

Cold climate PTSs are highlighted in grey.

*calculated based on available published data. ALD=anoxic limestone drain, BCR=biochemical reactor, CW=constructed wetland, HSSF=horizontal subsurface flow wetland, SAPS=successive alkalinity producing system.

3. NORTHERN ENVIRONMENTS

PTSs in northern environments are often located in remote locations with limited access and power, short growing seasons and cold winter temperatures, conditions which can present challenges for PTS design. These challenges however, are also often reasons for choosing PTSs, which can be constructed to operate year-round with little maintenance and no power.

For the purposes of this review, cold climates are described as those that may experience freezing conditions during the winter months. This definition allows the inclusion of any PTS that may experience seasonal variations in efficiency and may employ adaptations for cold temperatures. The main problems faced by PTSs in cold climates are hydraulic failure due to freezing, ice formation and insufficient biological activity at low temperatures (Wittgren & Maehlum, 1997; Mander & Jenssen, 2003). Due to the interest in implementing PTSs in cold climates and the need to develop site-specific systems, many adaptations for cold climate PTSs have been examined and case studies illustrating the implementation of cold climate PTSs are detailed in Section 3.2.

3.1. Cold climate effects

Seasonal variations occur in most PTSs due to changes in water flow, senescence of aquatic plants, metabolic activities of microorganisms and variations in temperature and pH. Some wetlands may lose efficiency during the winter months while still meeting water treatment objectives (Groudev et al, 2008). In other cases, no seasonal variation in effectiveness has been found due to complex relationships between oxidation, temperature and pH which maintain the treatment regime regardless of climatic conditions (Hedin, 2013). Some of the main cold climate conditions potentially affecting PTS effectiveness are discussed below.

3.1.1. Temperature

Water temperature changes diurnally and annually. Diurnal temperature changes by approximately 5°C, while annual changes vary depending on latitude and climate. For example, in warm seasons water temperature is approximately equal to air temperature. During periods of ice cover, water temperature is maintained near 0°C for the duration with no diurnal variation (Kadlec & Reddy, 2001). Water temperature directly affects microbial activity by reducing metabolic reaction rates (Oberholster et al, 2014). In addition, plant matter decomposition and adsorption has been shown to decrease as temperature is lowered (Kadlec & Reddy, 2001). The solubility of oxygen (Kadlec & Reddy, 2001) and carbon doxide (Hedin, 2013) is also strongly temperature dependent with greater solubility at lower temperatures. The increased oxygenation in winter can aid aerobic processes, although ice cover can impede oxygenation during the winter and create anoxic conditions (Fortin et al, 2000). Maintaining oxic conditions in sediments during winter has been recommended to increase Fe and Mn retention (Goulet & Pick, 2001). In a PTS in Pennsylvania, Hedin (2013) found there was greater mixing of unfrozen ponds in winter due to density gradients in the water column. Cool water on top continually sunk to the bottom which forced the CO_2-rich deep water to the surface where it degassed. This caused changes in pH and subsequently Fe oxidation rates (Hedin, 2013). This PTS is discussed in greater detail in Section 3.2.10. In general, lower temperatures in winter have the effect of slowing down both biotic and abiotic processes that are essential to the functioning of PTSs, however, in many cases temperature

and efficiency are not directly related. For example, at Silver King mine, Yukon, Canada samples were collected with distance from an adit into a natural wetland/muskeg in the months of December, January and February, when temperatures ranged from -26°C to -49°C (Sobolewski, 2003a). In all three months Zn concentrations dropped from 1.2 mg/L at the adit to 0.15-0.61 mg/L within 160 m from the adit into the wetland. Diagnostic sequential leach analysis was used to identify metal removal processes during these winter months and both Cd and Zn were found mostly adsorbed onto or coprecipitated with iron and manganese oxides (Sobolewski, 2003b). More discussion on cold climate impact on microbial activity is presented in 3.1.3.

3.1.2. pH

pH is very important in PTSs treating mine-impacted water as it affects the solubility, oxidation, adsorption and biological removal of metals (Sheoran & Sheoran, 2006). The solubility of many metals is pH-dependent, with metal solubility typically increasing to toxic levels at lower pH values (Figure 5). For certain metals, such as aluminum or iron, raising water pH to neutrality is usually sufficient to decrease their concentrations to acceptable levels. Other metals, such as cadmium, manganese or zinc, can be soluble at neutral pH and cannot be removed by simple pH adjustment. The solubility of certain contaminants, such as nitrate or selenium, is largely unaffected by pH. Finally, the solubility of certain gases, particularly carbon dioxide, is pH-dependent and changes in solution pH will affect their concentrations. CO_2 degassing has been found to increase at colder temperatures due to greater mixing of the water column (Hedin, 2013) and as CO_2 is released, pH increases. CO_2 degassing has also been found to improve iron and trace metal removal in PTSs likely due to the increase in pH (Nairn, 2013). Conversely, CO_2 solubility also increases at lower temperature which may have the effect of lowering pH.

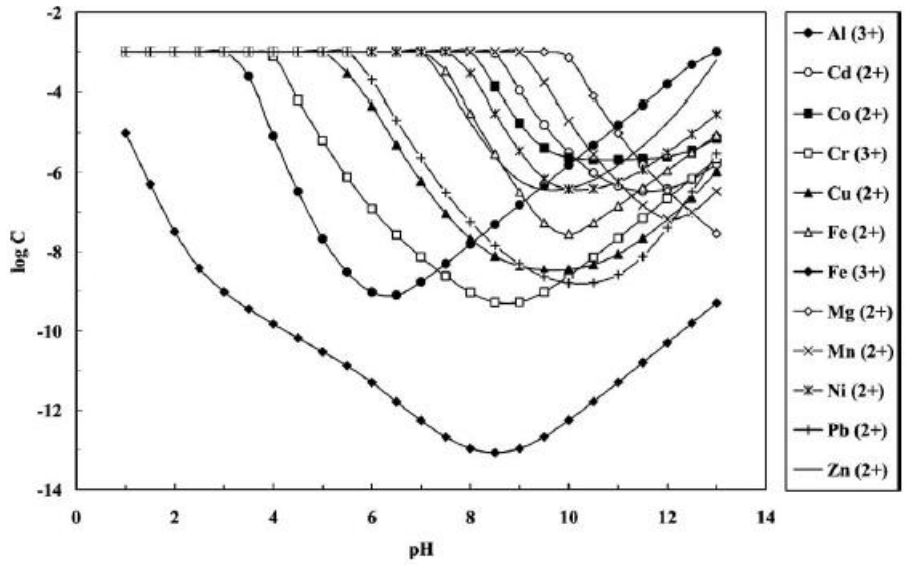


Figure 5: Solubility of different metal hydroxides based on chemical equilibrium calculations using the MINQL+ software. Stimulation conditions: T=25°C, $CI_i = 10^{-2}$ M and $(metal)_i = 10^{-3}$M (Blais et al, 2008, p.137).

Additionally, the precipitation of metals salts, such as aluminum or iron hydroxides can drive significant changes in pH. In some cases, the oxidation and precipitation of dissolved iron may be sufficient to acidify mine water to unacceptable levels. The alkalinity and acidity of water are essential parameters to consider in predicting overall changes in pH that might occur in PTSs.

Biological processes, such as the decomposition of organic matter and plant uptake of metals, are affected by water pH. The sulphate-reducing bacteria (SRB) that are responsible for metal removal, grow within a pH range of 5.5-8.5. Therefore, low water pH hinders their growth and ability to remove metals. Lowering pH has been shown to decrease sulfate reduction rates (Tsukamoto et al, 2004), which is why many PTSs employ pretreatment by ALDs or other limestone-based unit processes. Photosynthesis and respiration have the effect of increasing pH due to the removal of CO_2, therefore pH is likely to be greater in the summer due to growth of algae and plant biomass. pH has been found to have a positive effect on the bioavailability of some metals to some plant species (Deng et al, 2004). Numerous studies have found that temperature and seasonal variation affect pH in PTSs, however the relationship between temperature and pH is complex and requires further study.

3.1.3. Microbial activity

In general, microbial activity decreases with temperature. However, cold-adapted SRB have been studied extensively in the Arctic and Antarctic (Camenzuli et al, 2014; Robador et al, 2009; Sagemann, et al, 1998) and many have adaptations that sustain sulfate reduction rates at colder temperatures. Anaerobic bacteria have been found to grow very slowly below 15°C (Hiley, 2003), although in a CW in Ontario, SRB were found to thrive during winter. Goulet and Pick (2001) showed that the largest SRB populations in a wetland were in December when the water was ~1°C and determined that sulfate reduction rates were highest under those conditions. While sulfate reduction rates are generally lower at colder temperatures and cold-adapted SRB may have higher optimum growth temperatures, sulfate reduction rates may still be maintained at levels similar to those in temperate climates (Fortin et al, 2013). Cold-adapted SRB in the Arctic have been found to be more limited by organic substrate availability than by temperature (Sagemann et al, 1998). Fortin et al. (2013) suggest that decreased organic decomposition in cold temperatures caused the SRB to compensate by increasing their numbers, which maintained the sulfate reduction rates throughout the year. Panos et al. (2013) found that temperature has a large influence on the development of SRB; SRB did not develop at temperatures below 6°C. Despite this, Fe removal efficiency was still relatively high indicating other processes, such as adsorption, may be responsible for maintaining metal removal at lower temperatures (Panos et al, 2013). On the other hand, in a bioreactor at the Calliope mine (Section 3.2.8), results suggested that freezing SRB did not affect their activity during the rest of the year (Nordwick et al, 2006). In a pilot bioreactor in Wyoming, sulfate reduction rates were reduced by 20% in the winter when water temperatures were below 1°C, although this was not enough of a reduction to affect the treatment performance of the bioreactor (Gusek, 2002). In a column experiment on the performance of anaerobic bioreactors at low temperatures, Gould et al. (2012) found that Zn removal fell from 99% to 60% when the temperature was lowered from 20°C to 4°C. They compensated for the loss of efficiency by feeding the columns with liquid carbon (glucose and lactate/acetate) and achieved >95% Zn removal efficiency at 4°C (Gould et al, 2012). Liquid carbon sources can maintain microbial activity in bioreactors over the winter months when cold temperatures reduce organic matter decomposition (Sobolewski, 2010).

3.1.4. Water flow

In cold climates, water flow changes seasonally with large increases in flow in the spring when the snow melts and low flows throughout the winter. Drastic changes in flow present challenges to PTS designers. In a natural wetland in the Rocky Mountains, spring snowmelt caused an increase in the flow to the wetland, which decreased the concentration of metals. The wetland was found to be a sink for Zn and Mn in the summer and a source in the winter due to changes in flow conditions and microbial activity, with the greatest disturbances to treatment efficiency occurring during spring snowmelt (August et al, 2002). Higher flows during spring runoff and throughout the summer likely created more exposed mineral surface area and allowed more of the products of weathering to be flushed out. The higher flows, however, were offset by the increased retention of metals in the wetland. Similar flushing effects were experienced at a subsurface bioreactor constructed in a mineshaft in Montana (Nordwick et al, 2006). Oxygenated spring run-off infiltrated through the ground and mobilized historic metal precipitates creating higher metal concentrations in the effluent in the spring. At a bioreactor in Norway, Cu removal efficiency was found to be highest when water flows were low and constant during the summer (Ettner, 2007). Unlike the majority of sites that experience lower flows in the winter, at this site flows were found to increase in the winter, which resulted in a dramatic drop in removal efficiency. These factors must be accounted for in the design of PTSs.

It is clear that seasonal variations affect the efficiency of PTSs but more work is needed to elucidate the specific mechanisms occurring in cold climate PTSs. Understanding of a site's hydrology, climate, precipitation regime and seasonal water flows allows PTS designers to address site-specific limitations in cold climates. In addition, better understanding of seasonal variations and their effects on metal leaching and metal removal mechanisms will improve the efficiency and reliability of PTSs operating year-round in cold climates.

3.2. Cold climate case studies

Numerous PTSs have been constructed in cold climates at various scales. Below are highlighted case studies of PTSs that demonstrate adaptations in their design for year-round operation in cold climates. Some are successful full scale designs, while others reveal some of the obstacles that may be encountered by PTS designers in cold climates.

3.2.1. United Keno Hill Mine, Yukon – Constructed wetland

In 1995, a pilot wetland was constructed at UKHM and monitored over one year to assess the possibility of treating adit discharge with high levels of Zn (30 mg/L) and other heavy metals (Sobolewski, 1996; Burns, 2000). An area below the Galkeno 900 adit was excavated, fertilized and planted with *Carex aquatilis* collected from a nearby uncontaminated wetland. The plants were allowed to establish for approximately one month, then effluent was piped into a lined pond and then into the wetland. Plywood baffles were subsequently added to distribute the flow evenly throughout the wetland (Figure 6). Zinc removal rates reached up to 90% efficiency in the first season (Table 2), however, the concentration never dropped below 3 ppm, which is well above the 0.5 ppm discharge limit. Other heavy metals were below acceptable limits and more than 80-90% of Co, Ni and Mn were removed. Results from this CW indicated that longer hydraulic retention times within the pilot wetland would have increased the Zn removal efficiency. In addition, Sobolewski (1996) suggested that allowing

vegetation to more fully establish (>35% was unvegetated) would likely improve efficiency. Metal removal in the CW was directly correlated with sulfate reduction, suggesting that Zn was removed as a Zn sulfide precipitate. Wetland plants were analyzed from the natural wetland and the results suggested that contaminants uptake from the sediments into the plants was limited.



Figure 6: CW at Galkeno 900 adit with plywood baffles to help distribute flow evenly (Burns, 2000, p.38).

The CW at the Galkeno 900 adit was only operational for a short time and never reached a steady state before flow was redirected to a limestone treatment system inside the mine adit. The wetland was, however, subject to further analysis in 1999 (Burns, 2000). The author reported that four years after transplant, *Carex aquatilis* had fully covered the constructed wetlands. Below-ground seepage from a waste rock pile was observed to be travelling to the wetland so samples were taken to determine the levels and distribution of contaminants in the wetland. The metal concentrations in sediments decreased with distance from the seep while the concentrations in plants were relatively consistent, except for the concentration of Zn which decreased with distance from the seep. The data indicates that the wetland continues to attenuate metals in the discharge waters.

3.2.2. United Keno Hill Mine, Yukon – Anaerobic bioreactor

In 2008 at UKHM, a pilot horizontal flow bioreactor was constructed on-site at the Galkeno 900 adit (Figure 7 and 8) (Alexco, 2012). A pit was excavated, lined and then filled with waste rock. The pit contained 3 m deep waste rock with a 1.2 m soil cover on top to reduce ice formation in the bioreactor. In March 2011, there was up to 60 cm of ice in the bioreactor. All of the pipes and valves were buried at least 1 m belowground and those running under roadbeds were covered in heat trace. Baffles were installed to distribute the flow throughout the pit. The bioreactor was filled with untreated adit water and sucrose, methanol and/or milk solids were added to stimulate SRB growth in October 2008 and

January and July 2009. From October to July of 2009, the water was recirculated in the bioreactor in a closed circuit and strong sulfate-reducing conditions developed. The flow-through phase then began and constant additions of methanol were initiated. The flow rate was initially 0.5 L/sec (21 days residence time), which was then increased to 1 L/sec (10.5 days residence time) and then reduced to 0.75 L/sec for the rest of the operational phase. At low flows 99.8% of Zn was removed and at higher flow rates 97.8% was removed (Table 2). While the Zn discharge limit (0.5 mg/L) was met consistently at the low flow rate, it was sometimes exceeded at higher rates. It was observed that the residence time within the bioreactor was a major factor affecting metal removal efficiency. While Zn was the primary contaminant of concern, 80% of As was removed at a flow rate of 1 L/sec. Cd was removed to below detection limits and 97.5% of Ni was removed at low flows, but only ~50% was removed at higher flows. Iron and Mn were efficiently removed (99%) during the recirculation phase, but during the operational phase, when the reducing conditions were fully established, Fe and Mn were remobilized resulting in slow release of these metals over the course of operation. The bed of the bioreactor was composed only of waste rock, so sorption was not likely a factor in removing metals; sulfate reduction and metal sulphide precipitation were the primary mechanisms. Some of the engineering problems encountered included uneven distribution of flow and decreased contact with the substrate (i.e. so-called 'dead zones') and pump failure and power outages resulting in pipes freezing and the system having to be shut-down temporarily. A gravity fed system and/or back-up power would have helped to avoid the difficulties of maintaining a constant flow in the winter (Alexco, 2012).



Figure 7: Bellekeno pilot bioreactor under construction in 2008 (left) and after 5 years (right) (Alexco, 2012, p. 6).

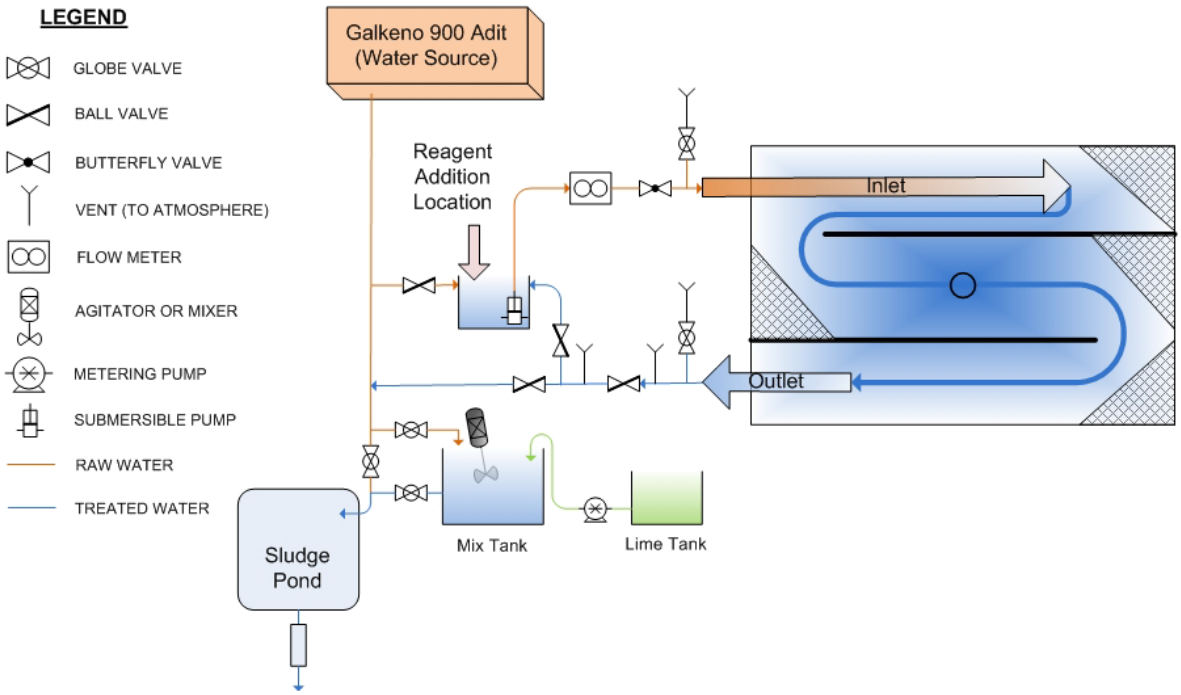


Figure 8: Layout of Galkeno 900 bioreactor (Alexco, 2012, p.7).

3.2.3. Tulsequah Chief & Smoky River Coal Mine, BC

At the Tulsequah Chief Mine (Cu, Pb/Zn) in Northern British Columbia, acidic rock drainage was successfully treated using a 66 m^3 anaerobic bioreactor built inside the mine adit (Sobolewski 2010). Wood mulch was used in the bioreactor; however, as the ambient temperature in the reactor was low (6-8°C), wood mulch decomposition was too slow to maintain anaerobic conditions. To overcome the issue, ethylene glycol was subsequently added to the influent to create reducing conditions, decreasing the dissolved oxygen levels and kick-starting SRB activity. A full scale five cell, 200 m long, bioreactor was then built based on the pilot test results and monitored over four years. The first three cells received a wood mulch/limestone mix to reduce acidity and the two final cells received sulfur prills (elemental sulfur in pellet form) and supported SRB. Ethylene glycol was dripped into cells one and four. The front three cells consistently removed Al and Fe, but also gradually accumulated sludge, which caused failure after four years of operation, while the final cells removed Cd, Cu and some Zn (Table 3). The bioreactor operated year-round without maintenance in the winter and was constructed in areas with limited space, access and power.

Table 3: Metal concentrations in drainage and discharge from Tulsequah Chief pilot and full scale bioreactors (adapted from Sobolewski, 2010).

Parameter	ARD	Pilot-scale bioreactor	Full-scale bioreactor
pH	3.0-3.7	6.0-6.7	6.1-6.7
Al (mg/L)	10-30	0.1-1.0	0.06-2.5
Cd (mg/L)	0.22-0.47	<0.050	0.07-0.30
Cu (mg/L)	16-30	0.1-1.0	2-7
Fe (mg/L)	20-120	0.1-2.0	0.04-4.0
Zn (mg/L)	56-120	30-50	42-77

3.2.4. Smoky River Coal Mine, BC

Two 5 m^3 pilot scale bioreactors were constructed in parallel at the Smoky River Coal Mine to treat Se-contaminated water in an area where access, space and power were severely restricted, (Sobolewski, 2010). The bioreactors were filled with gravel, wood chips, manure, lime and bonemeal, inoculated with Se-reducing bacteria and fed with ethylene glycol as a liquid carbon source. The liquid carbon source helped to sustain necessary microbial processes (Sobolewski, 2010). The bioreactors effectively removed 97% of the Se from September to November 2008 (Figure 9), even when temperatures dropped to 2°C. This case study, along with other studies previously mentioned (i.e. Galkeno 900 and Tulsequah Chief) demonstrates that addition of a liquid carbon source may allow anaerobic bioreactors to keep operating with high efficiency on northern mine sites under winter conditions.

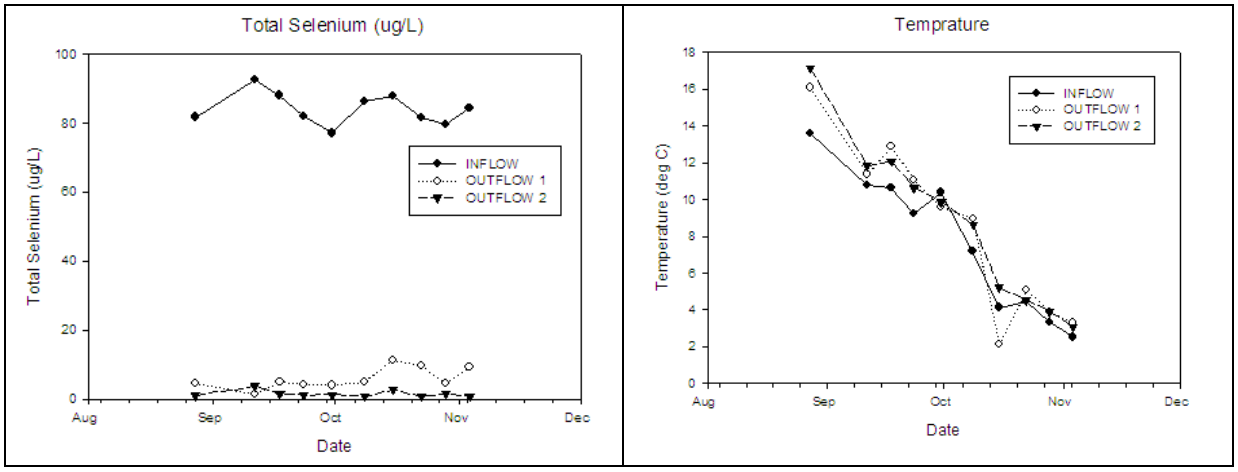


Figure 9: Selenium removal as a function of temperature at Smoky River Coal (Sobolewski, 2010, p. 2)

3.2.5. Kongens & Folldal Mines, Norway

In Norway, bioreactors have been tested for the treatment of acidic mine drainage at both active and abandoned mines in cold climates (Ettner 2007). A first pilot bioreactor system was constructed at the Kongens Mine in northern Norway in 1999, consisting of a pre-treatment limestone drain and four anaerobic cells filled with organic waste materials, rotted hay, sawdust, tree clippings and $CaCO_3$. However, the substrate was found to be inappropriate due to low hydraulic conductivity which caused clogging. Highlighting the importance of thorough design, the substrates were revisited and a new bioreactor system was constructed in 2002 using rotted hay, sand and coarse birch tree materials. In this reactor, up to 85% Cu 48% Zn, 98% Cd, 82% Pb, 71% Cr and 24% Ni were removed in this second pilot system, however Cu removal was significantly reduced in winter months. This reduction was correlated with a drastic increase in the flow rate in the bioreactor (Figure 10). To overcome this issue and avoid high flow variations, a full-scale bioreactor was constructed in 2006 which consists of two identical cells, one receiving a constant flow and the other receiving smaller, but variable flow rates.

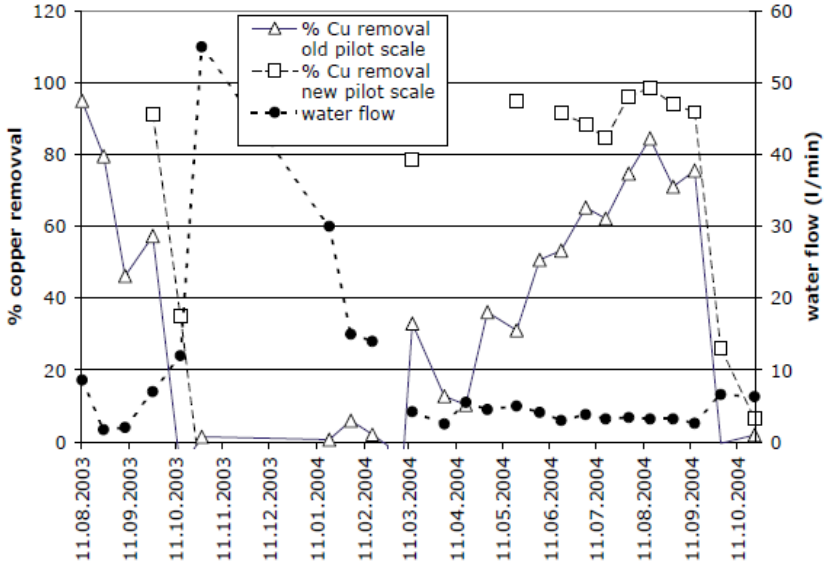


Figure 10: Copper removal (%) by pilot anaerobic reactors versus water flows (Ettner 2007, p.3)

Using a similar design, a pilot bioreactor system was built at the Folldal mine in 2006, with four 8 by 1.5 m basins filled with rotten hay, tree clippings, shell sand and gypsum to act as an extra sulfate source (Ettner 2007). The bioreactors were filled with water in the fall and left to rest for the winter with no flow. Unfortunately, no monitoring data were available from when system was restarted in the spring. However, the study indicated that cold winter temperatures did not prevent inoculation of the bioreactors by microorganisms and development of anaerobic conditions, low Eh and signs of sulfide precipitates were reported.

3.2.6. Bell Copper Mine, BC

At the Bell Copper mine in Smithers, BC, two experimental wetlands were constructed to determine the effectiveness of a year-round CW in a northern environment for treatment of Cu-contaminated water (Sobolewski et al, 1994). Two membrane lined ponds (300 m^2 and 75 m^2) were constructed, fertilized with manure and planted with peat mats dominated by sedges (*Carex aquatilis* and *Carex laeviculmis*). The ponds were also planted with cattails (*Typha latifolia*) and beaked sedges (*Carex rostrata*) and were fully vegetated within a year (Figure 11). For the first year, the wetlands were fed with low flows of mine drainage with low levels of Cu (0.3-1 ppm) at a pH of 6-8. They were 98% effective at removing Cu (Figure 12) throughout the winter months when the wetlands were covered in ice and even when the influent Cu concentrations occasionally spiked to 10 ppm (Sobolewski et. al., 1994). Mine drainage with high levels of Cu (35-50 ppm) at pH 3.5 was then introduced to the wetlands. For the first six weeks, they maintained removal efficiency, but then gradually started deteriorating reaching 40% efficiency for the large wetland and 80% for the small one. Both a decrease in pH and SRB population were observed concurrently with the reduction of Cu removal efficiency. The reduction of efficiency of the wetland was likely due to reduction in the activity and growth of SRB, which were not acclimated to the low water pH. Longer retention times and pretreatment to increase pH were suggested as means to address the shortcomings of these wetlands for treatment of highly contaminated mine drainage (Sobolewski et al, 1994).

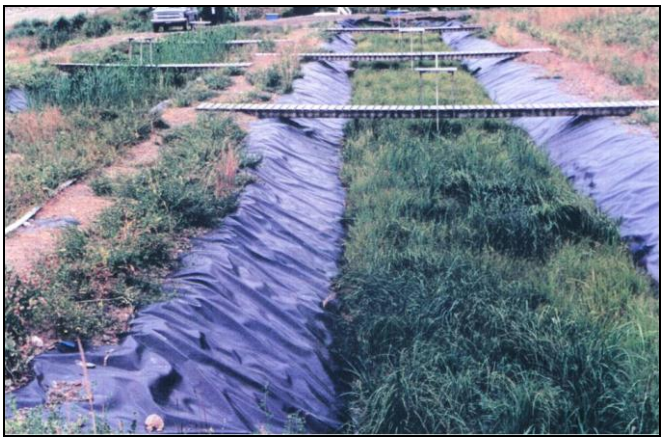


Figure 11: Pilot wetlands at the Bell Copper Mine (Sobolewski A., personal communications, November 12, 2014).

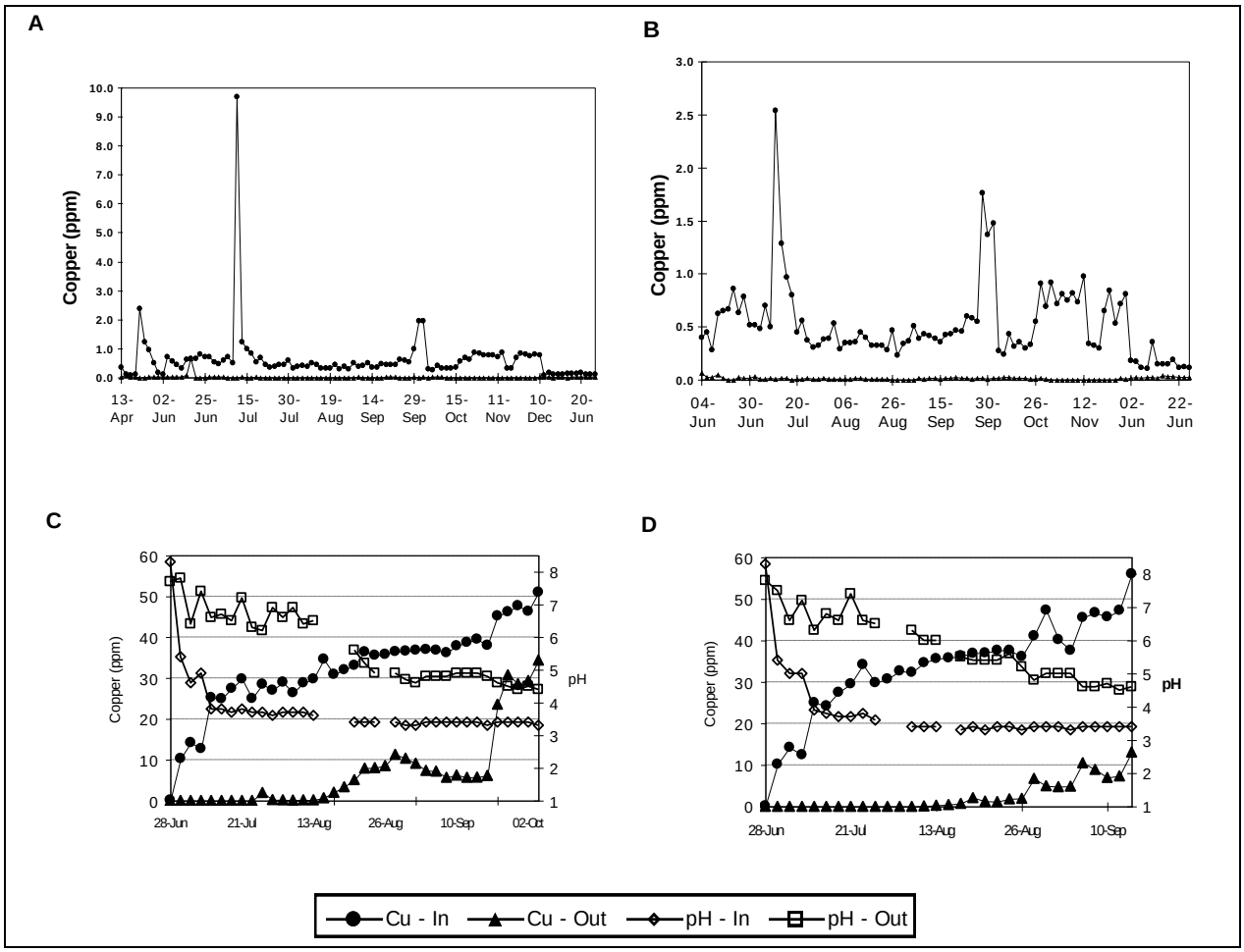


Figure 12: Copper concentrations and pH of influent and effluent for the large (A, C) and small pond (B, D) at low strength (A, B) and high strength feed (C, D) (April 1992 to Oct 1993, Sobolewski et al, 1994, p. 686). Note different scales used in A and B.

3.2.7. Lilly/Orphan Boy Mine, Montana

At the Lilly/Orphan Boy Mine in Montana, USA an in-situ bioreactor was constructed and operated between 1994 and 2005 to treat ARD at the abandoned mine (Canty, 2000; Nordwick et al, 2006; Bless et al, 2008). The bioreactor was built within an old mineshaft, approximately 9 m below the static water level. Organic matter, cow manure and straw were placed on a platform inside the shaft with mine water flowing upward through the organic substrate (Figure 13). This below-ground design offered protection from the cold winter temperatures (ambient temperature was 8 °C) and worked successfully for over 11 years. Removal efficiencies were between 98% and >99% for Al, Cd, Cu and Zn and 96% for As. However, the mineshaft bioreactor design also came with challenges, including metal leaching within the mine tunnel as water travelled out through the portal, creating effluent with, in some cases, higher contaminant concentrations (As and Fe) (Table 4). Additionally, this system was affected by snowmelt and spring run-off. Higher metal concentrations in the spring were attributed to greater metal leaching from the rocks by oxidation due to oxygenated surface water infiltrating into fractures in the rocks and tunnel walls (Nordwick et al, 2006). For most metals, metal removal had

seasonal variability with high removal efficiencies during the summer, but low removal efficiencies at all other times of the year (Figure 14). However, Mn and Zn were removed effectively year-round.

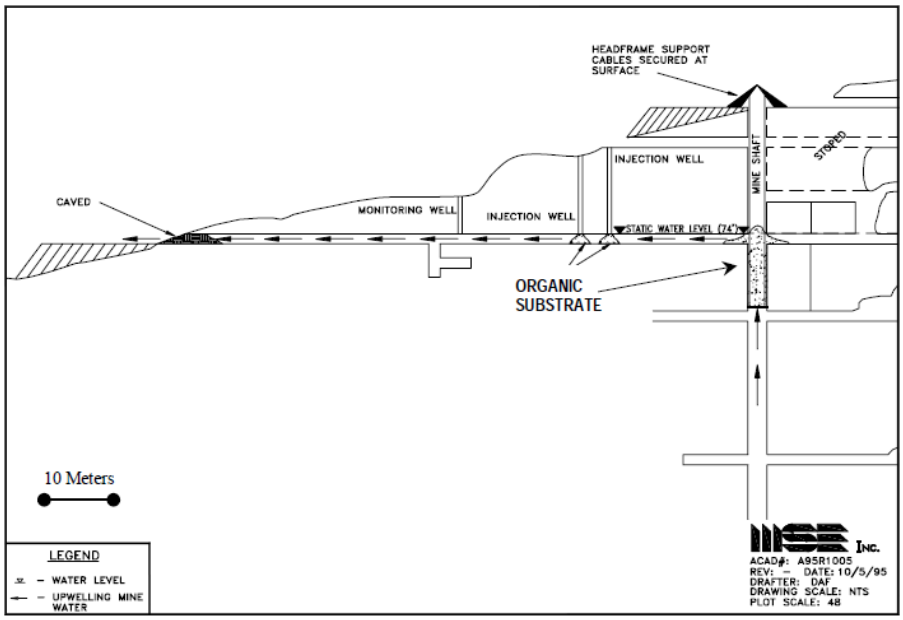


Figure 13: Underground bioreactor at Lilly/Orphan Boy Mine, Montana (Nordwick et al, 2006, p. 1412).

Table 4: Representative mine water chemistry at Lilly/Orphan passive treatment system (dissolved metals in mg/L) (Bless et al, 2008, p. 243).

Sample	Month	Fe	Zn	Al	Mn	As	Cd	Cu	SO_4	pH
Pretreatment shaft	Several	27.7	26.1	9.7	6.2	1.07	0.33	0.32	277	3.0
Pretreatment portal	Several	14.1	19.4	7.4	5.5	0.08	0.24	0.33	213	3.4
Treated tunnel water	March 2001	9.3	<0.01	<0.02	1.4	0.02	<0.005	0.022	59	7.4
	May 2001	13.2	0.06	<0.02	2.7	0.13	<0.005	<0.005	214	7.0
Treated portal effluent	March 2001	30.8	10.1	0.2	5.5	5.26	0.040	<0.002	161	6.1
	May 2001	11.2	28.8	11.2	6.4	0.05	0.301	0.686	394	3.4

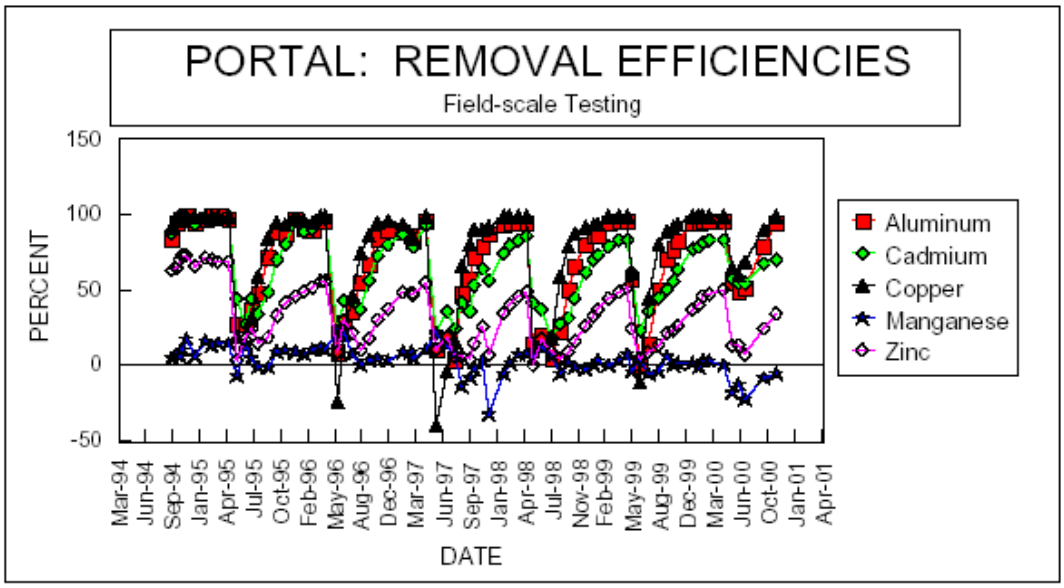


Figure 14: Metal removal in Lilly/Orphan Boy Mine (Canty, 2000, p. 3).

3.2.8. Calliope Mine, Montana

Pilot-scale bioreactors were built at the Calliope Mine in Montana to determine the effect of freezing on SRB (Nordwick et al, 2006; Wilmoth 2002). Two bioreactors were placed in trenches (21.8m and 18.6m long) and one was constructed aboveground (22.1m long) to investigate the impact of seasonal freezing and thawing on treatment performance (Figure 15). The trenches were filled with cow manure, straw, limestone and Terracell^{TM} to prevent organic matter settling, improve permeability and ensure uniform flow through the bioreactors (Figure 16). The systems were operated with a horizontal flow and 4.5 days residence time (+1 day pretreatment in the longer belowground system). Once the SRB populations were established, the mine water was introduced. Zinc, Cu, and Cd were removed as sulfides through bacterial activity while Fe, Mn, Al and As removal was affected by SRB only in an indirect manner by responding to increased pH caused by SRB activity. Zn, Cu and Cd were removed from the ARD to approximately 500 to 800 µg/L for Zn, 80 µg/L for Cu, and 5 µg/L for Cd in both the belowground and aboveground configurations, indicating that at Calliope site, the bioreactor efficiencies were not affected by freezing and thawing. Removal of Fe, Al and Cu was very effective (99%), whereas As was not removed at all and Mn were removed to a lesser extent (32%). Plugging by chemical precipitates affected the flow rate during operation. However it was observed after deconstruction of the aboveground bioreactor that less organic material would have been just as effective, which would have increased the permeability without compromising the efficiency. Overall, a uniform horizontal flow was successfully achieved in the bioreactors. The pilot project also demonstrated that SRB need time to establish, but once established and supplied with organic carbon, they can maintain an active population at temperatures ranging from 2°C to 16°C, without being affected by winter conditions (Figure 16). Additionally, a well-established population can withstand freezing in winter with little or no effect on their activity during the rest of the year.

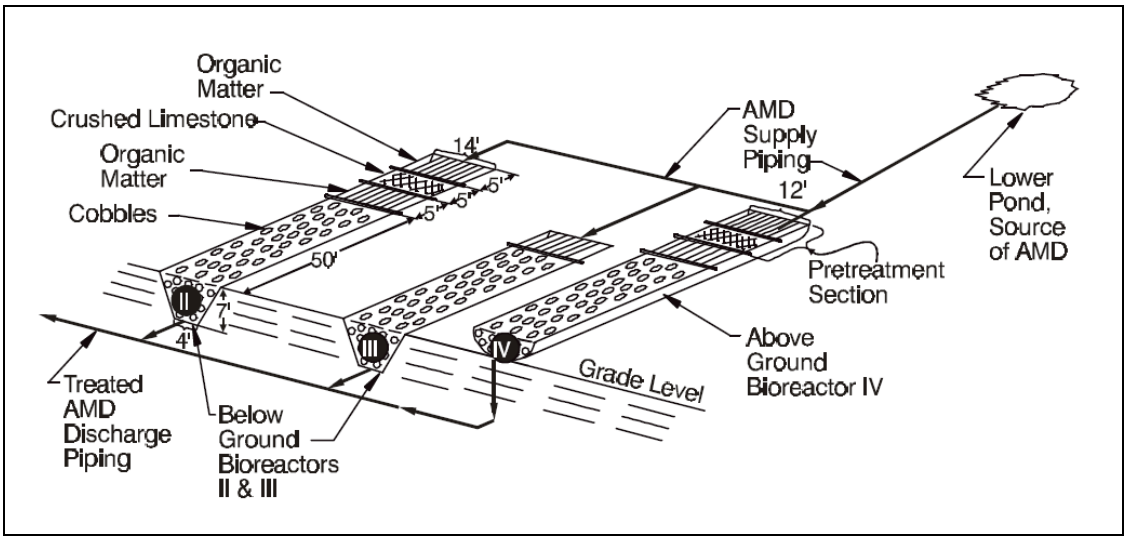


Figure 15: SRB bioreactors at Calliope Mine (Wilmoth, 2002, p.21).

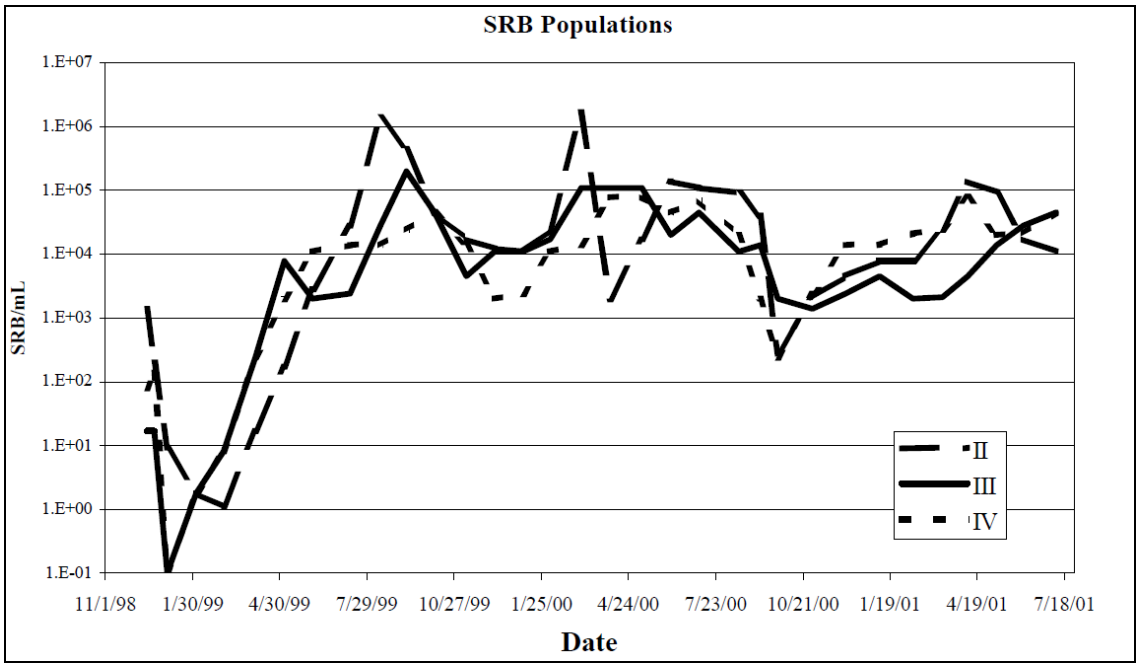


Figure 16: SRB population variation over 3 years in below-ground (II and III) and above-ground (IV) bioreactors at Calliope mine, Montana (Wilmoth, 2002, p. 35).

3.2.9. Cadillac Molybdenite Mine, Quebec

At the decommissioned Cadillac Molybdenite Mine in Northern Quebec a 170 m^3 bioreactor was constructed to treat ARD with acidic pH ranging from 2.7-5.6 (Kuyucak et al, 2006). Passive treatment was chosen due to the lower cost and maintenance as compared to an active system and the remoteness and limited access for much of the year. The extreme cold for 6 months of the year (average -20°C) also presented a challenge in the design of the system. The treatment unit consisted of a collection ditch, an anaerobic cell filled with wood chips, limestone, hay and manure, followed by an oxidation pond and a limestone drain (Figure 17). The nutrient mixture was allowed to condition for 2 months prior to installation in the cell to allow the establishment of SRB before winter. In addition, an overflow drain was installed in the anaerobic cell and the collection ditch to allow excess mine drainage to bypass the SRB cell and help keep uniform flow in the bioreactor. The surface of the collection ditch and anaerobic cell were covered with 50 mm polystyrene sheets and 0.25 m of clay to prevent freezing (Figure 18). During the winter, the effluent temperature dropped to 3°C and the anaerobic cell was at 4°C. Since its implementation in 2004, removal to below regulated limits for Cu (0.3 mg/L), Ni (0.5 mg/L) and Zn (0.5 mg/L) has been successful (Table 5). Iron removal was not as successful during the winter, when settling of Fe precipitates in the oxidation pond was inhibited by freezing. Aluminum removal was also improved during the summer as SRB activity increased. Monitoring of the site continues and an expansion is planned to accommodate all of the effluent.

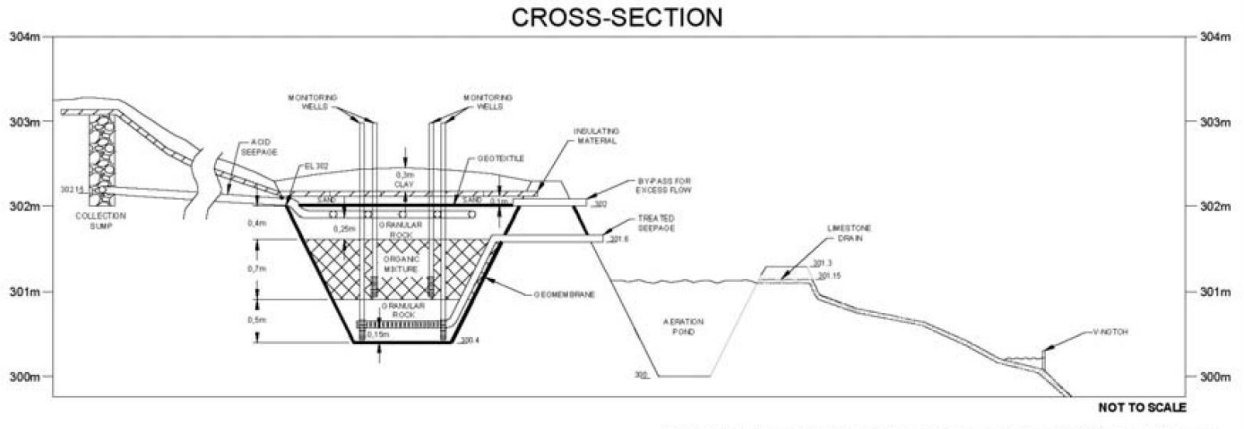


Figure 17: Bioreactor design at the Cadillac mine in Quebec (Kuyucak et al, 2006, p. 988).

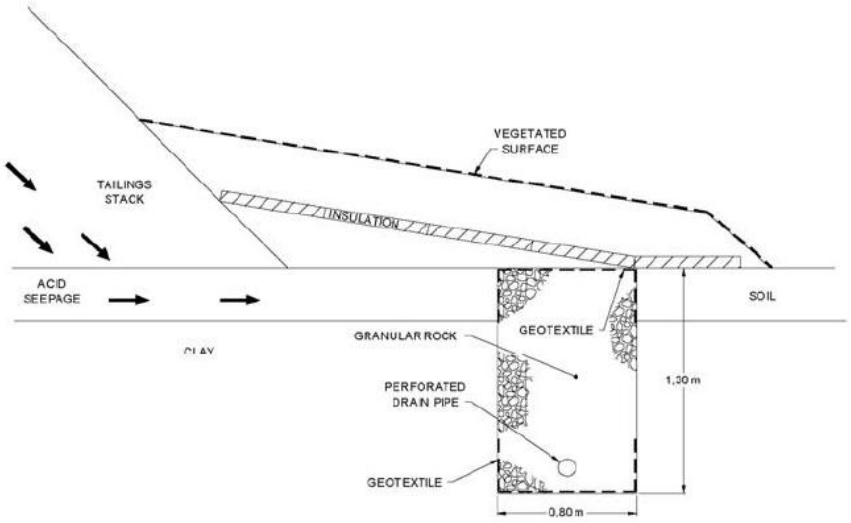


Figure 18: Cross-section of the collection ditch at the Cadillac mine PTS illustrating the use of insulation above the seepage (Kuyucak, et al, 2006, p.989).

Table 5: Water quality before and after passive treatment system at Cadillac mine, Quebec (from Kuyucak et al, 2006, p.982)

Parameter *	Directive 019	Before Treatment	After Treatment						
		Average *	Nov'04	Dec'04	Jan'05	Feb'05	Mar'05	Apr'05	Average 2005
pH	6.5	3.45	6.4	6.3	6.3	6.3	6.4	6.6	6.7
TSS	25	230	32	3.5	17	22	14	17	11.7
Al	-	43	-	-	-	18	19	11	9.4
Cu	0.3	0.3	0.1	0.06	<0.01	<0.01	<0.01	<0.01	0.008
Fe**	3	13.5 (32)***	10.5	11	2.8	1	0.6	0.3	0.12
Mn	-	5.8	-	-	-	5.7	5.5	3	3.5
Ni	0.5	0.6	0.33	0.18	0.04	0.02	0.02	<0.01	0.01
Zn	0.5	1.35	0.48	0.3	0.02	0.02	0.02	0.02	0.012
SO_4	-	887	798	690	700	620	500	360	-

* All in mg/L except pH
** >90% of iron was in Fe(II) form
*** average in 2005

3.2.10. Marchand Mine, Pennsylvania

In a PTS treating coal mine drainage in Pennsylvania, Hedin (2013) found that seasonality did not significantly affect Fe removal efficiency over a six year monitoring period. The system is comprised of 6 connected ponds and a CW planted with a mix of aquatic species (Figure 19). Models predicted Fe oxidation rates would be 10 times slower in cold seasons than in warm seasons (-15°C to +35°C); however, that was not the case in this PTS; Fe removal was found to be temperature independent (Figure 20). An inverse relationship between pH and temperature offset the expected reduction in efficiency. CO_2 solubility increases as temperature decreases, so it was unexpected when CO_2 degassing increased at colder temperatures in the ponds. This was likely due to more thorough mixing at colder temperatures. Surface waters are continually cooled and sink due to density gradients resulting in deep water that is more saturated with CO_2 coming to the surface and degassing. The increased degassing causes an increase in pH, which in turn increases Fe oxidation rates. Although this process can account for the results observed in the ponds, the seasonal dynamics in the wetland cell were far more complex. While the temperature in the oxidation ponds never fell below 4°C, portions of the wetland froze during cold weather and it was largely covered with ice during cold periods. The ice cover reduced gas exchange processes during the winter and biological activity increased during the summer. As a whole, the PTS was effective year-round at reducing Fe levels to below permissible limits (Table 2) and Fe removal efficiency did not change seasonally. Additionally, the iron sludge precipitated in the ponds is recoverable and may be sold to offset the treatment costs (Hedin, 2013). This case study highlights the complex interactions that can occur between temperature-sensitive processes, complicating predictions of temperature effects on removal rates.

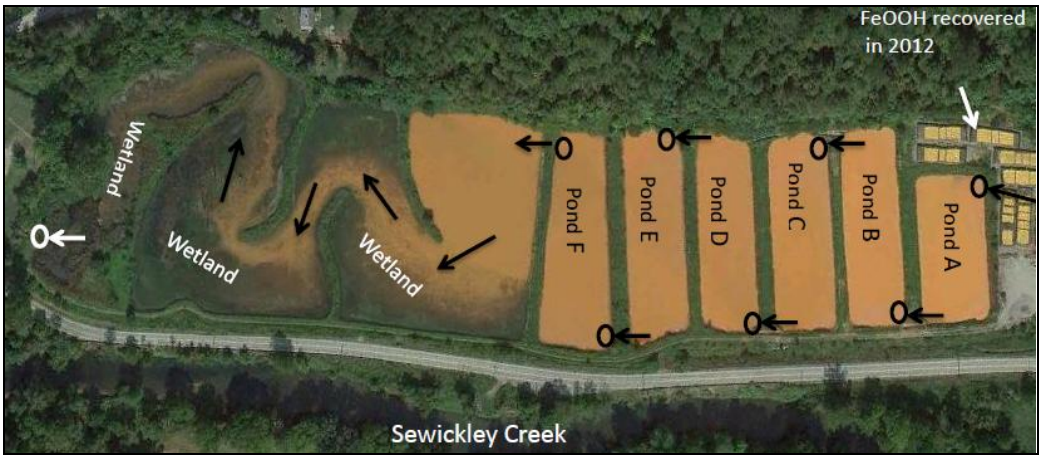


Figure 19: Aerial view of the Marchand mine bioreactor ponds, wetlands and recovered iron sludge (Hedin, 2013, p.9).

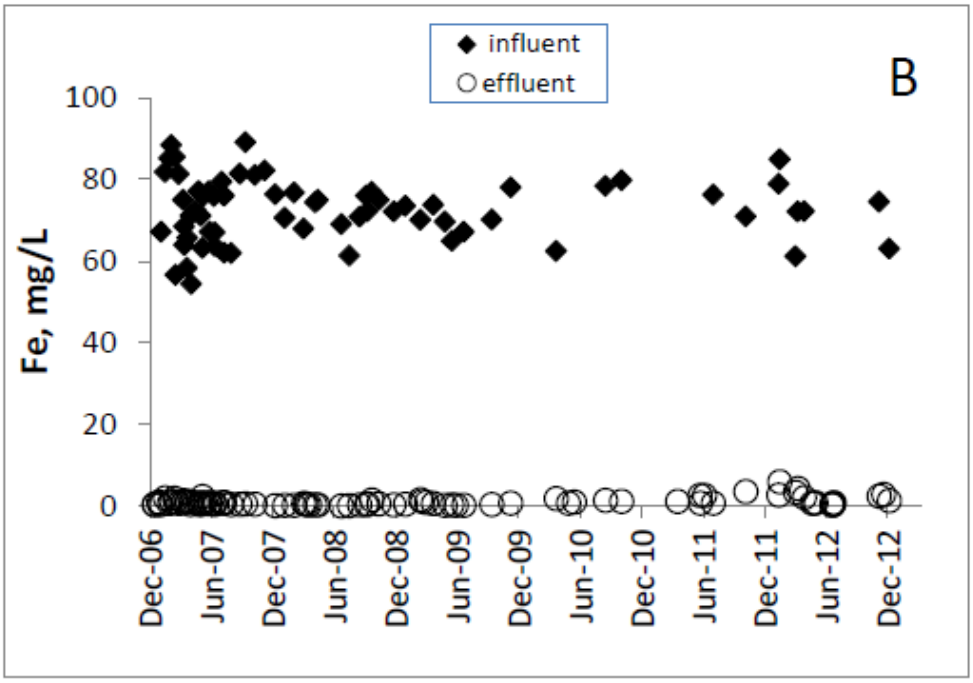


Figure 20: Total Fe concentration at influent and effluent of the Marchand mine treatment system, Pensylvania (Hedin, 2013, p.10).

3.2.11. Teck Smelter, Trail, BC

A PTS was constructed near Trail, BC to treat effluent containing very high concentrations of As, Zn and Cd from a Pb/Zn smelter (Table 6) (Duncan et al, 2002; Mattes et al, 2004). The first phase, constructed in 1997, consisted of three wetland cells (50 m^2 for 1st and 2nd cell and 300 m^2 for 3rd cell). The first cell was planted with *Brassica spp*. and *Helianthus annuus*, the second planted with *Calamagrostis canadensis* and other native grasses from the local area and the third cell was planted with *Typha latifolia* (Figure 21). The cells were initially watered with stream water to allow root growth to establish during the first year. In 1998, a vertical sub-surface flow bioreactor was built upstream with pulp mill biosolids, sand and cow manure. It was designed to allow 1 m of standing water to sit on top to protect it from winter freezing and to ensure it stayed anaerobic. Additionally, all pipes and control valves were buried below 0.9 m. Due to plugging in the first bioreactor and to increase Zn removal, another bioreactor cell was similarly constructed in 2000, upstream of the first (Figure 21), which was subsequently rebuilt. The second cell included limestone to increase the pH and thus improve Zn removal efficiency. The system was fully winterized for year-round operation, although was shut down due to a frozen pipe after a year of operation. After two years of operation (spread over a 5 year period), the system reached a net removal efficiency of 96% for As, Cd and Zn (Table 6), although As levels in the effluent were still not below stringent discharge limits. While seasonal efficiencies are not available, this system purportedly works efficiently year-round and successfully withstands freezing conditions.

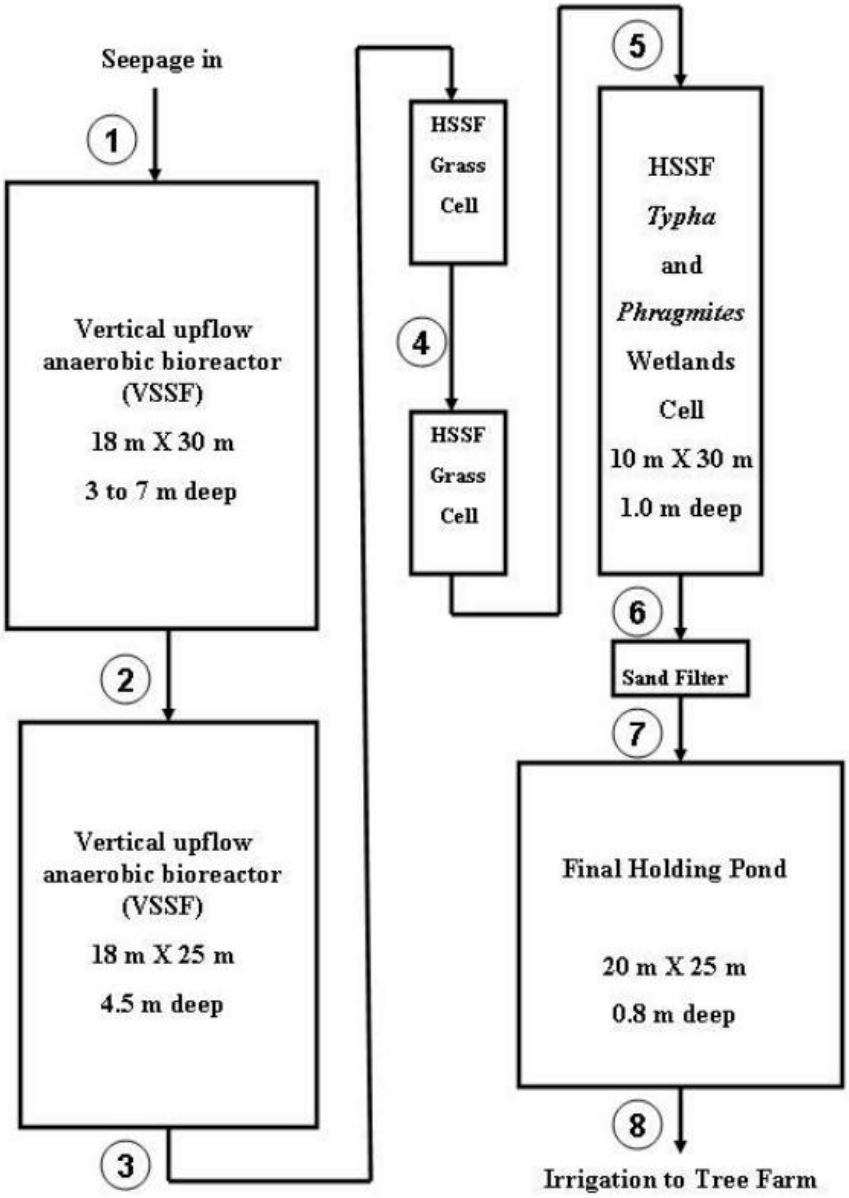


Figure 21: Diagram of the sequence of PT components at the Teck smelter, Trail, BC (Duncan, 2010, p. 40).

Table 6: Metal concentrations (ppm) and percentage removal during to operating periods (257 and 576 days) of the passive treatment system at Teck smelter, Trail, BC (Duncan et al, 2002, p.5).

Sample Point	As. Conc.	% Removed	Cd. Conc.	% Removed	Zn Conc.	% Removed
Input	69.5		5.1		355	
Anaerobic 1	18.7	73.1	2.1	58.8	177	50.0
Anaerobic 2	8.2	56.1	0.4	81.0	101	43.4
Cell 1	5.0	39.0	0.1	75.0	55.4	45.2
Cell 2	4.7	1.5	0.1	0.00	46.8	15.5
Cell 3	1.5	68.1	0.04	60.0	19.8	57.7
Final Pond	1.3	13.3	0.03	25.0	15.1	23.7
Total %		98.1		99.4		95.7

3.2.12. Uranium mine, Curilo, Bulgaria

A four cell constructed wetland in Curilo, Bulgaria successfully treated acidic drainage (pH 2-4) from a uranium deposit over a 10 year period (Groudev et al, 2008). The wetland cells were lined with a mixture of soil, plant and spent mushroom compost, cow manure, crushed limestone, silt and sand. Several barriers of this mixture were placed perpendicularly to the water flow. The wetland was vegetated with *Typha latifolia*, *Typha angustifolia, Phragmites australis, Scirpus lacustris,* and some *Juncus, Eleocharis, Poa* and *Carex* species. The wetlands significantly reduced heavy metal concentrations year-round, operating with a flow-rate between 0.2 to 1.0 L/s and a residence time between 0.5 and 5 days (Table 7). While efficiency was strongly temperature dependent, the effluent metal concentrations during the winter months (when water temperatures were below 5°C) were still below permissible discharge concentrations. Microbial activity was lower in wintertime; however, the longer residence time (i.e. lower flow) helped to sustain satisfactory removal efficiency. High metal concentrations measured in dead biomass indicated that sorption processes by dead plants and clays played an important role in removing metals in during the winter (Groudev et al, 2008).

Table 7: Water quality data before and after treatment by constructed wetlands at Curilo, Bulgaria (Groudev et al, 2008, p.94).

Parameters	Before treatment	After treatment	Permissible levels for waters used in agriculture and industry
Temperature, °C	(+0.1)–(+25.1)	(+0.1)–(+28.0)	–
pH	2.15–4.15	6.51–7.92	6–9
Total dissolved solids, mg/l	590–3250	341–2804	1500
Solids, mg/l	23–170	15–122	100
Dissolved organic carbon, mg/l	0.3–4.6	18–88	20
Sulphates, mg/l	341–1784	280–1254	400
Uranium, mg/l	0.28–4.82	<0.10	0.6
Radium. Bq/l	0.05–0.55	<0.05	0.15
Copper, mg/l	0.41–14.9	<0.1–<0.5	0.5
Zinc, mg/l	0.80–24.2	<0.5	10
Cadmium, mg/l	0.01–0.12	<0.01	0.02
Lead, mg/l	0.10–0.82	<0.10	0.2
Nickel, mg/l	0.32–7.35	<0.1–<0.5	0.5
Cobalt, mg/l	0.23–6.20	<0.1–<0.5	0.5
Iron, mg/l	73–1072	<1–14	5
Manganese, mg/l	0.95–55	<0.5–6.4	0.8
Arsenic, mg/l	0.01–0.59	<0.01–<0.1	0.8

3.2.13. Wood Cadillac, QC

An anaerobic bioreactor was built at the historic Wood Cadillac mine site, in northwestern Quebec, to treat an As-rich effluent. The tailings at Wood Cadillac are sulphidic with an excess of buffering capacity, producing neutral mine drainage (Tasse et al, 2003). The 50 x 57 x 1 m bioreactor was filled with local yellow birch bark to create reducing conditions and fed with seepage at average flow rates of 7.3L/sec in 2000 and 5.0 L/sec. in 2002 (Germain and Cyr, 2003). The biofilter displayed high As removal efficiencies, even in November with a typical seasonal temperature decrease (Figure 22) and the concentrations of As were lowered to below 0.057 mg/L except in June 2001. Overall, this bioreactor fulfilled its objectives over the first three years when it was monitored. Later in 2004, after 5-years of operation and with no interventions, Libeiro (2007) studied the bioreactor again and reported that As removal was still achieved by the reactor, lowering the inlet concentration of 0.03-0.26 mg/L down to 0.002-0.05 mg/L at the bioreactor outlet.

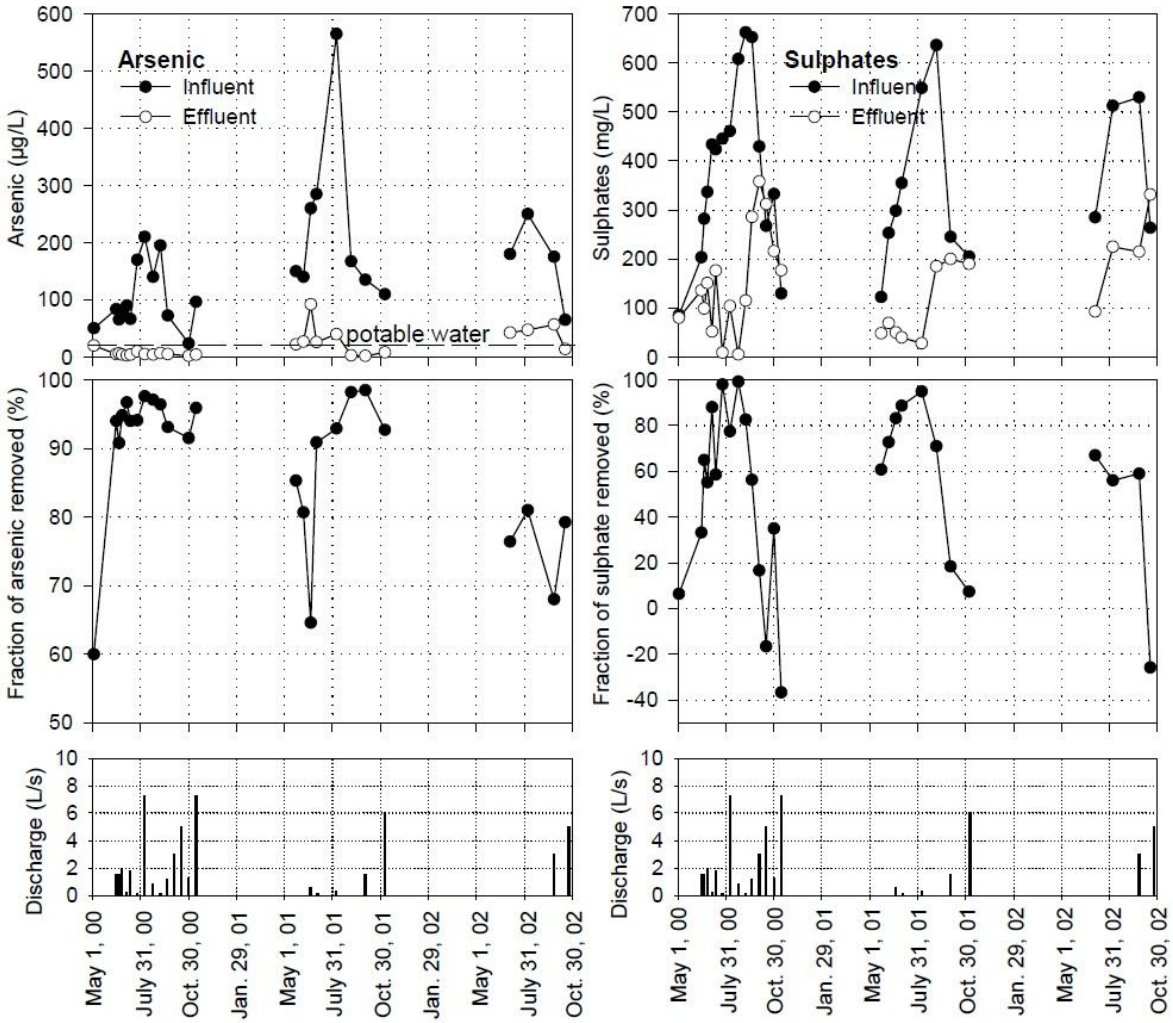


Figure 22: Arsenic and sulphates at the influent and effluent of the biofilter and their respective fraction removed from May 2000 to October 2002. Measured discharge rates are also shown (Germain and Cyr, 2003, p. 7).

3.3. Cold climate solutions

Several pilot scale and full scale PTSs have been built in cold climates and while the efficacy of these PTSs varies, many have successfully treated mine-impacted water (Sobolewski et al, 1994; Nordin, 2000; Duncan, 2002; Wilmoth, 2002; Kuyucak et al, 2006; Groudev et al, 2008; Sobolewski, 2010; Alexco, 2012; Hedin, 2013). It is clear, however, that cold climate adaptations are required for PTSs in these environments. While site-specific adaptations are often required, some basic principles are common to most cold climate PTSs, discussed below.

3.3.1. Burial and insulation

Freezing temperatures cause obvious problems where liquid water is concerned. Solutions are also relatively straightforward. Freezing of PTSs due to cold ambient winter temperatures can be avoided by underground burial or belowground operation. To avoid hydraulic failure caused by freezing, pipes should be buried below the frost line and/or heat-traced (Duncan, 2002; Alexco, 2012). Bioreactors may also be built in abandoned mineshafts to allow year-round operation in cold climates (Nordwick et al, 2006).

Insulating PTSs from freezing can also be achieved in various ways. Insulation may be in the form of burial under organic matter, vegetation or standing water, as in the case of horizontal sub-surface flow wetlands (Duncan et al, 2002); insulation with a layer of straw (Kadlec et al, 2003); polystyrene sheets (Kuyucak et al, 2006); air pockets (Giaever, 2003); or snow cover (Kadlec et al, 2003). For systems in the far north, the design must account for interactions with permafrost, both in the short-term (potential freezing from the sides and bottom of excavations) and in the long-term (subsidence induced by loss of permafrost). If precautions are taken then maintenance of above zero temperatures in bioreactors or CWs can be relatively easy, as decomposition and bacterial activity help to maintain temperatures.

3.3.2. Establishment of biotic communities

PTSs rely on biotic components for which seasons of high productivity are often short and also coincide with periods when construction takes place. Bacteria and vegetation in northern environments are adapted to survive and thrive in these conditions, however, in engineered systems the time needed to establish these communities can be overlooked. Due to extreme seasonal variation in cold climates, any PTS with components of vegetation or microorganisms must prepare for periods of low or no productivity. Construction should be planned such that vegetation is allowed to fully establish in wetlands before mine-impacted water is introduced (Goulet & Pick, 2001). Typically, excavation of beds and other earthworks will be done in the fall, while plant propagation and fertilization is done in early spring, allowing a full growing season to recover from transplantation shock and establishment of a sturdy root system.

Similarly, SRB populations need time to colonize substrates prior to introduction of contaminated waters and cold temperatures (Gusek, 2002; Kuyucak et al, 2006; Nordwick et al, 2006; Alexco, 2012). Starting passive systems in warm ambient temperatures at the beginning of the summer is often the best way to ensure the survival and establishment of SRB and macrophytic communities. Burial of the organic layer can also aid in the establishment of dense biotic communities (Kuyucak et al, 2006). More specifically, when a new PTS is commissioned in the fall, establishment of the microbial community and satisfactory removal efficiencies might require 3 to 12 months (Wilmoth, 2002; Hedin, 2013). Sufficient establishment of biotic communities can be a challenge in cold climates with short growing seasons, but is often crucial to the efficient functioning of PTSs.

3.3.3. Maintenance of constant flow

Constant, steady flow through a PTS is essential to maintain hydraulic retention times and to avoid freezing. Hydraulic failure due to freezing may occur if flow is decreased below a minimum rate. Additionally, increased flow during spring run-off can be detrimental to the efficiency of a PTS. Flow

through PTSs should be maintained at a constant rate through different seasons to reduce the potential of flushing out heavy metals (August et al, 2002; Nordwick, 2006). Flushing of metals may also occur as a result of system shutdowns or addition of new treatment cells (Duncan, 2010). To aid in maintaining constant flow, flow equalization ponds should be designed upstream of the treatment system. Overflows may also be necessary to accommodate spring run-off or surges in flow (Kuyucak et al, 2006). Bypasses may be necessary for components that may not function in winter. Parallel systems can also be used to accommodate increases in flows (Ettner, 2007). Recirculation of treated water at times of low flow volume may also be a solution for some PTSs. While maintaining constant flow is not an easy task in areas with extreme seasonal variation in flow rates, solutions do exist and further innovation will continue to improve this aspect of PTSs.

3.3.4. Liquid carbon sources

Bioreactors that rely on bacterial activity to treat mine-impacted water experience reductions in organic matter decomposition during the winter when cold temperatures cause limited productivity. To offset the reduction in organic matter decomposition, which feeds SRB, the addition of liquid carbon may be advantageous (Tsukamoto et al, 2004; USEPA, 2005; Sobolewski, 2010 Alexco, 2012; Gould et al, 2012). Often, the increased and year-round treatment performance more than offsets increased costs incurred by the need for reagent addition (Sobolewski, pers. Comm., October, 2014). Glucose, lactate/acetate, ethanol, methanol, ethylene glycol and other carbon sources have all been used to supplement bioreactors. Finding the optimal liquid carbon source and concentration required often relies on bench or lab-scale testing.

3.4. Knowledge gaps

Mining companies in the North attempting to implement PTSs face many challenges and despite the growing body of knowledge on their performance in cold climates, there are areas that require future research. As more cold climate PTSs are developed and implemented, our understanding of the factors affecting their efficiency and long term performance will continue to grow.

3.4.1. Seasonal variation in efficiency

While some studies have assessed seasonal variation in pilot-scale PTSs (Goulet & Pick, 2001; August et al, 2002; Gusek, 2002; Hedin, 2013; Panos et al, 2013), a greater understanding of the factors that affect efficiency losses would help PTS designers maximize the potential of their PTS. Understanding the metabolic activities of SRB and the entire scope of the microbial communities present in bioreactors and wetlands at permanently low temperatures is crucial (Robador et al, 2009). More importantly, studies are needed to determine if a relationship can be established between summer and winter metal removal rates and rates of sulfate reduction, carbon consumption, metal precipitation and sorption (Gammons et. al., 2000). Such seasonally-adjusted rates will support the development of seasonally-adjusted treatment performance and design criteria for PTSs that function year-round. Often, site-specific factors such as precipitation, temperature, pH, type of mine discharge and PTS design will interact in novel ways creating unique situations. However, with more PTS being built in cold climates, patterns about the behaviour of such systems are starting to emerge.

3.4.2. Abiotic factors in winter

A number of studies have highlighted the importance of abiotic factors in removing metals during winter months (e.g., Kwong and Whitley, 1993; MacGregor, 2002). Freeze/thaw cycles affect metal attenuation in sediments and can cause diffusion into permafrost which may lead to long-term storage (MacGregor, 2002). Sedimentation may also play an important role in CWs in the winter (Wittgren & Maehlum, 1997). These abiotic factors could be incorporated into the design of PTSs to improve winter treatment performance. As in Section 3.3.1, these factors may be unique in each setting; however as more cold climate PTSs are developed, the interplay between biotic and abiotic factors will be better understood.

3.4.3. Local species and feedstocks

Most of the research about wetland plants and organic substrates in PTSs has been done in temperate regions. As PTSs are introduced into new environments, native species and local feedstocks will have to be identified. Native plant species should be chosen to minimize the risk of introducing invasive species and to ensure that the plants are adapted to their environment. Identification of native plants that are metal tolerant and are low shoot accumulators (Stolz & Greger, 2002) requires lab, bench and pilot trials. Additionally, locally available substrates for SRB activity in bioreactors and CWs should be identified. Ideally these will be waste materials that are available on-site or nearby. While organic substrates like manure, peat, woodchips and sawdust might be easily obtained in more southern areas, these materials are often not as plentiful in remote, northern mine sites. Identification and characterization of potential feedstocks would allow PTS designers to choose the appropriate substrate for their system.

3.4.4. Expected lifetime of PTSs in cold climates

The design life of PTSs are generally not well-understood, especially in cold climates, although many natural wetlands seem to demonstrate the longevity sought after by PTS designers. Predicting the lifetime of a PTS is essential to planning its construction, as well as potential maintenance requirements. Characterization of potential organic substrates can help to optimize the long-term performance of bioreactors (Neculita et al, 2010). Research into organic substrates available in the north and their behaviour in PTSs would serve to better predict the potential lifespans of cold climate PTSs. Further research and monitoring of natural wetlands receiving mine drainage might also help elucidate the mechanisms and characteristics of long term treatment wetlands.

3.4.5. Optimal organic carbon source

Addition of a liquid carbon source to PTSs can be a useful approach to offset the loss of efficiency in cold temperatures. Reduced decomposition of organic matter can cause a reduction in microbial activity and populations. SRB and other microorganisms can be fed with a liquid carbon source to maintain their activity and population throughout the winter months. Studies have assessed various different organic carbon sources for supplementing bioreactors in cold climates (Tsukamoto et al, 2004; EPA, 2005; Gould et al, 2012; Sobolewski, 2010). Further research is required to assess the effect of carbon feed and the rate of carbon consumption in order to help predict the carbon amounts required to design efficient PTS in cold climate locations. Optimizing a carbon source for cold climate

bioreactors will enhance their performance; however, the engineering requirements and costs for systems that supply organic carbon sources should also be assessed.

4. CONCLUSION

With increasing industrial activity in northern Canada there is a need for research, development and implementation of cost effective systems that ensure long term environmental protection. Passive treatment of mine impacted water has become increasingly common over the last 30 years. Passive treatment systems (PTSs) often consist of constructed wetlands (CWs), bioreactors, or some combination and/or variation on both of these components. These PTSs are sustainable alternatives to active treatment systems and represent the next generation of mine water treatment.

Natural wetlands have been treating mine-impacted water in cold climates since mining activity began and provide important information about the processes that drive PTSs, as well as providing insight into the potential for the long-term performance of CWs. Numerous studies have found evidence of metal retention in natural wetlands from both natural and anthropogenic sources of contamination. Following observed natural attenuation processes and metal retention demonstrated in natural wetlands, engineered PTSs have been designed and implemented to treat contaminated water worldwide.

Mine sites in northern environments are often located in remote locations with limited access and power, short growing seasons and cold winter temperatures, conditions which can present challenges for PTS design. These challenges however, are also often reasons for choosing PTSs, which can be constructed to operate year-round with little maintenance and no power. PTSs should ideally be able to function for decades with no power and while most systems are not truly “walk-away” scenarios, they are generally much lower maintenance than active systems. Implementation of PTSs in cold climates has been less common to date; however, several pilot scale and full scale PTSs have been built in cold climates. While the efficacy of these PTSs varies, many have successfully treated mine-impacted water to meet or exceed water quality objectives.

While success in cold climates has been variable, many PTSs have been highly successful (Norway, Bulgaria, BC, Yukon, and Quebec). Often, site-specific factors such as precipitation, temperature, pH, mine discharge chemistry and PTS design will interact in novel ways creating unique situations. As PTSs are constructed in cold climate, remote environments, patterns regarding the behaviour of such systems are starting to emerge. It is clear from this review that PTSs can be successfully implemented in cold climates, provided extensive planning and research in regards to design and construction are taken into consideration to address challenges encountered in northern environments. Some of the challenges facing PTSs in cold climates include hydraulic failure due to freezing in winter, reduced microbial activity, and increased water flows during spring melt. Many adaptations have been developed to overcome these challenges such as burial and insulation of pipes to prevent freezing, allowing sufficient time for the biotic community to establish following construction, ensuring constant flow over the season and identifying appropriate feedstocks and carbon sources that promote SRB and other microorganisms. Due to not only the site-specific challenges associated with implementing PTSs, but the additional challenges in cold climates, laboratory, bench- and field- scale experiments are needed prior to full scale implementation. However, due to the many advantages PTSs provide over active systems, these systems should be strongly considered for use in the North.

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PASSIVE REMOVAL OF SELENIUM FROM GRAVEL PIT SEEPAGE USING SELENIUM REDUCING BIOREACTORS[1]

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Abstract: Water quality in the lower Colorado and Gunnison Rivers in western Colorado, and many of their tributaries, is impaired by selenium, which originates from the local Mancos shale. Because of the diffuse and widespread nature of this source, there are limited opportunities to reduce selenium inputs. One option is to treat selenium-contaminated surface water at strategic locations, such as point-source discharges. Gravel extraction is common along these rivers, and treatment of discharges from pit dewatering presents an opportunity for reducing selenium loading.

The goal of this study is to determine: 1) whether a passive selenium-reducing bioreactor can accomplish high-efficiency selenium removal from the basic, saline water typical of the Grand Valley; 2) whether zero-valent iron is beneficial as a bioreactor component; and 3) optimum detention time. To date, bacterial reduction of selenium has been successfully accomplished using power-, and equipment-intensive "active" treatment systems. The passive bioreactors we are testing can function unattended, ideally by a gravity feed (no pumps), and the "fuel" for the bacteria would be agricultural wastes (e.g., wood chips, hay, cow manure inoculum) and other materials (e.g., quarried limestone) collected locally.

Four 208-liter (55 gallon) bioreactors were constructed with varying amounts of cow manure, hay, sawdust, wood chips, limestone, and zero-valent iron. Influent to the reactors is drawn from a dewatering trench in a gravel pit next to the Colorado River near Grand Junction, Colorado. The reactors were operated, with varying detention times, over a six-month period from July through November 2006. The results of this study demonstrate that passive bioreactors can accomplish up to 98% removal of Se from surface and ground waters in the Grand Valley of western Colorado. A bioreactor designed to promote microbial processes functioned as efficiently as reactors incorporating ZVI, in spite of the potential of the ZVI to enhance the biological removal process. The highest removal rates were achieved using a detention time of 12 hours, but circumstances prevented optimization of detention time.

Additional Keywords: Selenium reduction; passive treatment; agricultural runoff

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Introduction

Selenium in surface and ground water has generated concern since 1982, when Se was found responsible for mortality of fish and birds inhabiting the Kesterson National Wildlife Refuge in California (National Research Council, 1989). The western United States is susceptible to Se contamination of ground and surface water due to a combination of geology, climate, and irrigated agriculture. Over 777,000 km^2 (17%) of the total land area in the western U.S. is composed of seleniferous bedrock, much of which is irrigated (Seiler et al, 2003). Selenium is mobilized as irrigation drainage waters leach it from the bedrock and soils. The arid and semi-arid climates promote high rates of evaporation, which can lead to high concentrations of Se in surface waters, causing some areas to be out of compliance with water quality standards.

Although Se forms the active center of certain enzymes and is thus an essential nutrient, in large concentrations it is toxic to invertebrates, fish, birds, and mammals. The oxidation state of Se determines its bioavailability and toxicity (Amweg et al, 2003). Selenium can occur in its elemental form (Se^0), as selenate (SeO_4^{2-}, Se^{6+}), selenite (SeO_3^{2-}, Se^{4+}), inorganic selenide (Se^{2-}), or organic selenide (organic-Se). Elemental Se has little effect on living organisms. The inorganic forms selenate and selenite are both water soluble and bioavailable, with selenite being the more toxic of the two. Organic selenide is the most bioavailable form of Se, and is taken up by algae 1000 times more easily than the inorganic forms. Selenium is also bioaccumulative; its concentration may increase in organisms at successively higher levels in the food chain.

The Grand Valley in western Colorado is underlain by the highly seleniferous Mancos shale. Selenium in surface waters here has been measured at concentrations exceeding 100 μg/L (Spahr et al, 2000), which is well above the U.S. Environmental Protection Agency's criterion of 5.0 μg/L as a maximum continuous concentration of total recoverable Se for protection of freshwater aquatic life (EPA). Because of the diffuse and widespread occurrence of the Mancos shale, there are limited opportunities to reduce selenium inputs to surface waters. One option is to treat Se-contaminated surface water at strategic locations, such as point-source discharges (Bureau of Reclamation, 2006). Gravel extraction is common along the Colorado River, and treatment of discharges created by dewatering of groundwater seepage into the pits presents an opportunity for reducing selenium loading to the river.

Various approaches to treatment of Se-contaminated waters have been investigated (Kapoor et al, 1995). Bioremediation is one such approach (Frankenberger and Arshad, 2001). There are several Se removal processes that may take place in typical bioreactors, microbial reduction of soluble selenate and selenite to elemental Se being the most obvious. Reducing conditions created by the depletion of oxygen from aerobic microbial respiration can result in the chemical reduction of selenate and selenite. If sulfur is present in the water, precipitation of a Se sulfide is possible. Certain algae and microorganisms have been shown to converts Se to organo-selenium compounds, some of which are volatilized to the atmosphere. The bacterial-algal removal of Se has been successfully demonstrated at the pilot scale using a power- and equipment-intensive "active" treatment system (Lundquist, 1994).

The goal of this study is to determine: 1) whether a passive Se-reducing bioreactor can accomplish high-efficiency selenium removal from the basic, saline water typical of the Grand Valley; 2) whether zero-valent iron is beneficial as a bioreactor component; and 3) optimum detention time. If effective, the passive Se-reducing bioreactor promises to be a low-cost treatment method with the potential to reduce Se toxicity in waters found throughout western

Colorado and at other high-selenium locations. The passive bioreactors described here can function unattended, potentially by a gravity feed (no pumps), and the reactor components would be agricultural wastes (e.g., wood chips, hay, cow manure inoculum) and other materials (e.g., quarried limestone) that may be collected locally. The passive nature of the system and the use of low-cost, locally-derived substrate (that might require replacement on a decade-plus schedule) should combine to reduce the costs.

Materials and Methods

Site description

The study was performed in a gravel pit on private land adjacent to the Colorado River in western Grand Junction, Colorado. Groundwater seepage into the gravel pit is collected in a trench extending along the pit perimeter, and then pumped into the Colorado River. This site was chosen because of the significant Se concentrations in the dewatering trench, which ranged from 31 to 93 µg/L during the year prior to our study (Kerr, 2006). The site was also within a secure area which prevented theft and vandalism of the equipment.

Materials

Four bioreactors were constructed using 208-liter (55 gallon) polyethylene drums with varying proportions of sawdust, hay, wood chips, agricultural limestone, zero valent iron (ZVI) powder, and manure (Table 1). ZVI (obtained from Connelly Inc., Chicago) was included in varying amounts in order to determine if chemical reduction of Se would be a significant enhancement to the biological reduction of Se. Reactor 1, with no ZVI, served as a baseline. Reactors 2, 3, and 4 had increasing weight percentages of ZVI. The materials were weighed out and homogenized manually before transfer into each bioreactor. The manure, which was collected from cows grazing in areas known to have Se-rich soils, was included as a source of microorganisms acclimated to the presence of Se. The organic materials were chosen to provide substrate for the growth of the microorganisms. Figure 1 shows the bioreactors at the study site.

Table 1. Bioreactor compositions.

Component	Proportion of Each Component by Weight			
	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Sawdust	30%	30%	20%	2.5%
Hay	10%	10%	10%	0%
Wood chips	30%	30%	20%	2.5%
Agricultural limestone	20%	5%	5%	5%
Zero valent iron	0%	15%	35%	85%
Cow manure	10%	10%	10%	5%



Figure 1. Bioreactors at field test site.

Operation

An automatic sampler (Teledyne Isco, Model 6712) was modified to deliver influent from the dewatering trench to the bioreactors. Power was provided to the sampler by three deep-cycle 12-volt marine batteries connected in parallel and recharged by two 40-watt solar panels. The sampler was programmed to deliver specific volumes to each bioreactor at designated time intervals (e.g., 1.25 L every 10 minutes). Upon completion of bioreactor construction on June 27, 2006 the bioreactors were filled with water from the dewatering trench and allowed to sit until July 10, 2006. From July 10 to September 21, 2006 the flow rate was set at 7.5 L/hr to each bioreactor to attain a detention time of 12 hours. Flow sometimes decreased to as low as 6.4 L/hr between site visits; the sampler was recalibrated to bring flow back to the desired 7.5 L/hr. The flow rate was changed to 8.8 L/hr on September 21, 2006 and then to 9.6 L/hr on September 28, 2006 to measure bioreactor performance at a shorter detention time of 9.4 hours. Flow rate was decreased on November 16, 2006 to 7.4 L/hr to return to a 12 hour detention time while temperatures were lower. Equipment problems resulted in downtimes of one to five days, particularly during weeks 10 to 19. Operation of bioreactor 4 was suspended in mid-November in order to reduce demand on the storage batteries. Operation of the remaining bioreactors was suspended on November 27, 2006 (week 20) because of persistent freezing temperatures and malfunctions in the automatic sampler. Routine operation was restored on March 29, 2007 at a flow rate of 7.5 L/hr (12 hour detention time).

Sampling and analysis

Weekly, unfiltered samples were collected manually from the influent and effluent of each bioreactor from July 18, 2006 (week 1) through November 21, 2006 (week 19), except for weeks when the system was down. Whenever operations were re-started following equipment failures, the reactors were run for at least three days before samples were collected. Filtered samples were collected in addition to unfiltered samples on September 19, 2006 (week 10) and November 21, 2006 (week 19). Samples for Se speciation were collected on December 27, 2006 by using a small propane heater to thaw enough of the bioreactor to obtain effluent samples. Samples of

influent, reactor 1 effluent, and reactor 2 effluent were collected on March 30, 2007 in order to compare the results of analysis both with and without sample digestion.

Unfiltered influent and effluent samples were analyzed immediately in the field for temperature, pH, and conductivity using an Oakton pH/CON 10 meter. Dissolved oxygen and oxidation-reduction potential were analyzed immediately using a Hach HQ20 meter. Meters were calibrated and operated according to the manufacturer's instructions.

Analysis for Se and metals was performed by ACZ Laboratories, Inc. (Steamboat Springs, Colorado). Weekly, unfiltered samples were analyzed for total Se using EPA method 200.2 for digestion and method 200.8 for analysis by inductively-coupled plasma (ICP) mass spectroscopy. Duplicate samples for Se analysis were collected on August 8 (reactor 1), September 6 (reactor 3), and October 11 (reactor 1). Once per month, unfiltered samples were digested using method 200.2 and analyzed by ICP-optical emission spectroscopy for total Ca, Fe, and Mn using method 200.7. Unfiltered and filtered sample pairs collected on September 19, 2006 and November 21, 2006 for were analyzed for dissolved Se (no digestion, method 200.8 for analysis by ICP-mass spectroscopy). Samples of influent, reactor 1 effluent, and reactor 2 effluent collected on December 27 were processed using EPA method 3030B then analyzed by atomic absorption-hydride generation for dissolved Se, Se(VI), Se(IV), and organic Se. Samples of influent, reactor 1 effluent, and reactor 2 effluent collected on March 31, 2007 were split, with one portion analyzed directly by method 200.8 without digestion, and the other portion analyzed by method 200.8 following digestion by method 200.2. All samples collected between July 8, 2006 and November 21, 2006 were analyzed for sulfate by ion chromatography at Mesa State College.

Results

Selenium

Selenium (Se) concentrations in bioreactor influent and effluent are shown in Table 2 along with Se removal efficiencies. Reactor 4 had the highest initial Se removal efficiency; reactor 1 had the lowest initial efficiency. During weeks 4 through 10 of operation, there was no significant difference in Se removal efficiency between the four bioreactors, with each bioreactor averaging either 95% or 96% removal. During this time period, the detention time was 12 hours and average daily temperature varied from 24°C to 11°C. Detention time was shortened to 9.4 hours in week 11. Samples taken in weeks 13 and 14 showed a significant decrease in performance in reactors 2, 3, and 4, with removal efficiencies falling to values between 55% and 85%. The removal efficiency of reactor 1 remained high, with values of 94% and 98%. Average daily temperatures decreased during this period from 11 C to a low of 7.8 °C. Although the longer detention time of 12 hours was restored in week 19, removal efficiencies remained low except in reactor 1. The average daily temperature associated with the week 19 sampling event was only 5.2 °C.

Filtered and unfiltered sample pairs were collected in weeks 10 and 19 (Table 3) in order to determine the proportion of Se in the dissolved form. In general, the dissolved analyte concentration determined from the filtered sample should be less than or equal to the total analyte concentration determined from the unfiltered sample. In week 10, this expectation was met only for effluent from reactors 3 and 4, which showed 100% and 95% of Se in the dissolved form, respectively. In week 19, this expectation was met for the influent as well as the effluent

from reactors 2 and 3, with 98%, 93%, and 86% of Se in the dissolved form, respectively. Contrary to expectations, dissolved Se was greater than total Se for influent, reactor 1 effluent, and reactor 2 effluent in week 10, as well as for reactor 1 effluent in week 19.

Table 2. Bioreactor Performance.

Week and Date	Detention Time (hr)	Temperature[1] (°C)	Selenium Concentration (µg/L) and Removal Efficiency[2] Influent	Reactor 1	Reactor 2	Reactor 3	Reactor 4
1 07/18/2006	12	29.6	20.6	9.6 53%	6.1 70%	5.8 72%	0.7 97%
2 07/25/2006	12	30.6	19.4	2.7 86%	1.5 92%	1.4 93%	0.9 95%
3 08/01/2006	12	25.9	27.7	7.9 71%	0.9 97%	0.9 97%	0.8 97%
4 08/08/2006	12	24.4	20.9	1.7, 1.6 92%	1.0 95%	1.3 94%	1.1 95%
5 08/16/2006	12	23.9	24.1	1.4 94%	0.9 96%	1.5 94%	0.8 97%
6 08/24/2006	12	25.6	25.0	0.9 96%	0.9 96%	0.7 97%	0.4 98%
8 09/06/2006	12	22.6	27.2	0.8 97%	0.7 97%	0.7, 0.7 97%	1.2 96%
9 09/13/2006	12	20.6	23.2	0.8 97%	0.7 97%	0.7 97%	1.3 94%
10 09/19/2006	12	11.3	24.8	0.9 96%	0.9 96%	0.6 98%	2 92%
13 10/11/2006	9.4	11.5	42.5	0.8, 0.7 98%	8.4 80%	9.5 78%	6.2 85%
14 10/18/2006	9.4	7.8	68.6	4.0 94%	26.1 62%	30.6 55%	12.7 81%
19 11/21/2006	12	5.2	29.4	0.7 98%	11.2 62%	14.1 52%	-- --

[1]The temperature reported here is the average of the daily high and low temperatures for a 3-day period starting 2 days before the sampling event and ending with the day of the sampling event.
[2]Removal efficiency is calculated as [(influent Se – effluent Se)/(influent Se)]100%.

Table 3. Comparison of Total and Dissolved Selenium in Bioreactor Influent and Effluent.

Week and Date	Detention Time (hr)	Temperature (°C)	Selenium Concentration (µg/L)				
			Influent	Reactor 1	Reactor 2	Reactor 3	Reactor 4
10 9/19/2006	12	11.3	24.8 total 25.3 diss.	0.9 total 30.7 diss.	0.9 total 4.4 diss.	0.6 total 0.6 diss.	2.0 total 1.9 diss.
19 11/21/2006	12	5.2	29.4 total 28.7 diss.	0.7 total 3.6 diss.	11.2 total 10.4 diss.	14.1 total 12.1 diss.	- -

Samples analyzed for *total* Se are acidified in the field, then digested and analyzed in the laboratory, while samples analyzed for *dissolved* Se are filtered then acidified in the field, and analyzed without digestion. Given that there is no digestion step in the procedure for dissolved Se, we hypothesized that a portion of the Se in the anomalous samples may be occurring in a volatile form that is driven off during digestion, resulting in a *lower* concentration for a digested sample (total Se) relative to the companion undigested sample (dissolved Se). We tested this hypothesis by having the laboratory analyze the same, unfiltered samples both with and without digestion. The results in Table 4 show that the digested samples have Se concentrations that are *higher* than in the undigested samples, thus disproving our hypothesis. At this time we have no explanation for the anomalous results in Table 3, but expect to pursue this problem in a future investigation.

The variation in toxicity among the different forms of Se (Amweg et al, 2003) provided motivation for determining the speciation of Se in bioreactor effluent. From a toxicity standpoint, the most desirable form of Se in the reactor effluent is Se(0). If the effluent Se has a greater proportion of Se(IV) or organic-Se than the influent Se, there is a possibility that the effluent will be more toxic than the influent even if the total Se is less. Samples collected on December 27, 2006 were analyzed for Se(VI), Se(IV), and organic-Se. The influent had 28 µg/L of dissolved Se, of which 57% was Se(VI), 14% Se(IV), and 29% organic-Se. Unfortunately, all forms of Se in the effluent samples were less than the practical quantization limit or the method detection limit, and results were inconclusive. Speciation will be re-attempted in future work.

Table 4. Comparison of Selenium in Split Samples, Analyzed With and Without Sample Digestion.

Sample Preparation	Selenium Concentration (µg/L)			
	Influent	Reactor 1	Reactor 2	Reactor 3
Without digestion	21.9	2.8	3.5	6.5
With digestion	25.1	4.1	3.8	7.0

Other parameters

Results of dissolved oxygen (DO) measurements are shown in Table 5. DO in the influent ranged from 7.0 mg/L to 10.4 mg/L over the period of operation. DO in the bioreactor effluents ranged from 0.1 to 1.7 mg/L, with 91% of the measured values less than 1.0 mg/L. These results support our expectation that aerobic microbial respiration is consuming DO in the reactors.

The oxidation-reduction potential (ORP) was monitored to confirm that reducing conditions occurred within the bioreactors (Table 5). The ORPs of the effluents ranged from -393 mV to -79 mV, with 93% of these values being more negative than -200 mV. The ORP of the influent ranged from -185 mV to +143 mV. On every date the effluent ORPs were more negative than the influent ORPs, as expected.

Table 5. Dissolved Oxygen and Oxidation-Reduction Potentials for Influent and Effluent

Week and Date	Detention Time (hr)	Temperature[1] (°C)	DO concentration (mg/L) and ORP (mV) Influent	Reactor 1	Reactor 2	Reactor 3	Reactor 4
2 07/25/2006	12	30.6	NM -50.1	NM -356.3	NM -195.9	NM -213.9	NM -253.1
3 08/01/2006	12	25.9	NM -102.0	NM -366.1	NM -243.1	NM -270.1	NM -291.8
4 08/08/2006	12	24.4	10.1 -21.7	0.2 -379.6	0.1 -315.8	0.1 -310.8	0.6 -289.7
5 08/16/2006	12	23.9	9.3 -185.1	0.4 -371.2	0.4 -292.6	0.2 -307.6	0.2 -289.6
6 08/24/2006	12	25.6	8.3 -154.8	0.1 -393.1	0.2 -311.3	0.2 -315.9	0.7 -277.7
8 09/06/2006	12	22.6	10.4 -152.1	0.1 -373.7	0.3 -296.8	0.8 -288.6	0.9 -272.9
9 09/13/2006	12	20.6	8.6 -150.0	0.1 -386.2	0.5 -295.6	0.6 -287.2	1.0 -289.5
10 09/19/2006	12	11.3	7.7 79.5	1.0 -350.8	0.7 -320.0	0.9 -316.7	0.8 -280.4
13 10/11/2006	9.4	11.5	9.6 6.1	0.7 -264.6	0.5 -254.0	0.5 -280.7	0.9 -216.6
14 10/18/2006	9.4	7.8	7.9 143	1.7 -78.8	0.8 -197.5	0.8 -228.1	0.7 -238.2
19 11/21/2006	12	5.2	7.0 -75	0.5 -226.0	0.2 -251.0	0.1 -272.0	-- --

[1]The temperature reported here is the average of the daily high and low temperatures for a 3-day period starting 2 days before the sampling event and ending with the day of the sampling event.

With one exception, the pH of the influent ranged from 7.61 to 8.17 (Table 6). The pH of effluent from reactor 1 ranged from 6.53 to 7.22 from weeks 1 through 10, and then ranged from 7.39 to 7.69 during weeks 13 through 19. The pH of effluent from reactor 2 ranged from 6.64 to 7.20 from weeks 1 through 3, and then ranged from 7.52 to 8.12 from during weeks 4 through 19. The pH of effluent from reactor 3 ranged from 6.73 to 7.24 in weeks 1 and 3, but ranged from 7.66 to 8.21 in week 2 and during weeks 4 through 19. The pH of effluent from reactor 4

was generally more basic than that of the other reactors, ranging from 7.78 to 8.79 from weeks 2 through 19.

The conductivity of the influent ranged from 3.4 mS/cm to 5.8 mS/cm (Table 6). During weeks 2 through 4, the conductivities of the effluent of all bioreactors were between 5.26 mS/cm and 5.93 mS/cm, which were greater than influent conductivity, which ranged from 3.46 mS/cm to 3.69 mS/cm in that period. Thereafter, the effluent conductivities were generally much more similar to the influent conductivities, ranging from 0.94 mS/cm below the influent conductivity to 0.34 mS/cm above.

In weeks 2 through 4, the sulfate concentrations in the influent ranged from 1,132 mg/L to 1,239 mg/L (Table 6). During that same period, sulfate concentrations in effluent from reactors 1 through 4 were greater, ranging from 1,356 mg/L to 2,293 mg/L, with reactor 4 effluent always showing the highest concentration. Thereafter, the sulfate concentrations in the effluents were always less than the influent sulfate concentration, which ranged from 1,105 mg/L to 1,980 mg/L.

Calcium and Fe concentrations were measured in order to monitor the depletion of bioreactor components (Table 7). The concentration of calcium in the influent ranged from 180 mg/L to 207 mg/L from July through September. With the exception of reactor 1, effluent Ca concentrations were always less than influent concentrations. The effluent from reactor 1 showed Ca concentrations ranging from roughly equal to influent to 30% higher than influent. Influent Fe concentrations ranged from 0.19 mg/L to 0.43 mg/L. Effluent concentrations in reactors 2, 3, and 4 were all much higher, ranging from 4.5 mg/L to 96 mg/L, 8.6 mg/L to 116 mg/L, and 5.4 mg/L to 13.5 mg/L, respectively. Two of the three iron concentrations measured in reactor 1 effluent were lower than the influent concentrations. Manganese was monitored to determine if this element was being leached from the bioreactor bed materials. In July, all four bioreactor effluents were greater in Mn (0.61 mg/L to 1.7 mg/L) than the influent (0.31 mg/L). Subsequently all four effluent manganese concentrations were less than the influent concentrations.

Table 6. Sulfate Concentration, Conductivity, and pH for Influent and Effluent

Week and Date	Detention Time (hr)	Temperature[1] (°C)	Sulfate Concentration (mg/L), Conductivity (mS/cm) and pH				
			Influent	Reactor 1	Reactor 2	Reactor 3	Reactor 4
1	12	29.6	1116	1042	1024	1008	1145
07/18/2006			0.90	0.98	0.81	1.12	1.86
			7.70	6.57	6.64	6.73	7.15
2	12	30.6	1132	1806	1626	1356	2180
07/25/2006			3.50	5.93	5.70	5.55	5.33
			8.90	7.06	6.97	7.82	8.26
3	12	25.9	1239	2011	1861	1910	2200
08/01/2006			3.69	5.68	5.46	5.47	5.26
			7.83	6.56	7.20	7.24	8.02
4	12	24.4	1162	1674	1779	2012	2293
08/08/2006			3.46	5.77	5.56	5.68	5.52
			7.99	6.62	7.93	7.77	8.43
5	12	23.9	1105	596	940	968	1063
08/16/2006			3.43	3.75	3.36	3.39	3.14
			8.17	6.53	7.90	7.79	8.58
6	12	25.6	1218	873	912	972	1098
08/24/2006			4.05	4.10	3.78	3.88	3.62
			7.82	6.86	8.09	7.90	8.79
8	12	22.6	1407	1193	1073	1094	1164
09/06/2006			4.26	4.26	3.94	4.02	3.77
			7.89	6.93	7.99	7.92	8.56
9	12	20.6	1208	1050	1036	1069	1104
09/13/2006			4.23	4.31	4.05	4.08	3.88
			7.69	7.05	7.99	7.99	8.54
10	12	11.3	1295	1185	1134	1211	1253
09/19/2006			4.39	4.34	4.10	4.08	3.92
			7.87	7.22	8.00	8.21	8.29
13	9.4	11.5	1607	1228	1247	1230	1225
10/11/2006			5.12	4.50	4.24	4.29	4.18
			7.61	7.39	7.72	7.94	8.26
14	9.4	7.8	1980	1830	1681	1607	1598
10/18/2006			5.76	5.56	5.26	5.32	5.06
			7.62	7.54	7.52	7.66	7.78
19	12	5.2	--	--	--	--	--
11/21/2006			4.21	4.14	4.09	4.05	--
			7.68	7.69	8.12	8.15	

Table 7. Calcium, Iron, and Manganese Concentration for Influent and Effluent

Week and Date	Detention Time (hr)	Temperature (°C)	- - - - Calcium (mg/L), Iron (mg/L), and Manganese (mg/L) - - - Influent	Reactor 1	Reactor 2	Reactor 3	Reactor 4
1	12	29.6	180	234	156	161	148
7/18/06			0.43	1.54	95.8	115	13.5
			0.312	0.606	1.120	0.970	1.720
6	12	25.6	183	185	131	143	85.7
8/24/06			0.19	0.09	4.47	9.19	5.39
			0.407	0.195	0.258	0.233	0.271
10	12	11.3	207	206	153	172	107
9/19/06			0.25	0.08	10.1	8.56	0.255
			0.446	0.039	0.221	0.255	0.247

Discussion

During weeks 4 through 10, all four bioreactors achieved selenium removals of at least 92%. These results demonstrate that for a detention time of 12 hours and average daily temperatures between 11 °C and 26 °C, passive bioreactors of the compositions tested here are effective at removing selenium from ground water in the Grand Valley. The reactor with 0% ZVI maintained this high removal efficiency at temperatures down to 5 °C.

The first two sampling events showed a difference in removal efficiencies between the reactors, with reactor 1 having the lowest and reactor 4 having the highest. This suggests that initially the ZVI was responsible for most of the Se removal. The removal efficiencies of the bioreactors increased as the proportion of ZVI in the reactors increased. By the fourth sampling event, all bioreactors achieved a Se removal efficiency of 95% to 96%, suggesting that microorganism populations were well developed and that Se removal through reduction by ZVI was not providing a significant enhancement to removal by microbial processes.

Average daily temperature appeared to have no effect on the efficiency of the reactors through week 10. During this period, while the detention time was 12 hr and average daily temperature decreased from 31°C to 11°C, all four reactors maintained over 90% removal efficiency. Detention time was shortened to 9.4 hr in week 11. Shortly thereafter, the temperature dropped from 11°C to 8°C and influent Se concentration increased from 24.8 mg/L to 68.6 mg/L. These uncontrollable, simultaneous changes in two other factors affecting performance made it impossible to assess the effect of decreased detention time alone. Under these new conditions, the performance of reactors 2, 3, and 4 decreased significantly. Reactor 1 was the only reactor to maintain a removal efficiency over 90%. The detention time was returned to 12 hr prior to the last sampling event in week 19. The influent concentration (29.4 mg/L) simultaneously returned to roughly its value during the original period of high removal efficiency, while the temperature dropped further to 5°C. Removal efficiencies of reactors 2 and 3 remained low (62% and 52% respectively), while the efficiency of reactor 1 remained high (98%). It is surprising that reactor 1 continued to perform so well at the lower temperature even though reactors 2 and 3 performed poorly.

DO and ORP measurements confirm that aerobic microbial respiration is taking place and that conditions within the reactors are reducing. Conductivity and sulfate results support the expectation that during the initial period of operation, salts were leached from the reactor materials. Calcium concentrations that are lower in effluent than influent for reactors 2, 3, and 4 indicate that dissolved Ca is being precipitated as $CaCO_3$ within these reactors. In contrast, Ca results for reactor 1 suggest that Ca from the agricultural limestone is being lost initially, but is unaffected subsequently. As expected, Fe results show that soluble Fe (II) was being removed from the reactors by oxidation of the ZVI in reactors 2, 3, and 4. In two out of the three effluent samples from reactor 1 that were analyzed for Fe, the Fe in the effluent was much less than the Fe in the influent. This result is consistent with the absence of ZVI in this reactor, and suggests that Fe in the influent may be reduced to an insoluble form and retained within the reactor.

Conclusion

The results of this study demonstrate that passive bioreactors can accomplish up to 98% removal of Se from surface and ground waters in the Grand Valley of western Colorado. A bioreactor designed to promote microbial processes functioned as efficiently as reactors incorporating ZVI, in spite of the potential of the ZVI to enhance the biological removal process. The highest removal rates were achieved using a detention time of 12 hours, but circumstances prevented optimization of detention time. Selenium speciation and the effects of detention time, influent concentration, and ambient temperature will be explored more fully in future work.

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Benefits of using liquid carbon sources for passive treatment systems

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Abstract Using liquid carbon sources provides tangible benefits for bioreactors treating mine water. Microbial activity can be maintained at <4°C, which allows bioreactors to function in cold climates, as shown for bioreactors at the Tulsequah Chief and Smoky River Coal mines. Such carbon sources do not restrict the choice of matrices supporting bacterial growth. This benefit is illustrated in another bioreactor designed to avoid plugging problems associated with decomposing organic matter. The latter is widely perceived as a cheap and sustained carbon source for microbial growth. However, liquid carbon sources overcome its limitations imposed by temperature and susceptibility to plugging.

Key Words bioreactors, liquid carbon, temperature, plugging

Introduction

Passive treatment systems are often idealized as "walk-away" solutions: systems that treat water without an operator and little to no maintenance. In part, this ideal draws after natural wetlands that were shown to detoxify mine drainage, at times for decades (Sobolewski, 1997). The promise of a walk-away solution is especially appealing at closed mines in remote locations where access is difficult and power is typically unavailable.

One type of passive treatment system is the bioreactor, which relies on microbial processes to detoxify mine water. Bioreactor design is strongly guided by the walk-away ideal, typically using a compost/manure mix that slowly decomposes to supports the requisite microbial processes. The key weaknesses of this design are a propensity to become plugged and reduced function at low temperatures. The most successful bioreactors have been operated in warm climates (e.g., Cellan et al., 1997) or have resolved the problems of residual management (e.g., Kepler and McLeary, 1997).

One approach to circumvent these limitations is to supply liquid carbon, such as alcohol, rather than rely on organic matter decomposition. These bioreactors are termed "enhanced" passive systems, though the distinction is academic. This approach has been strongly promoted by Tsukamoto and Miller (e.g., 2002), but it has been used by others in the past twenty years (e.g., Reinsel and Plumb, 1999). Despite its advantages, use of liquid carbon for bioreactors is not prevalent, perhaps because of the perception that such bioreactors cannot become walk-away systems.

Low temperature treatment

Use of a liquid carbon source proved crucial for the successful operation of a bioreactor at the Tulsequah Chief Mine, in Northern BC, Canada. This polymetallic (Cu, Pb/Zn) underground mine was abandoned in the late 1980's and discharged ARD into the Tulsequah River. The highly acidic water (Table 1) flowed from the lowest portal at 5—7 L/sec. Environment Canada required the new owner to treat water during mine exploration, an understandable but onerous demand for the cash-strapped junior.

Treatment options were severely constrained by limitations imposed by the site. The two main portals discharged on the side of a steep, remote mountain, with little flat land available. Access was by helicopter, power was provided by a small diesel generator and equipment was very limited. There was no room for a conventional lime treatment, which, in any event, would have been prohibitively expensive. A bioreactor was eventually developed inside the lowest adit: it combined limestone to neutralize acidity and remove aluminum and iron, and sulfate-reducing bacteria (SRB) to remove other metals. Its design was intended to provide treatment during exploration and until mine start up, when better financing and cash flow would allow the development of a more robust solution.

A 66m^3 pilot-scale bioreactor was first constructed and tested inside the adit. Unfortunately, wood mulch decomposition was too slow at 6—8°C (ambient temperature) to keep the bioreactor anaerobic, with dissolved oxygen (DO) concentrations remaining at 8—9 mg/L. Ethylene glycol (EG) was supplied to mine water, which quickly decreased dissolved oxygen concentrations to

Table 1 *Metal concentrations in drainage and discharge from Tulsequah Chief bioreactors*

Parameter	ARD	Pilot-scale bioreactor (after EG addition)	Full-scale bioreactor (Limestone cells only)	Full-scale bioreactor (Limestone + SRB)
pH	3.0-3.7	6.0-6.7	4.0-6.0	6.1-6.7
Al (mg/L)	10-30	0.1-1.0	0.9-7.7	0.06-2.5
Cd (mg/L)	0.22-0.47	<0.050	0.22-0.38	0.07-0.30
Cu (mg/L)	16-30	0.1-1.0	9-13	2-7
Fe (mg/L)	20-120	0.1-2.0	0.03-0.7	0.04-4.0
Zn (mg/L)	56-120	30-50	56-118	42-77

near zero. SRB started being active soon thereafter, as evident by detection of hydrogen sulfide and the concomitant removal of cadmium and copper (Table 1).

Based on this trial, a 200m long, 5 cell bioreactor was constructed inside the lowest mine adit. The first three cells received a wood chip/limestone mix to neutralize pH and remove aluminum and iron. The last two cells also received sulfur prills to promote SRB activity. Ethylene glycol was dripped into Cell 1 (to remove oxygen) and Cell 4 (to support SRB activity).

The front limestone cells gradually failed (over four years) from accumulated sludge, yet consistently removed aluminum and iron, while the SRB cell removed cadmium, copper, and some zinc (Table 1). Most remarkable, the bioreactor operated without human intervention from October to April, when the site was shut down and inaccessible. Despite the (expected) cell failures, the bioreactor provided low cost (≈ $50,000/yr for EG) treatment and enabled the company to successfully complete its exploration program.

Another bioreactor that relied on EG was constructed at the Smoky River Coal mine, which produces selenium contaminated drainage. Again, the lack of power and cost constraints dictated the choice of a bioreactor for passive treatment, but the design challenge was to provide year-round treatment.

A trial was conducted in 2008, using two parallel 5 m^3 pilot-scale bioreactors (5 m long x 1 m^2) that received a mix of crushed gravel, wood chip/manure, lime and bone meal. The objective of the trial was to determine treatment performance during summer and winter operation and to derive design parameters for a full-scale bioreactor. The bioreactors were inoculated with selenium-reducing bacteria and received EG. Although they were constructed at the surface, it was intended that the full-scale bioreactor would be constructed below the frost line so that it could operate year-round.

The bioreactors proved very effective in removing selenium (Figure 1). They received drainage with selenium at 80—90 µg/L and consistently discharged it at 1—5 µg/L. Treatment performance was unaffected by temperature, even when it decreased to 2°C.

Unfortunately, Alberta Environment terminated the trials in 2008 and did not proceed to construction of the full-scale treatment system.

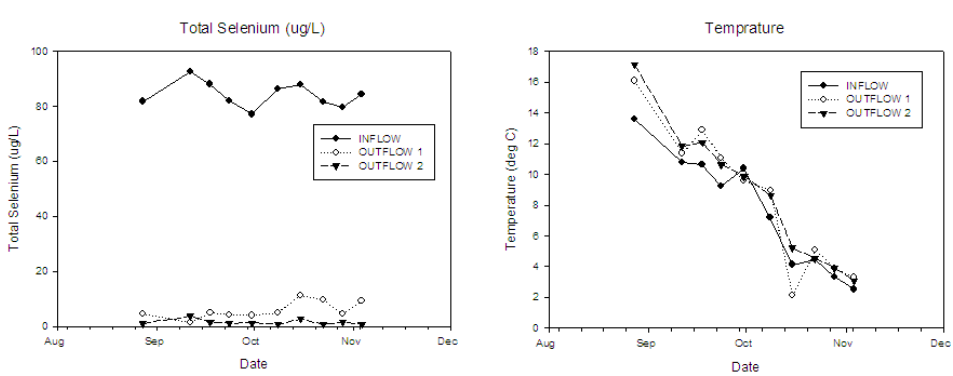


Figure 1 *Selenium removal as a function of temperature at Smoky River Coal*

Design to prevent plugging

It was not surprising that the bioreactor at Tulsequah Chief would become plugged because the design did not allow for effective removal of aluminum and iron. However, the design allowed for continual operation in spite of accumulating metal sludge, which was adequate for a temporary treatment system. A more porous medium might have prevented metal accumulation, but it may not have provided enough reactive surface area for proper treatment. This trade-off between high reactive surface and high porosity is at the crux of bioreactor design.

The US EPA sponsored a number of studies to develop designs that overcome the plugging problems associated with decomposing organic matter. Different SRB-based bioreactors were tested at the Calliope Mine by holding the organic substrate and cobble in a cellular containment system (Terracell™) to prevent channeling and uneven settling (MSE, 2002). Despite careful construction, substrate compaction and plugging problems developed in some of the bioreactors. Subsequent projects helped to improve design (Bless et al., 2008).

Trading off permeability with flow rates is a problem inherent to the use of decomposing organic matter. Unfortunately, this was not possible in the case of an operating underground lead/zinc (confidential) mine. The neutral underground drainage was contaminated with low concentrations of blasting residues (largely nitrate) and zinc, but proximity to a fish-bearing lake prevented its direct discharge. The restricted space underground and high volumes of drainage meant that high permeability and high reactive surface area were both necessary.

The solution involved designing a high-rate bioreactor that could be shoehorned into a sump at the bottom of the mine. This bioreactor used a matrix comprising elemental sulfur, crushed limestone and Raschig rings (ceramic saddles with high surface area). Its design involved a two-part treatment of mine water: a front section with sulfur-based denitrifiers to remove oxygen and nitrate, and to produce sulfate, and a back section seeded with SRB that received ethanol and removed zinc.

This bioreactor design was evaluated using two 2.5 m long columns inside the mine. The columns were fed mine water and operated with decreasing residence times.

Although dissolved oxygen concentrations were not measured, measurements of oxidation-reduction potential (ORP) indicated that oxygen was entirely removed in the first column (Table 2). Similarly, nitrate was rapidly removed in the first column, even though the retention time in that column was (at its lowest) 1.5 hours. Nitrate removal was clearly effected by sulfur-based denitrification, because sulfate concentrations in the column discharge increased by an average of 100 mg/L, very close to theoretically-predicted concentrations based on stoichiometry.

Inflow into the SRB column was anaerobic, but it received ethanol to support SRB activity. Despite increasing influent zinc concentrations and decreasing overall retention time, zinc removal in the second column produced a discharge with average concentrations of 0.029 mg/L (Figure 2). This consistency was maintained throughout the entire four month trial, indicating that the bioreactor was robust. Its fast performance can be attributed to the high surface area of the matrix used in the columns, although warm underground temperatures (21—22°C) helped. Unfortunately, the client opted for a different treatment system, so it was not possible to determine the performance of a full-scale system.

Conclusions

Arguably, bioreactor designs that use liquid carbon provide improved performance and reliability. As the Tulsequah Chief bioreactor demonstrates, even such "enhanced" passive treatment systems can be operated unattended for prolonged periods at remote mine sites. Moreover, the low temperatures at which they can operate, as shown at Tulsequah and with the Smoky River Coal pilot-scale bioreactor, indicate that they can provide year-round treatment in cold climates. This

Table 2 *Changes in key parameters during column treatment of mine water*

Parameter	Inlet	Outlet first column	Outlet second column
pH	6.6	6.3	6.6
ORP (mV)	124	-5.9	-110
Nitrate (mg/L)	17.4	0.68	<0.05

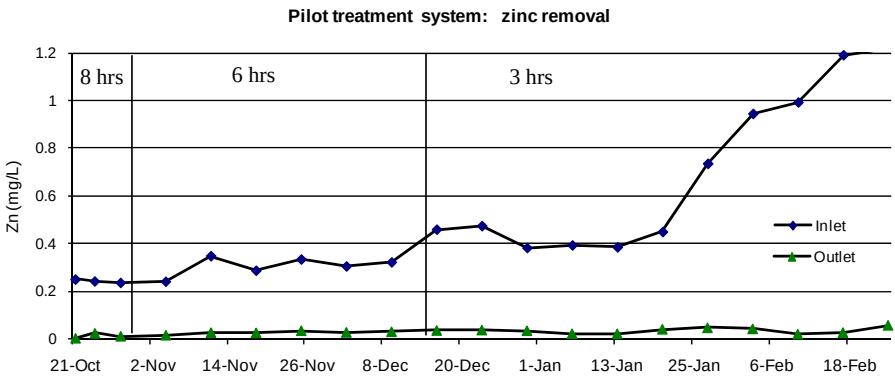


Figure 2 *Dissolved zinc concentrations in a bioreactor operated at different retention times and zinc loadings*

is difficult for bioreactors relying on organic matter decomposition. Conceivably, supplying ethanol or ethylene glycol to such bioreactors or constructed wetlands could sustain treatment during the winter in cold climates.

The reagent costs for operating these bioreactors were modest, rendering moot the argument that decomposing organic matter is preferable because it is a cheaper source of organic carbon. Taking away this argument, the choice of carbon source should be dictated by availability, year-round performance and reliability in treatment. In many circumstances, this gives the advantage to systems using liquid carbon sources.

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APPENDIX 5.5-2: ELK VALLEY WATER QUALITY PLAN

Elk Valley Water Quality Plan



Teck

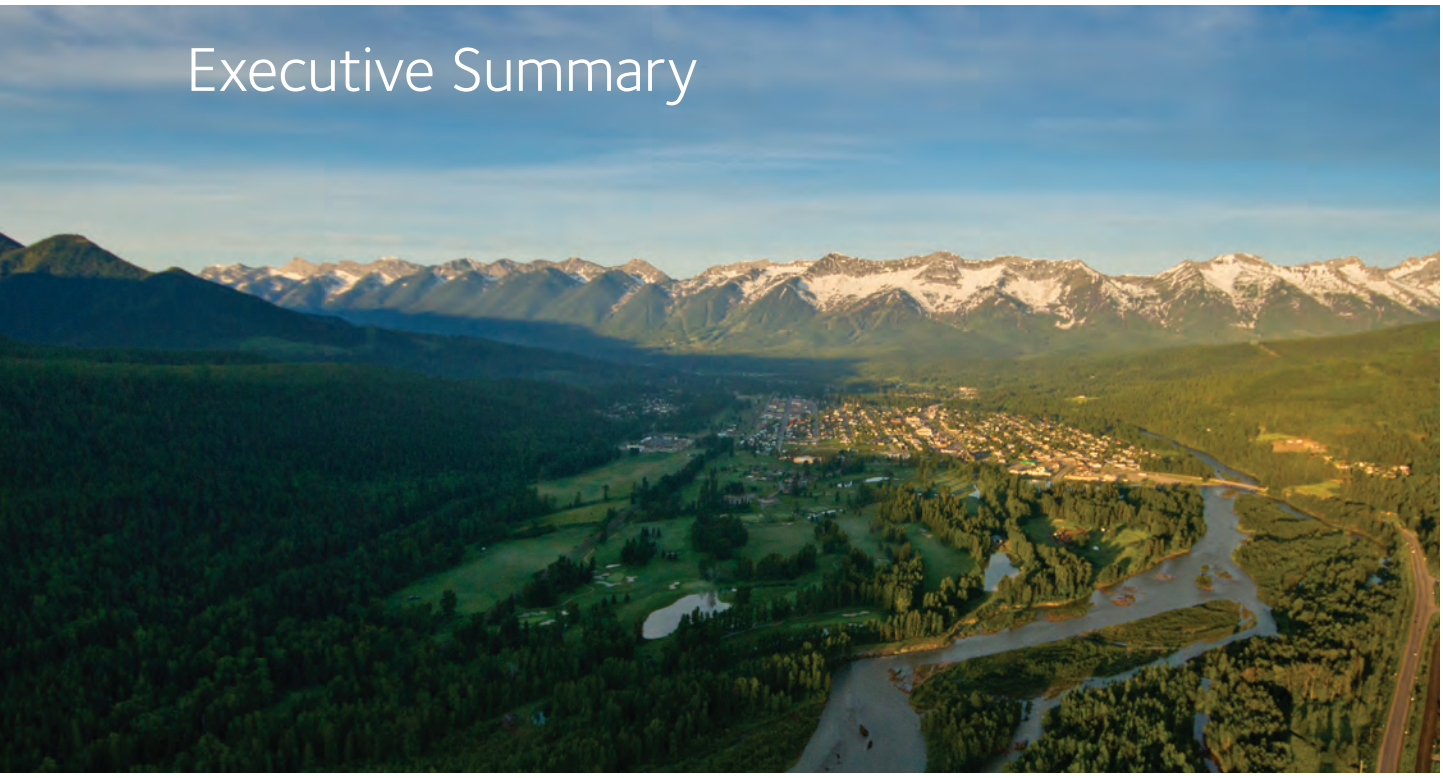
Ensuring the health of the watershed and supporting continued, sustainable mining in the Elk Valley

The Elk Valley Water Quality Plan (the Plan) was developed by Teck with input from the public, First Nations, governments, technical experts and other stakeholders. The purpose of the Plan is to identify a strategy and implement solutions to address increasing selenium and nitrate water concentrations within the Valley, and assess and track levels of cadmium and sulphate in waters; while at the same time allowing for continued sustainable mining in the Valley. The Plan also lays out a strategy to address calcite formation associated with historical and current mining activity.

The Plan was submitted to the British Columbia Minister of Environment for approval on July 22, 2014.

More information about the development of the Plan, including consultation materials, summaries and reports, can be found at www.teck.com/ElkValley.

Executive Summary



Introduction

Developed with input from technical experts, the Elk Valley Water Quality Plan will guide efforts to ensure the health of the watershed, while allowing for continued, sustainable mining

Teck is committed to taking the steps necessary to achieve the objectives of the Plan. Those steps include:

- Implementing water quality mitigation measures (e.g., treatment facilities and diversions)
- Continuing research and development to identify additional sustainable options to manage water quality now and in the future
- Ongoing monitoring to assess water quality and aquatic health during implementation of the Plan, to confirm that the objectives of the Plan are being met, ensure aquatic and human health are protected
- Adaptively managing implementation of the Plan to ensure that new data and information is continually assessed and considered, and actions taken when necessary to meet objectives
- Providing information to the public and other stakeholders on the results of the work undertaken, and continuing to consult and gather feedback throughout the Plan's implementation

About the Elk Valley Water Quality Plan

The Elk Valley has a long history of mining activity and is currently home to five steelmaking coal operations that are the primary economic driver in the region

Water Quality in the Elk Valley

The Elk Valley is located in the southeast corner of British Columbia and contains the main stem Elk River and many tributaries, including the Fording River. The regional economy of the Elk Valley and surrounding areas is heavily dependent on steelmaking coal mining and related activities, and has a long history of mining activity.

The Valley is currently home to five steelmaking coal mines operated by Teck (See Figure 1), directly employing more than 4,000 people, making Teck the single largest employer in the East Kootenay region. At a provincial scale, including direct and indirect employment and spinoffs, Teck's Elk Valley operations are estimated to support more than 15,000 jobs across B.C. The majority of employees at the Elk Valley operations also live in the Valley and are committed to ensuring the environment is protected for future generations.

Teck has been working with various stakeholders to address water quality challenges related to mining activity, such as issues associated with selenium. This work includes studies, research and development, and construction of water diversions and a water treatment facility at its Line Creek Operations.

Existing studies and monitoring indicate that selenium concentrations and other indicators of water quality within the watershed are at levels that have not affected populations of fish and other sensitive aquatic animals. Regardless of current conditions, action is necessary to ensure that concentrations do not increase to levels that could affect sensitive aquatic populations.



Figure 1: Teck's operations in the Elk Valley watershed

Teck's Approach to Responsible Development

The pursuit of sustainability guides Teck's approach to business and Teck is committed to establishing safe workplaces for its people and collaborative relationships with communities. Teck's sustainability strategy includes a focus on water stewardship and improving biodiversity. This includes reclaiming areas after mining, enhancing habitat, and conserving additional habitat.

See www.tecksustainability.com for more information.



Water quality and mining

Steelmaking coal occurs as layers or seams within rock. To access the coal, large quantities of this rock, referred to as waste rock, are mined and placed in piles within and adjacent to the mine pits (Step 1 in Figure 2).

Water from both precipitation and runoff flows through these rock piles and carries selenium and other substances, including cadmium and sulphate as well as nitrate from blasting residue, into the local watershed (Steps 2 and 3 in Figure 2).

Geochemical study indicates waste rock piles continue to release selenium for a very long period of time. Waste rock placed decades ago continues to release selenium at a steady rate today, and is expected to continue doing so for many decades more. This challenge requires a long-term approach to address water quality related to historical mining activity as well as future mining.

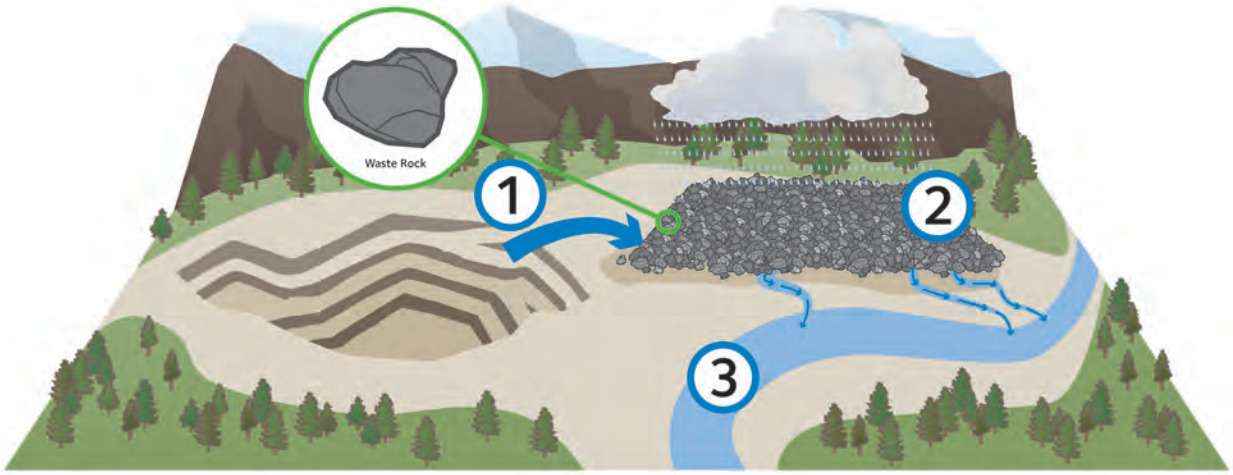


Figure 2: The coal-mining process and water quality

Development of the Elk Valley Water Quality Plan

The Plan was developed through a groundbreaking, area-based process that involved input from the public, First Nations, governments and other stakeholders

In April 2013, the B.C. Minister of Environment required Teck to develop an area-based water quality management plan. The Plan addresses increasing selenium and nitrate water concentrations, as well as cadmium, sulphate levels and calcite formation associated with historical and current mining activity. Teck developed the Plan in consultation with local communities, First Nations and governments.

The Plan is based on extensive research and study into aquatic health in the Valley, and consideration of current and future mining activity. Input was sought through three phases of consultation with the public, governments, First Nations and other stakeholders in the region (see Figure 3).

In addition, a Technical Advisory Committee was formed to provide science-based advice on the Plan. It included representation from the Ktunaxa Nation Council, the provincial government, the government of Montana, the Canadian and U.S. governments, and a third-party independent scientist.

The Plan incorporates a process for ongoing monitoring of the ecological health in the Valley and the effectiveness of the water management options employed. An adaptive management approach will ensure that the Plan evolves in step with changing circumstances, monitoring results, and the outcomes of Teck's research and development program, as well as advances in the science and technology available to manage water quality.

The boundaries of the Designated Area for which the Plan applies are shown in Figure 4.

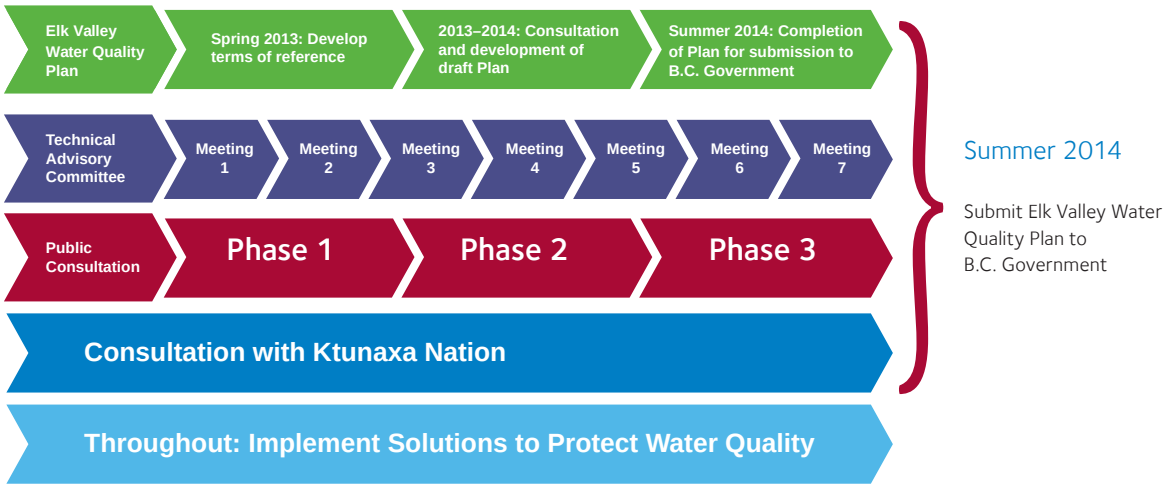


Figure 3: Timeline of the development of the Elk Valley Water Quality Plan

The Purpose of the Plan

The purpose of the Plan is to identify and implement solutions to ensure the ongoing health of the watershed, while allowing for continued sustainable mining in the Valley. To that end, the Plan sets out short-, medium- and long-term water quality targets for selenium, nitrate, sulphate and cadmium as well as targets to address calcite formation. The targets are designed to achieve the following environmental management objectives and outcomes:

- protection of aquatic ecosystem health
- management of bioaccumulation of constituents in the receiving environment (including fish tissue)
- protection of human health
- protection of groundwater

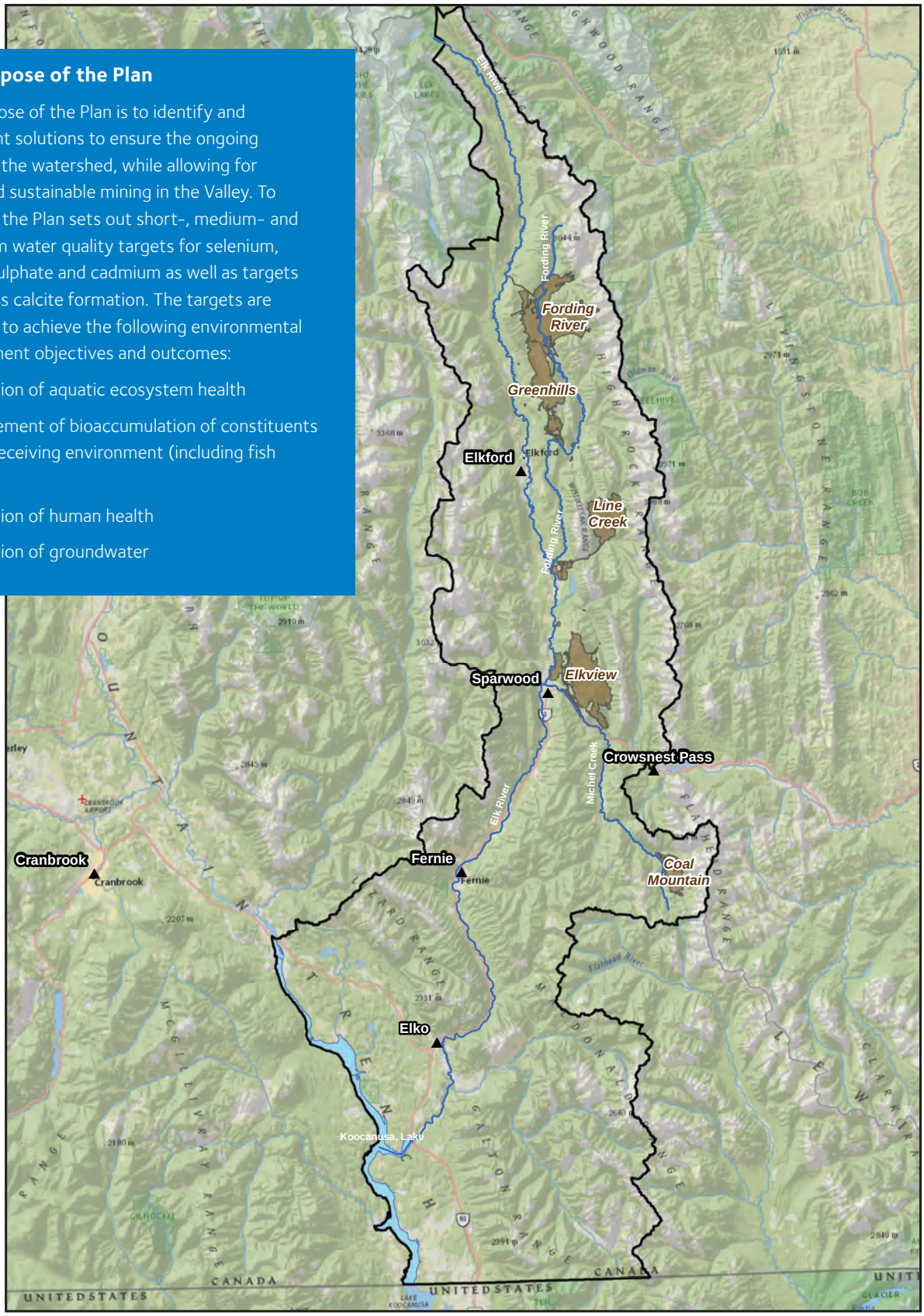


Figure 4: Designated Area boundary



How the Plan is Organized

The Elk Valley Water Quality Plan is organized into 11 chapters. Those chapters are listed below with a brief overview of what they cover and why it's important to the overall Plan.

This summary provides highlights from key chapters of the Plan. For further details, please refer to the specific chapters of the Plan.

Chapter	Description	Why it's important
1. Introduction	Teck's role in the regional economy and approach to sustainability, and the process for developing the Plan	Background information on the Plan
2. Regulatory Context	Summarizes the legal and regulatory requirements related to water quality relevant to the Plan	Context for the development of the Plan
3. Consultation and Technical Advice	Describes the processes that Teck undertook to receive and incorporate input and advice for the development of the Plan	Consultation and technical input were essential to the development of the Plan
4. Baseline Data	Outlines current conditions in the Elk Valley	Context for development of the Plan and measurement of progress during implementation
5. Protection of Human Health and Groundwater	Results of studies regarding human health and potential health impacts related to water quality	Context for development of the Plan in relation to protecting human health and groundwater quality
6. Development and Selection of Management Options	Explains the assessment process Teck used to select initial water quality management options for the Plan Describes Teck's research and development into future water quality management options	Establishes the water management methods that will be used under the Plan, and how water management will be improved moving forward
7. Calcite Management	Sets out targets for the rate of calcite formation and proposed actions to achieve the targets	A key outcome of the Plan is a plan for managing calcite formation
8. Short-, Medium- and Long-Term Water Quality Targets and Implementation Plan	Sets out short-, medium- and long-term water quality targets and timeframes for selenium, sulphate, nitrate and cadmium, and the process used to develop those targets Describes an initial implementation plan to achieve water quality targets	A key outcome of the Plan is to set out targets and an implementation plan to achieve them
9. Social and Economic Considerations	Examines the anticipated social and economic costs and benefits of the Plan	Implementation plan continues to support the social and economic values in the Valley
10. Monitoring	Outlines the monitoring program that will be undertaken to assess water quality and aquatic health during implementation of the Plan	Monitoring is necessary to confirm that the objectives of the Plan are being met
11. Adaptive Management	Describes the framework that the Elk Valley Water Quality Plan will be implemented within, and outlines the tiered decision-making to allow for refinements of the initial implementation plan	Allows the Plan to adapt through the incorporation of key learnings during implementation

Consultation and Technical Advice

Close to 700 pieces of science-based advice from the Technical Advisory Committee and feedback from three phases of consultation with members of First Nations and other stakeholders contributed to the Plan

The Technical Advisory Committee

Teck received science-based technical advice from a Technical Advisory Committee (TAC) in developing the Plan. The TAC was chaired by the B.C. Ministry of Environment and was composed of representatives from:

- B.C. Ministry of Environment (chair)
- B.C. Ministry of Energy and Mines
- B.C. Environmental Assessment Office
- Government of Canada represented by Environment Canada
- U.S. Federal Government represented by the U.S. Environmental Protection Agency and U.S. Geological Survey
- Montana State Government
- Ktunaxa Nation Council
- An independent third-party qualified professional scientist selected by the TAC
- Teck

The TAC held seven scheduled, multi-day meetings during the development of the Plan. In addition, working groups were established to focus on key development topics: Toxicology, Human Health, Monitoring and Lake Koocanusa. In total, the TAC dedicated more than 200 hours to meetings and discussion on the Plan, and provided close to 700 pieces of science-based advice to Teck.



Consultation

The Plan is also informed by extensive multi-phase consultation. Teck consulted the Ktunaxa Nation Council, local government, the public, governments in Canada and the United States, and other stakeholders.

Local governments, stakeholders and the public were consulted through a three-phase process. Consultation opportunities included in-person meetings in Fernie, Sparwood and Elkford, and online feedback. Notification of consultation phases was broad, including advertising and mailers to all households in the Elk Valley. In total, 213 people attended 11 meetings, and 164 pieces of written feedback were received during the three phases.

The Ktunaxa Nation Council was engaged through a consultation agreement and parallel multi-phase consultation process, which included numerous meetings with leadership and staff, five community presentations, and a mine site tour.

Input received throughout both consultation and input from the TAC has been considered, along with socio-economic information, in the development of the Plan. Teck has documented its consideration of this input in the Plan.

Ongoing Consultation

Teck will continue to undertake consultation with First Nations, communities and other stakeholders during implementation of the Plan. Input received will be considered in the ongoing management and implementation of the Plan.



Water Quality in the Elk Valley

Teck is focused on taking action to address water quality challenges to ensure both human and aquatic health are protected

Water Quality and Aquatic Health

As part of development of the Plan, existing levels of selenium, cadmium, nitrate, sulphate and other constituents were evaluated in the Elk River, Fording River, Lake Koocanusa and tributaries.

Current baseline conditions were examined in surface water, sediments and in tissues of aquatic life to assess the overall health of the aquatic environment. These conditions provided context for the development of the Plan.

Selenium and nitrate are the two constituents observed to most frequently exceed B.C. water quality guidelines and as such, are a primary focus of the initial implementation plan.

Protection of Human Health and Groundwater

Teck conducted a comprehensive evaluation of potential effects on human health and groundwater. This evaluation compared concentrations of selenium and other constituents against conservative health-protective benchmarks for swimming, incidental ingestion, eating fish or drinking groundwater. Results of this analysis concluded that current concentrations of constituents in water, sediment or fish for activities such as drinking, swimming, or consuming locally caught fish do not present unacceptable human health risks.

Drinking water guidelines for selenium and nitrate are exceeded in some parts of the watershed, meaning that local health authorities should be consulted prior to use of surface water as a drinking water supply. It was also noted that groundwater from a small number (5 of 91) of wells exceeded the guideline for selenium. Further monitoring will be conducted of wells that exceed guidelines, as well as those that are within 30% of guideline.

As groundwater is intrinsically linked to surface water quality in parts of the Elk Valley, it is expected that the actions taken through the Plan to reduce and manage surface water levels of selenium and nitrate will also manage groundwater quality over time.

Water Quality Management Options

Teck launched an extensive research and development program in 2011 to identify the best existing technologies to treat water and to develop new methods to manage water quality

Teck's research has determined that active water treatment and clean-water diversions are the most effective options to stabilize water quality in the short term:

- Active water treatment has been proven to reduce constituents of interest and is necessary to meet water quality targets in the short-term. Active water treatment takes water into a treatment facility, removes unwanted constituents, and returns the water back to the environment (see Figure 5);

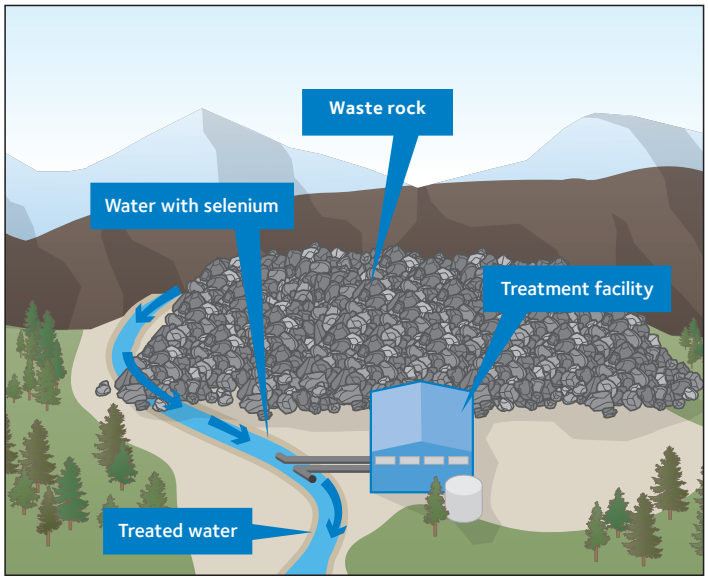


Figure 5: Active-water treatment of mine-affected water

- Clean-water diversions reduce the amount of water that needs to be treated, by keeping clean water clean. Diversions re-route existing water flows away from sources (waste rock) where they would otherwise pick up unwanted constituents, thus keeping clean water clean (see Figure 6).

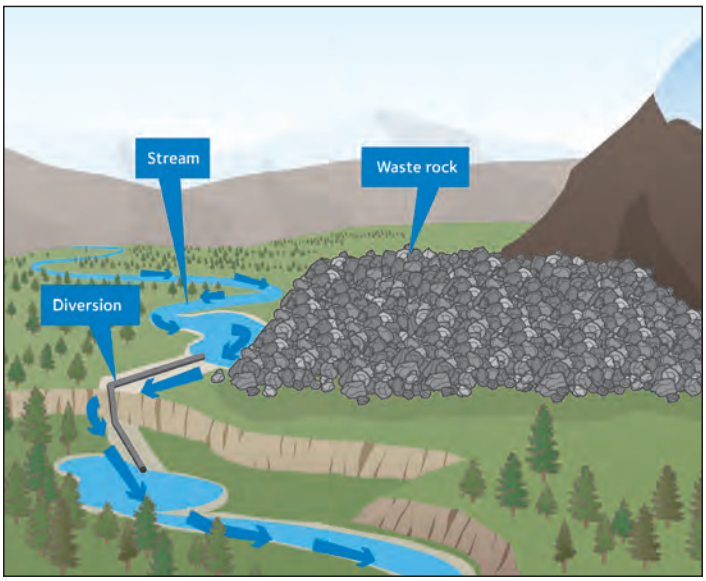


Figure 6: Typical gravity-driven clean-water diversion



Research and Development

Teck's ongoing Research and Development (R&D) program is focused on improving the effectiveness of water treatment technologies and clean-water diversions, while investigating potential long-term solutions that are focused on managing water at source, such as waste rock covers and saturated fills. New technologies and water quality management techniques developed through R&D have the potential to reduce the long-term reliance on active water treatment.

Technologies and techniques evaluated by the R&D program fall into two categories:

1. **Source control:** investigating the sources of water quality constituents and examining how mine design changes could reduce the release of these substances into the watershed. The source control R&D program depends on rigorous independent research.

   As a result, Teck has partnered with several research leaders from Canada and the U.S. The current team includes the University of Saskatchewan, McMaster University, and Montana State University, as well as various consultants with expertise in the field.

2. **Water treatment technology program:** identifying and evaluating the effectiveness of different water treatment technologies in addition to the water treatment technology already in use by Teck. Testing of technologies can range from small-scale laboratory tests to large-scale pilot projects in the field. Teck is working with various technology providers to evaluate alternative processes.

Setting Short-, Medium- and Long-Term Water Quality Targets

The Plan sets out targets that were derived through a scientifically rigorous process to ensure continued aquatic and human health

Setting Targets

A primary outcome of the Plan was to establish short-, medium- and long-term water quality targets at locations in the Designated Area (see Figure 3).

The long-term targets are set at levels that will ensure continued human and aquatic health. Short-term targets are set with the goal of stabilizing levels of substances at locations where concentrations are expected to exceed long-term targets without mitigation. Medium-term targets are intended to ensure the implementation plan is on track to meet the long-term targets. The targets are a key measure for successful implementation of the Plan, and contribute to determining what water quality mitigation measures may be necessary.

The water quality targets were developed following a comprehensive process. In many locations in the watershed, the existing B.C. Water Quality Guidelines for aquatic health, or their federal government equivalent, have been set as the long-term water quality targets for selenium, cadmium, nitrate and sulphate.

Where guidelines cannot be met, site-specific targets, which will ensure continued aquatic health, have been set based on:

- Input from the Technical Advisory Committee's Toxicology Working Group
- Assessment of effects on the most sensitive aquatic species
- Conservative effects assumptions to allow for uncertainty

The chart below (Figure 7) shows where site-specific targets have been identified as necessary in the watershed, and where existing water quality guidelines have been set as the target. Detail on the target levels is found in Chapter 8 of the Plan.

	Fording River	Elk River	Lake Koocanusa
Selenium	Site-specific target	Site-specific target	WQG
Nitrate	Site-specific target	WQG	WQG
Sulphate	Equivalent to WQG	Equivalent to WQG	WQG
Cadmium	Level of protection equivalent to CCME Guideline	Level of protection equivalent to CCME Guideline	Level of protection equivalent to CCME Guideline

WQG = B.C. Water Quality Guideline
CCME Guideline = Federal guideline

Figure 7: Determination of site-specific targets or guideline targets

Calcite Management

Given that calcite poses a concern when it precipitates out of water and forms on the beds of rivers and creeks, setting targets need to be done differently than for constituents such as selenium. Calcite precipitates naturally in some non-mine-affected waters, but its formation can be increased by mining activity. While calcite is not toxic, calcite deposition can negatively affect fish habitat if not controlled.

Surveys of 352 km of streams showed that 89% of mine-affected streams had calcite formation similar to streams not affected by mining. Four streams — Greenhills Creek, Corbin Creek, Dry Creek and Erickson Creek — have been identified as priority streams for calcite management. A long-term target for those locations has been set to achieve a level of calcite formation similar to the upper level in non-mine-affected streams.

Calcite mitigation technologies are being evaluated to determine the most effective method for implementation at a priority stream within three years.

Initial Implementation Plan

Water treatment and clean-water diversions will be part of the initial implementation plan to begin stabilizing and improving water quality in the Valley

Developing the Implementation Plan

Three active water treatment facilities (see Figure 8), combined with diversions, are proposed to reliably and efficiently reduce selenium and nitrate from mine sites in the short term.

Additional water treatment is also contemplated in the Plan, and will be assessed through the Adaptive Management Process as new technologies emerge and monitoring results are analyzed.

Teck developed the Elk Valley Water Quality Planning Model as a regional planning and assessment tool to determine the effectiveness of various mitigation measures, which will be refined and used during implementation. The Model estimates concentrations of selenium, nitrate and sulphate, and was calibrated using existing monitoring data.

More than 700 possible scenarios were evaluated to develop an initial implementation plan to meet the long-term water quality targets for selenium and nitrate.

During implementation, Teck will continue to refine the model based on site-specific investigations of mine-affected water, and new information from monitoring data and Teck's R&D program.

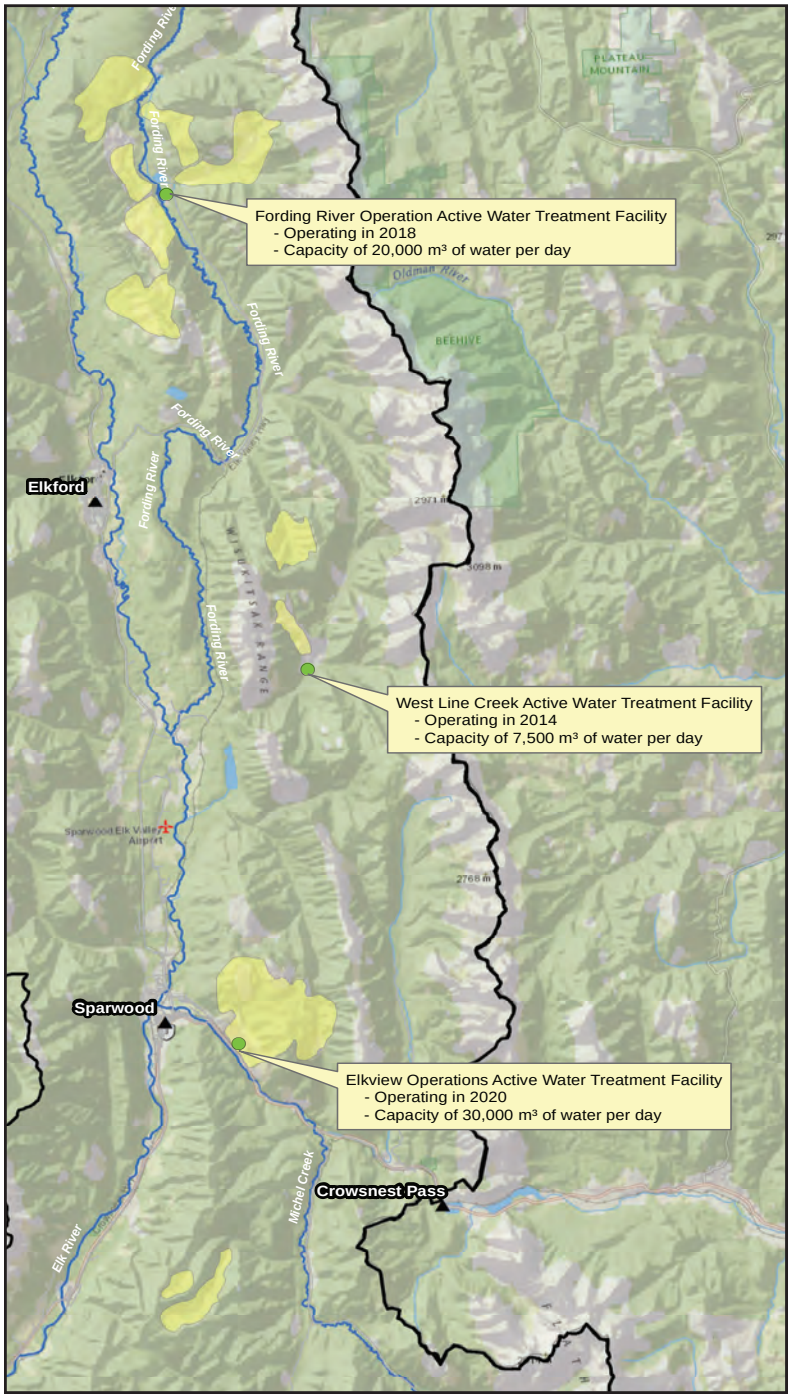


Figure 8: Initial active water treatment facilities

Reductions over the Plan timeframe

The charts below (Figures 9 and 10) were developed using the planning model described above. They show recent and projected levels of selenium (as mitigation measures are implemented) at two representative sites in the Fording and Elk rivers. Order station FR5 is at the mouth of the Fording River, and ER3 is on the Elk River downstream of Michel Creek.

The general pattern is for concentrations to gradually increase until mitigation is in place upstream, following which concentrations decrease.

The green dots represent measured concentrations of selenium from recent years at the Order station. The blue and orange shaded bands represent the range of monthly concentrations of selenium, under high-flow and low-flow conditions, and show the reductions over time as mitigation measures are put in place. The solid red line indicates the long-term selenium target for the Order station (more detail on these graphs can be found in Chapter 8 of the Plan).

The timeframes for stabilizing water quality trends and meeting long-term targets vary depending on the location in the system relative to mitigation measures and the timing with which those measures are implemented.

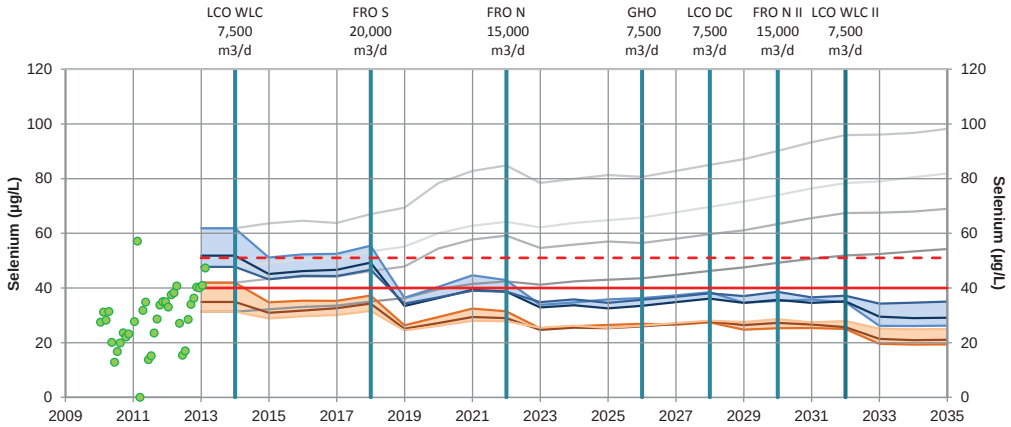


Figure 9: Predicted trend for selenium concentrations at FR5 during Plan implementation

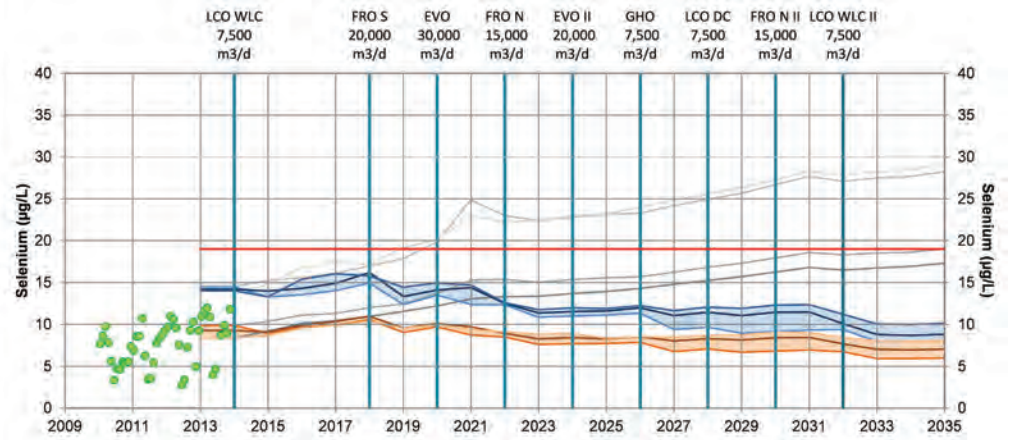
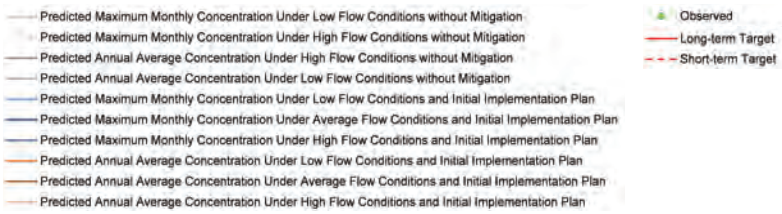


Figure 10: Predicted trend for selenium concentrations at ER3 during Plan implementation



Ongoing Aquatic Monitoring

Teck will continue to conduct extensive monitoring of aquatic health and water quality to ensure the Plan is meeting the objective of protecting aquatic and human health

Monitoring Program

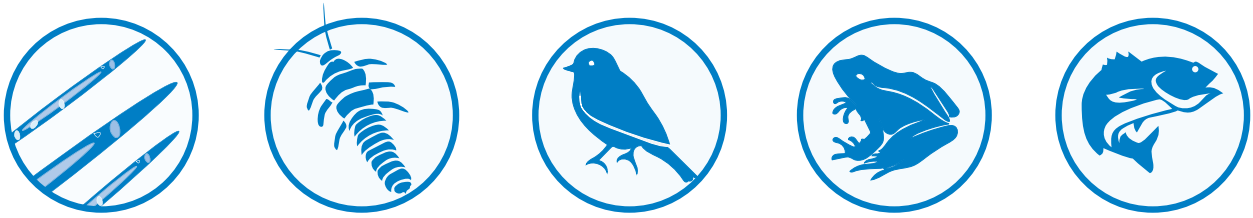
Teck will implement Plan-specific ecosystem monitoring and ecotoxicology assessment programs in parallel with the existing Regional Aquatic Effects Monitoring Program. The monitoring programs will be used to confirm that the Plan is achieving its objectives of protecting aquatic ecosystem health, managing bioaccumulation of constituents and protecting human health and groundwater, and in refining planning tools used in the development of the Plan.

The monitoring programs will include surface water quality, sediment, calcite formation, fish, benthic invertebrates (e.g., insects) and periphyton (e.g., algae and bacteria).

Monitoring results will be provided to government agencies and the Ktunaxa Nation Council, and will be publicly available on the Elk Valley Water Quality Plan website. Surface water quality data will be evaluated and compared to modelled water quality concentrations.

Results of these evaluations will be summarized and made available at www.teck.com/ElkValley. Analysis of the results will be used to inform the adaptive management component of the Plan.

Aquatic Organisms



Periphyton (algae and bacteria)

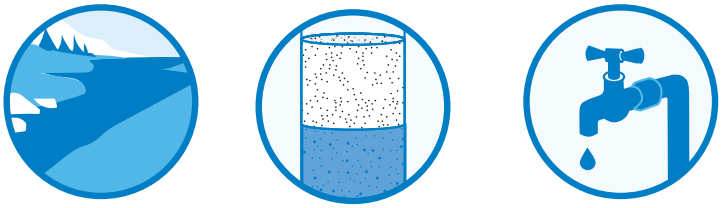
Benthic Invertebrates (small insects)

Birds

Amphibians

Fish

Environment



Surface water (creeks, rivers, lakes)

Sediment (creek, river, lake bottoms)

Groundwater (wells)

Figure 11: Aspects of the Monitoring Program

Adaptive Management

Through the Adaptive Management process, data from monitoring, results from research and other information will be incorporated into the ongoing implementation of the Plan

Adapting to Monitoring

Teck will be responsive to monitoring data and, as necessary, will adapt the Plan to continue to meet targets and objectives. Adaptive management is a systematic process for reviewing the Plan to ensure that objectives set in the Plan are being met, and to adjust and improve management actions as required to achieve those objectives. Monitoring of water quality, ecosystem health, periphyton, ecotoxicology and groundwater will provide the necessary information to assess results of the initial implementation and to make changes as necessary.

Adapting to R&D

Teck will also adapt the initial implementation plan based on advancements from the R&D program, development of mine plans and a review of other relevant management plans. Advancements in technology from the R&D program may lead to incorporation of new technologies and management approaches. Mine reclamation and closure plans, and changes to future mine plans, will be incorporated into the Plan as they are developed.

The process for assessing and reacting to data and information is shown in the Figure 12 below.

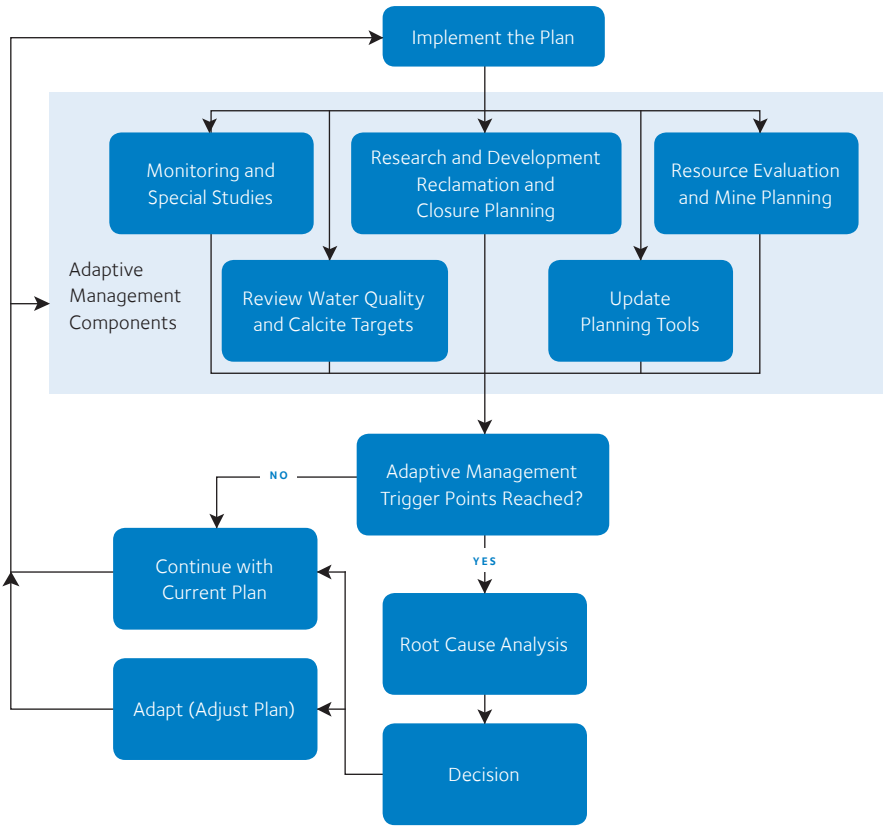


Figure 12: The Adaptive Management process

Conclusion

The Elk Valley Water Quality Plan was submitted to the B.C. Minister of Environment on July 22, 2014. The approved Plan is a public policy document that guides future regulatory applications in the Elk Valley as they relate to water quality.





For more information:

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Glossary of Terms

Active water treatment:	A method of removing constituents of concern from water that requires regular and/or frequent human intervention and management.
Adaptive management:	A systematic process for learning from management actions to confirm that the Plan's objectives are being met and to adjust and improve management actions during implementation.
Adsorption:	The surface retention of a solid, liquid or gas particles by a solid or liquid.
Amphibian:	A cold-blooded, smooth-skinned vertebrate (possessing a backbone) that spend part of their life on land and part in water.
Antiscalant:	A synthetic agent that inhibits precipitation of calcite by changing the molecular properties of ions in water.
Attenuation:	The process of reducing concentrations over time through degradation, dilution or sorption.
Benchmark:	A standard or point of reference against which things may be compared or assessed.
Benthic invertebrates:	Invertebrate organisms living at, in or in association with the bottom (benthic) substrate of lakes, ponds and streams. Examples of benthic invertebrates include some aquatic insect species (such as caddisfly larvae) that spend at least part of their lifestages dwelling on bottom sediments in the waterbody.These organisms play several important roles in the aquatic community. They are involved in the mineralization and recycling of organic matter produced in the water above, or brought in from external sources, and they are important second and third links in the trophic sequence of aquatic communities. Many benthic invertebrates are major food sources for fish.
Bioaccumulation:	The accumulation of substances, including both toxic and benign substances, within the tissues of an organism.
Biodiversity:	The variety of plant and animal life in a particular habitat (e.g., plant community or a country). It includes all levels of organization, from genes to landscapes, and the ecological processes through which these levels are connected.
Biological treatment:	A method of treating water through the use of organisms such as bacteria and other microfauna.
Biotic:	The living organisms in an ecosystem.
Calcareous:	Mostly or partly composed of calcium carbonate.
Calcite:	A mineral composed of calcium, carbon and oxygen. Calcite used in this assessment is from the carbonate class of minerals, and has the chemical formula CaCO3.
Calcite index:	A numeric expression of the extent and degree of calcite formation; typically given as a range from 0 to 3.00.
Clean-water diversion:	A physical construction that changes the course of water to avoid contamination of the water.

Closure plans:	Formal documents filed with the provincial government that detail the process of decommissioning a mine.
Community of interest: (COI)	Individuals or groups that may be affected by, have an interest in, or have the ability to influence, a site. These communities are: Indigenous Peoples whose lands or traditional territory are located on or adjacent to Teck's operations and associated infrastructure; academic and thought leaders such as universities, researchers, students and subject matter experts; business partners in joint ventures and customers who purchase materials, applied technology and equipment marketed by Teck; Teck's global employees; governments and regulatory staff at local, national and international levels; industry associations, including commodity-specific associations, sustainability-specific associations and industry sector associations; an investment community of shareholders, potential investors and financial analysts; local communities of remote, rural localities where Teck works; non-governmental organizations that focus on environmental and social issues at local, regional, national and international levels; and suppliers of materials, energy, transportation and services to Teck.
Conceptual model:	A holistic representation of the interplay between point- and non-point sources of constituents and the environment.
Constituents of interest:	An element or ionic compound that may pose a threat to ecological or human health when present at sufficient concentrations; includes Order constituents selenium (Se), cadmium (Cd), nitrate (NO3) and sulphate (SO4).
Contaminant of Concern:	A chemical that is emitted or released into the environment and poses a potential risk of exposure to humans or ecological receptors.
Critical effect size:	A threshold that indicates that an effect on an organism or community of organisms' performance.
Cumulative effects:	The effects of a development in combination with the effects of other past, present or reasonably foreseeable future developments.
Current baseline:	Represents current or existing conditions (or a temporal period specifically defined to represent baseline [e.g., the year 2010]) and serves as a reference point to which future conditions can be compared. Unless otherwise noted, baseline refers to a surveyed or measured condition, rather than one predicted through the use of models.
Designated Area:	A portion of southeastern British Columbia that contains the Elk Valley and is geographically defined by the Order.
Diversion:	Creation of earthen dykes or other physical barriers and/or pipes or other conduits to route water around mine waste spoils.
Ecotoxicology:	The study of the effects of harmful chemicals on plants, animals and other organisms.
Electrodialysis:	The use of electricity to transport salt ions from one side of a physical barrier (membrane) to the other.
Elk Valley:	The local name for the area of the Elk River valley.
Endpoint:	The completion of a stage of the life history or an organism; common endpoints include reproduction and growth.

Environmental Assessment (EA):	A review of the effects that a proposed development may have on the local and regional environment.
Exposure pathways:	The physical mechanism whereby a constituent of interest comes into contact with an organism; typically includes ingestion and direct contact.
Geomembrane cover:	Synthetic membranes composed of plastic polymers or bituminous (asphalt) materials that provide a waterproof barrier to prevent percolation through wastes.
Groundwater:	That part of the subsurface water that occurs beneath the water table, in soils and geologic formations.
Hardness:	Calculated mainly from the calcium and magnesium concentrations in water; originally developed as a measure of the capacity of water to precipitate soap. The hardness of water is environmentally important since it is inversely related to the toxicity of some metals (e.g., copper, nickel, lead, cadmium, chromium, silver and zinc).
Hazard quotient (HQ):	The ratio of the exposure estimate to an effects concentration considered to represent a "safe" environmental concentration or dose.
Integrated assessment:	A method of incorporating anticipated multiple effects of constituents in the development of long-term water quality targets.
Lentic:	Of or relating to or living in still waters (as lakes or ponds).
Lotic:	Flowing waters.
Management unit:	A portion of the Designated Area specified for water quality management purposes.
Order (the):	A directive issued by the B.C. Minister of Environment in April 2013 requiring Teck to develop the Elk Valley Water Quality Plan.
Order constituent:	Selenium (Se), cadmium (Cd), nitrate (NO3) or sulphate (SO4).
Order station:	A location specified by the Order to monitor water quality in the Designated Area; for example, the mouth of the Fording River is Order Station FR5.
Percolation:	The movement and filtering of water through porous materials, such as water rock.
Periphyton:	Algae, bacteria and other associated microorganisms attached to any submerged surface.
Plan (the):	The Elk Valley Water Quality Plan, an area-based plan that meets the requirements of Ministerial Order No.M113
Receptor:	The person or organism subjected to exposure to chemicals or physical agents.
Reference stream:	A watercourse that is not affected by point sources of contamination; used to compare the effects of mining activity on constituents of interest and calcite formation.
Reverse osmosis:	A process in which water is purified of solutes by being forced through a semipermeable membrane through which the solvent, but not the solutes, may pass.
Reviewable project:	An industrial activity that requires a government-level examination before a permit is issued to allow the activity to go forward.

Sentinel species:	An organism considered indicative or representative of a larger or ecosystem and suitable for monitoring.
Spoil:	Waste rock from mining processes.
Supersaturation:	A state in which water or another liquid contains more of a dissolved substance than can be dissolved under normal conditions.
Target:	A concentration of a constituent of interest or, in the case of calcite, a calcite index value, in Elk Valley watercourses that the Plan sets; based on water quality guidelines and feasibility.
Technical Advisory Committee:	A nine-member panel established by the Order to guide development of the Plan.
Terms of Reference:	A document produced by Teck and approved by the B.C. Minister of Environment that describes the purpose of the Elk Valley Water Quality Plan and the issues the Plan will address.
Threshold value:	A point along a spectrum of concentrations below which no significant or measurable effect on a receptor is expected.
Toxicity reference (TRV):	For a non-carcinogenic chemical, the maximum acceptable dose (per value unit body weight and unit of time) of a chemical to which a specified receptor can be exposed, without the development of adverse effects. For a carcinogenic chemical, the maximum acceptable dose of a chemical to which a receptor can be exposed, assuming a specified risk (e.g., 1 in 100,000). May be expressed as a Reference Dose (RfD) for non-carcinogenic (threshold-response) chemicals or as a Risk Specific Dose (RsD) for carcinogenic (non-threshold response) chemicals. Also referred to as exposure limit.
Treatment:	The use of a technology to either remove constituents of interest from water, or prevent calcite from precipitating on a streambed.
Valued Component:	Valued components represent biophysical, economic, social, heritage and health properties of the environment that are considered to be important by society.
Waste rock:	Rock moved and discarded in order to access coal resources.
Water management:	Planning, developing, distributing and making optimum use of aquatic resources; includes treatment and diversion, among other technologies.
Water quality guideline (WQG):	The concentration of a constituent of concern developed for the protection of ecological or human health; may be federal or provincial. (WQG):
Wolman Pebble count:	A method of determining the size distribution of gravels and sediment in a streambed; involves the random and periodic sampling of a streambed and analyzing the condition of a pebble or other particles. A modified version of this method is used to measure the extent of calcite formation in a streambed.

Abbreviations

ART	Applied Research and Technology
AWTF	Active Water Treatment Facility
BCMOE	BC Ministry of Environment
BLM	Biotic Ligand Model
BGM	Bituminous geomembrane
CCE	Crown of the Continent Ecosystem
CCME	Canadian Council of Ministers of the Environment
CEAA	Canadian Environmental Assessment Act
CEPA	Canadian Environmental Protection Act
COIs	Communities of interest
CSKT	Confederated Salish and Kootenai Tribes
CSM	Conceptual Site Model
CSR	Contaminated Sites Regulation
DEQ	Montana Department of Environmental Quality
DOC	Dissolved Organic Carbon
DQO	Data Quality Objective
DWPA	Drinking Water Protection Act
EA	Environmental Assessment
EAO	Environmental Assessment Office
EMA	Environmental Management Act
ENGOs	Environmental Non-Governmental Organizations
EPA	US Environmental Protection Agency
ERA	Elk River Alliance
EVWQP	Elk Valley Water Quality Plan
FLNRO	Forests, Lands and Natural Resource Operations
GDP	Gross Domestic Product
HQ	Hazard Quotient
HVE	High Viscosity Emulsion
IBWTA	International Boundary Waters Treaty Act
ISQG	Interim Sediment Quality Guidelines
KNC	Ktunaxa Nation Council
KTOI	Kootenay Tribe of Idaho
LAEMP	Local Aquatic Effects Monitoring Programs
LEL	Lowest Effects Level
MEM	B.C. Ministry of Energy and Mines
MOE	B.C. Ministry of Environment
MRC	Mine Review Committee
MU	Management Unit
PCC	Precipitate Calcium Carbonate
PEC	Probable Effects Concentration
PEL	Probable Effects Level

RAEMP	Regional Aquatic Effects Monitoring Program
SARA	Species at Risk Act
SEL	Severe Effects Level
SLERA	Screening Level Ecological Risk Assessment
SPO	Site Performance Objective
SQGs	Sediment Quality Guidelines
SSD	Species Sensitivity Distribution
SSWQOs	Site-Specific Water Quality Objectives
TAC	Technical Advisory Committee
TDS	Total Dissolved Solids
TEC	Threshold Effects Concentration
TEL	Threshold Effects Level
TRVs	Toxicity Reference Values
UL	Tolerable Upper Intake Level
WQGs	Water Quality Guidelines

Chapter 1
Introduction

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1.1 Introduction

The Elk Valley is in the southeast corner of British Columbia and contains the mainstem Elk River and many tributaries, including the Fording River. The regional economy of the Elk Valley and surrounding areas is heavily dependent on steelmaking coal mining and related activities, and has a long history of mining activity. The Valley is currently home to five steelmaking coal mines owned by Teck, which directly employ more than 4,000 people (see Section 1.6.1). Other mining companies have tenure in the Elk Valley but have yet to pursue operations.

Since the mid-1990s, Teck has been working with other stakeholders to address water quality challenges related to mining activity, particularly the challenges associated with increasing concentrations of selenium. Teck participated in various studies of selenium and aquatic health, and helped form the Elk Valley Selenium Task Force in 1998 and the Canadian Industry Selenium Working Group in 2006. In 2010, Teck commissioned an independent Strategic Advisory Panel on Selenium Management, made up of leading experts in the field. The Panel's report included recommendations that led Teck to undertake several large-scale selenium-management activities, including:

- construction of the Kilmarnock and Swift Creek Clean Water Diversions
- pilot testing of active water treatment technology at Line Creek Operations in 2011
- launch of a comprehensive research and development program in 2011 to develop improved methods to manage water quality through mine design and reclamation practices
- construction of a full-scale West Line Creek selenium active water treatment facility at Line Creek Operations, an investment of $105 million (currently in commissioning).

To date, studies and monitoring conducted by Teck indicate that selenium concentrations generally remain below levels that would affect populations of fish and other sensitive animals in the mainstem of the Elk River and the Fording River below Josephine Falls. In some tributaries selenium concentrations levels are above levels that could affect fish populations. Localized effects on sensitive insect larvae that live on stream bottoms, mainly in the tributaries closest to mining activities, have been detected, but overall larval insect communities throughout the Elk Valley are similar to areas where no mining occurs. However, additional action is necessary to ensure that concentrations do not increase to levels that would affect fish populations within the watershed.

To reduce calcite formation and to manage water quality to stabilize and reverse increasing trends in water contaminant concentrations in the short-term and to set achieveable water quality targets over the longer-term for selenium, cadmium, nitrate, and sulphate, in April 2013 the B.C. Minister of Environment's Order M113 directed that an area-based water-quality management plan be developed under Section 89 of the province's Environmental Management Act (Province of British Columbia 2013),. Teck was charged with developing the Plan in consultation with local communities, First Nations and governments. In July 2013, the province approved a Terms of Reference (Teck 2013a) that outlines the purpose, scope and process for the development of the Plan.

The process for developing the Plan, called the Elk Valley Water Quality Plan, is based on extensive research and study into aquatic health in the Valley. The Plan takes into account the effect of mining activity, the scientific advice provided by the independent Technical Advisory Committee, and broad consultations. The Plan incorporates a process for ongoing monitoring of water, and ecosystem health in the Valley and the effectiveness of water management. An adaptive management approach will ensure that the Plan evolves in step with monitoring results, technology advances, and the outcomes of Teck's research and development program. As such, the Plan is considered a living document and a process to consider adjustments to target and management actions for example, will be considered during implementation.

1.2 Purpose of the Plan

The Plan will identify a strategy and implement solutions to address increasing selenium and nitrate water concentrations within the Valley, and assess and track levels of cadmium and sulphate in waters, while at the same time allowing for continued sustainable mining in the Valley. To that end, Teck has set proposed short-, medium- and long-term water quality targets to achieve the following environmental management objectives:

- protection of aquatic ecosystem health
- management of bioaccumulation of constituents in the receiving environment (including fish tissue)
- protection of human health
- protection of groundwater.

1.3 Plan Management

Development of the Plan was informed by input obtained in a series of consultations with governments including First Nations, the public and other stakeholders, and a nine-member Technical Advisory Committee (TAC) that provided close to 700 pieces of science-based technical advice to Teck (See Figure 1-1). The Plan was also informed by federal and provincial legislation and international agreements, as detailed in Chapter 2.

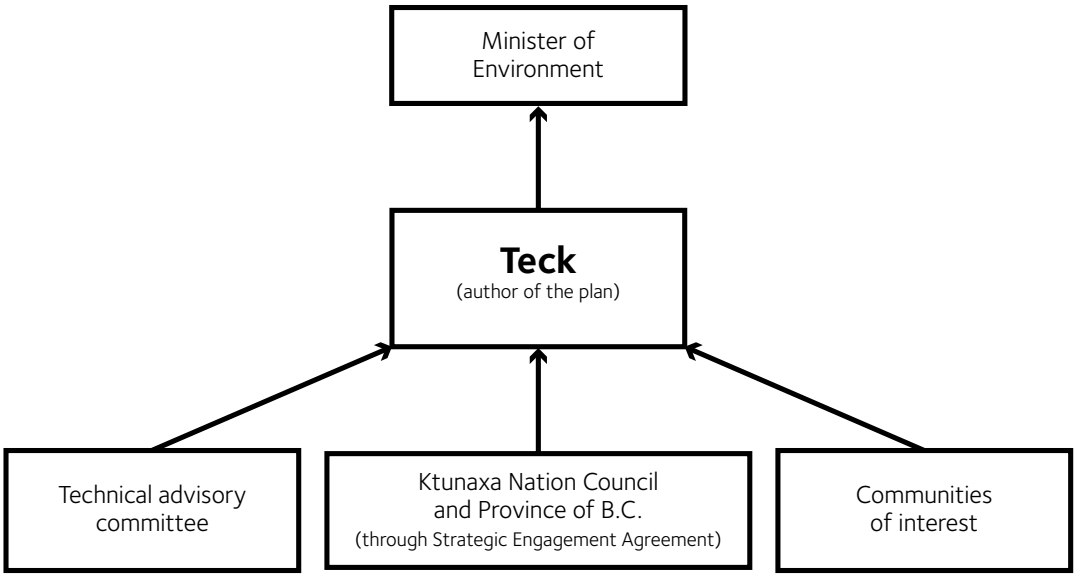


Figure 1-1. Participants and process for development of the Plan.

1.3.1 Technical Advisory Committee

Teck has received science-based technical advice from the TAC in developing the Plan. The TAC is chaired by a B.C. Ministry of Environment representative and is composed of representatives from:

- B.C. Ministry of Environment (MOE) – chair
- B.C. Ministry of Energy and Mines (MEM)
- B.C. Environmental Assessment Office
- Environment Canada
- US Federal Government
- Montana State Government
- Ktunaxa Nation Council
- an independent third-party scientist selected by the TAC
- Teck

The TAC held seven scheduled, multi-day meetings during the development of the Plan. In addition, working groups were established to focus on four key development topics: toxicology, human health, monitoring and Lake Koocanusa. In total, the TAC dedicated over 200 hours to meetings and discussion on the Plan, and provided close to 700 recommendations to Teck. Teck incorporated the majority of TAC recommendations into the analysis informing Plan development and implementation. Annex A includes all TAC recommendations together with how Teck considered each recommendation.

1.3.2 Consultation

As part of the development of the Plan, Teck consulted and engaged with a number of groups, including:

- the Ktunaxa First Nation
- Elk Valley residents
- local governments
- the US federal government
- the State of Montana Department of Environmental Quality
- the governments of Canada and B.C.
- the Shuswap First Nation
- the Kootenai Tribe of Idaho
- the Confederated Salish and Kootenai Tribes
- environmental non-government organizations
- other coal companies with interests in the Elk Valley (Coal Valley Resources Inc., Crowsnest Pass Coal Mining Ltd., NWP Coal Canada Ltd., Centermount Coal Ltd. and Centerpoint Resources Inc.).

In addition to ongoing consultation throughout the development of the Plan, three formal consultation phases were held. During this time, Teck made extensive efforts to notify the public and stakeholders, produced consultation materials, and held open houses and small group meetings in communities in the Elk Valley. A separate, parallel consultation process was conducted with the Ktunaxa Nation Council (KNC) in accordance with the KNC-Teck Elk Valley Water Quality Consultation Agreement, which was jointly developed by Teck and the KNC.

In total, 213 individuals participated in meetings and public open houses during the consultation phases, and 164 feedback forms were received. The chair of the TAC attended six open houses and three small group meetings held during Phase 1 and Phase 2, to provide the TAC's perspective on the Plan process. Chapter 3 provides further details on each phase of consultation, and Annex C provides details on the feedback received and how it was addressed in development of the Plan.

1.4 The Elk Valley Designated Area

The area covered by the Plan is defined in Appendix A of the Terms of Reference. The boundaries of the Designated Area, as identified in the Order, are shown below (Figure 1-2).

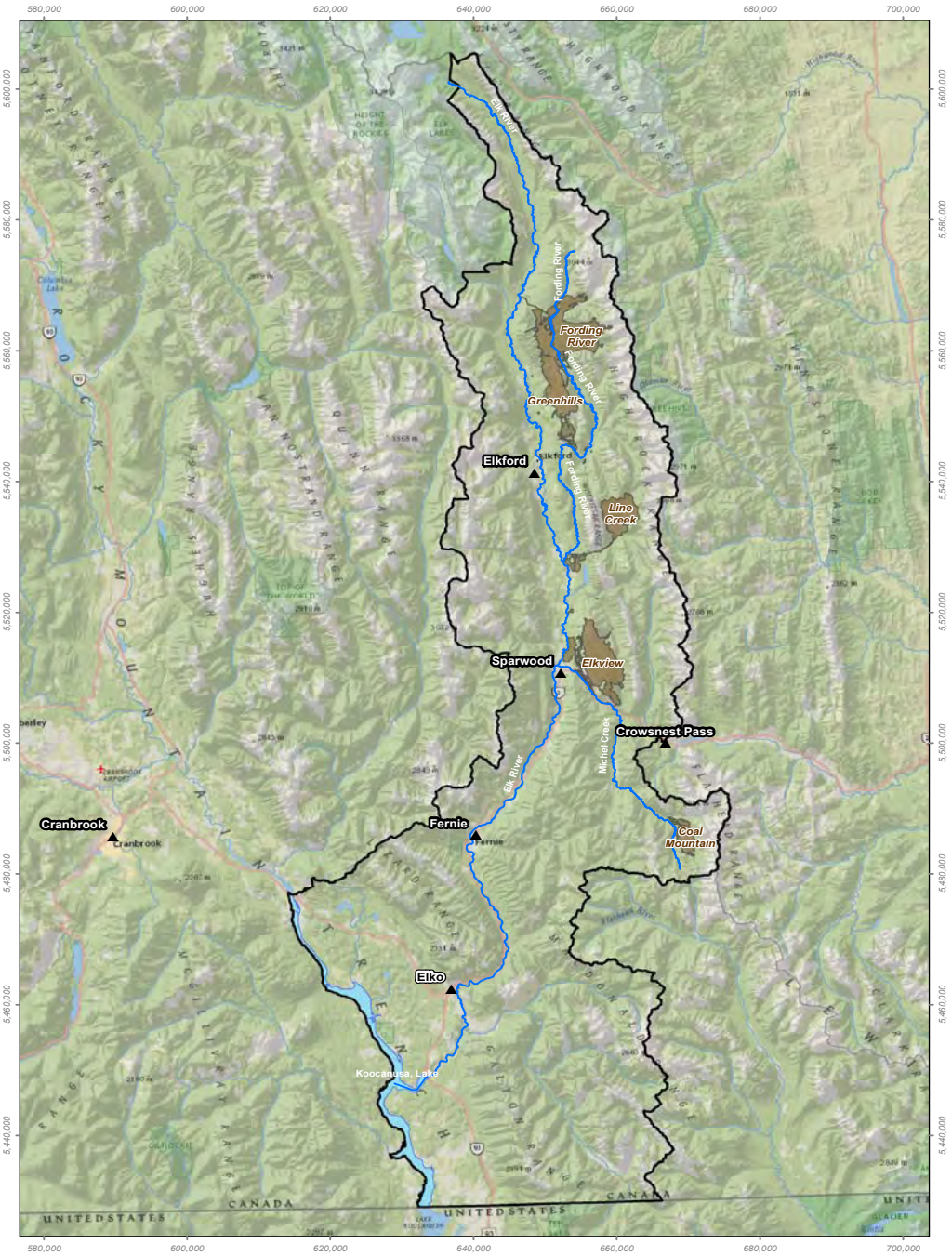


Figure 1-2. Designated Area boundaries.

The East Kootenay Coalfields of southeastern British Columbia lie beneath the Front Ranges of the southern Rocky Mountains. They are divided into three distinct coal deposits: the Elk Valley (also known as the Upper Elk) near the communities of Elkford and Sparwood; the Crowsnest near Fernie; and the Flathead, to the south of Fernie and straddling the U.S. border (Figure 1-2). The Elk Valley Designated Area overlies portions of all three coalfields.

Coal mining has occurred in the Valley since 1897. Most of the coal seams in the Valley are mined for metallurgical purposes (the production of steel). The relatively shallow depth of the seams has led to the use of open-pit mining practices.

The Elk River Watershed and the neighboring Flathead River Watershed comprise the northwest corner of the 7.2-million-hectare Crown of the Continent Ecosystem (CCE), straddling the Continental Divide. The CCE includes headwaters of the Columbia, Missouri-Mississippi and Saskatchewan rivers, making it a dominant element in the larger landscape. In addition, the Flathead and Elk River watersheds represent a critical wildlife connectivity corridor between the Waterton-Glacier International Peace Park on the Alberta-Montana border, and Banff and Jasper national parks on the Alberta-B.C. border.

The Elk River Watershed drains 4,450 km^2 and includes the communities of Elkford, Sparwood, Hosmer, Fernie and Elko, along with the five steel-making coal mines. Its outlet is the Kootenay River at Lake Koocanusa. It contains the mainstem Elk River and many of its tributaries, including the Fording River and Michel Creek.

1.5 Water quality in the Designated Area

In recent years, much of the attention given to water quality in the Elk Valley involved the element selenium. Teck has been taking steps to understand and address selenium concentrations for several years. Cadmium, nitrate, sulphate and calcite formation have also been identified in the Order as mining-related constituents to be addressed in the Plan. The summaries below are based on studies detailed in Chapter 5.

1.5.1 Selenium

Selenium is a common element in the rocks and minerals of the earth's crust. It is an essential nutrient, meaning trace amounts are necessary for cellular function in many organisms, including plants, animals and people. However, selenium can be harmful when it builds up in an organism's tissues beyond natural levels. When elevated it can interfere with reproductive processes in egg-laying vertebrates. In an aquatic environment, selenium is taken up from water by algae and other microorganisms and transferred through the food web to aquatic invertebrates, fish, birds, and other vertebrates.

1.5.2 Cadmium

Cadmium is a metal that can be harmful at elevated concentrations. As with selenium, mining can accelerate the release of cadmium to the environment by exposing waste rock to air and water. Unlike selenium, however, the primary concern with cadmium is from direct contact with surface waters, rather than bioaccumulation in tissue (CCME 2012).

1.5.3 Nitrate

Nitrate is typically leached from waste rock piles of blasting reagents used in mining (Environment Canada 2003). As with cadmium, the primary concern associated with nitrate is exposure through direct contact with surface water, which in some cases can contribute to eutrophication. Concentrations at the sites identified in the Order have been trending up in recent years.

1.5.4 Sulphate

Sulphate can accumulate to higher levels in mining environments when it interacts with other substances. Concentrations of sulphate in the lower Fording River and Elk River immediately downstream of Michel Creek have remained below the B.C. guideline and have been stable at most monitoring sites identified in the Order since 2000.

1.5.5 Calcite formation

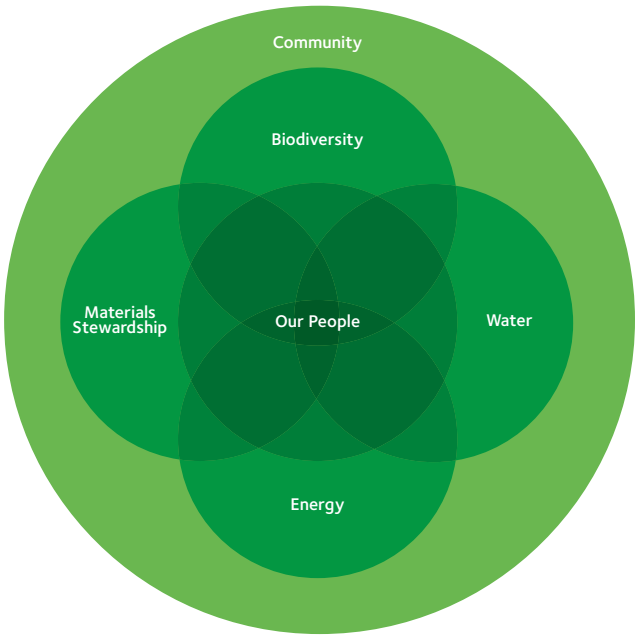
Calcite, in the form of calcium carbonate from the shells of dead marine organisms, is found in sedimentary rocks of the Rocky Mountains. As water travels through the ground or through mining waste rock, calcite can dissolve and then re-crystalize elsewhere in a watercourse. The scaling seen in kettles or hot-water heaters involves a similar chemistry. Increasing rates of calcite buildup have been observed in streams downstream of waste rock dumps. Traces are generally only found on boulders and most watercourse substrates show no evidence of calcite. High calcite buildup does not pose a health threat, but can change the characteristics of the stream substrate by cementing rocks together, adversely affecting habitat for fish and invertebrates.

1.6 About Teck

Teck is Canada's largest diversified resource company, committed to responsible mining and mineral development with business units focused on copper, steelmaking coal, zinc and energy. Headquartered in Vancouver, B.C., Teck owns or has an interest in, 13 mines in Canada, the United States, Chile and Peru, as well as a large metallurgical complex and a wind-power facility in Canada.

Teck's expertise spans a wide range of activities related to exploration, development, mining and mineral processing including smelting and refining, safety, environmental protection, materials stewardship, recycling and research.

1.6.1 Teck's Approach to Sustainability and Biodiversity



In 2011, Teck developed a comprehensive sustainability strategy that set out long-term (to 2030) and short-term (to 2015) goals in six focus areas: Community, Our People, Water, Biodiversity, Energy, and Materials Stewardship (Figure 1-3). These focus areas represent the most significant sustainability-related challenges and opportunities facing the company.

Although water is the focus of the Plan, Teck is also working on the conservation or restoration of biodiversity. These efforts can have a significant impact on water quality and quantity, and relate directly to the protection of aquatic life and the aquatic ecosystem.

Figure 1-3: Teck's sustainability focus areas.

Teck's long-term vision for biodiversity is to achieve a net-positive impact, which equates to leaving the areas where the company operates better off, from a biodiversity perspective, than before mining began. This can be achieved through a number of avenues, including reclamation of disturbed areas, habitat enhancement, and through conserving additional habitat outside the mining area.

This approach is exemplified by Teck's acquisition, in 2013, of several properties of high conservation value close to its areas of operation in the Elk Valley. Teck invested $19 million to acquire three parcels of land for conservation purposes:

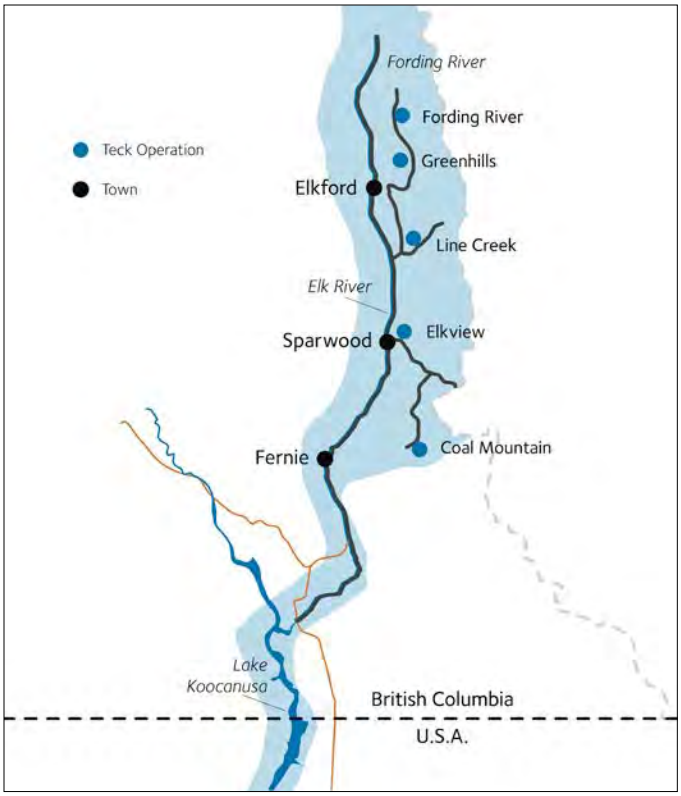
- Grave Prairie (3,059 hectares)
- Alexander Creek (3,098 hectares)
- Flathead Townsite (992 hectares).

These conservation lands lie within a larger ecosystem described by many provincial, national and international organizations as having global significance for biodiversity. The lands preserve key aquatic values such as free-flowing rivers and intact riparian areas that help preserve water quality and influence water temperature. These lands also provide cold-water habitats for native bull trout (a blue-listed species of special concern in B.C.) and westslope cutthroat trout (a blue-listed species in B.C. and a federal species of special concern).

Preservation of these lands will help to conserve aquatic values over the long-term and are also important for the movement of wildlife that uses the river valleys and high elevations to migrate north, south, east and west over the Rocky Mountains.

1.6.2 Social and Economic Impact of Teck's Elk Valley Operations

The Plan considers the economic importance of mining in the Valley and the social and economic impact of water quality mitigation measures.



In 2008, Teck secured a controlling interest in all five active steelmaking coal mines in the Valley: Fording River, Greenhills, Line Creek, Elkview and Coal Mountain (Figure 1-4). Together, these steelmaking coal operations make Teck the single largest employer in the larger East Kootenay region. Directly or indirectly, they contribute 6,440 jobs to the local economy, or one in five of the 33,000 jobs there.

In 2014, Teck's Elk Valley operations are projected to support more than 15,000 jobs in B.C. and 19,000 jobs in Canada (including direct and indirect employment and spin-offs). For every job at Teck, another 2.7 are created elsewhere in the provincial economy due to the capital-intensive nature of the mining industry. Teck's Elk Valley operations will pay approximately $525 million in wages and benefits and support a total of $1.8 billion in wages and benefits across B.C. and $2.6 billion Canada-wide.

Figure 1-4. Teck's operations in the Elk Valley watershed.

Employment in the mining sector is well-compensated. A report for the Mining Association of B.C. found that average income per employee at B.C. mines, comprising salary and benefits, was more than $120,000[1]. By providing high-paying jobs, Teck's Elk Valley operations contribute to the standard of living across the region. Projected per-capita income — total income divided by the entire population, including children and others who are not working — in 2014 in the East Kootenay is $44,000[2], compared to $40,000 for B.C. and $41,000 for Canada as a whole.

In 2014, Teck's Elk Valley operations will generate an estimated $4.5 billion in economic output in B.C., as measured in gross domestic product (GDP). This includes approximately $1.4 billion in goods and services provided by East Kootenay suppliers. Of that amount, approximately $600 million will remain in the East Kootenays, generating economic activity. The remainder will flow through to suppliers of equipment and consumables (e.g. diesel fuel or tires).

Teck's Elk Valley mines are a significant source of tax revenue. In 2014, the economic activity from the five steel-making coal operations will contribute approximately $1.1 billion to federal, provincial and local governments. Key indicators of the economic contribution of Teck's Elk Valley operations are summarized in Table 1-1, and more details are provided in Appendix M, the Ernst & Young report *"Elk Valley Water Quality Plan Socio-economic Analysis."*

Table 1-1. Projected economic impact of Teck's Elk Valley operations.

Indicator	2014 value
Direct Jobs with Teck	4,155
East Kootenay Jobs Supported	6,440
B.C. Jobs Supported	15,240
Wages Generated in B.C.	$1.8 billion
Total Tax Liabilities Generated[3]	$1.1 billion
East Kootenay Procurement	$1.4 billion

1.6.2.1 Supply and Demand – Price

Approximately 80% of all of the steelmaking coal produced in B.C. originates at the five Elk Valley operations. The high-quality steelmaking coal mined in the Valley is a major Canadian export to the fast-growing economies of the Asia Pacific region, where it is used to make steel that, in turn, is used in a range of products, from major public infrastructure like buildings, bridges and transit, to everyday items such as appliances and automobiles.

The steelmaking coal industry is a competitive global market with prices established by the market forces of supply and demand. Demand is generated by steel mills that require coal for their blast furnaces. Domestic producers such as Teck face significant competition in the seaborne and export market from producers in Australia, the US, Mozambique, Mongolia and inland China.

Steelmaking coal prices are cyclical. In recent years, producers from all regions increased production to meet the increase in demand, but over-supply has now resulted in steelmaking coal prices falling by close to 70% from 2011.

[1] The Mining Industry in British Columbia 2012.
[2] Economic impacts are derived using Teck's 2013 Life-of-mine plans and Consensus Economic steelmaking coal prices and foreign exchange rates from its October 2013 forecast. Results may vary based upon actual prices.
[3] Total tax liabilities generated is an estimate of Teck's incremental tax liability before adjustments resulting from tax pools.

1.6.2.2 Cost of Production

Currently, Teck's mines operate sustainably and safely with total costs below today's price for steelmaking coal. Table 1-2 outlines Teck's average cost for producing a tonne of coal in 2013.

Table 1-2. Average production costs at Teck operations.

Average cost to produce 1 tonne of coal	2013 Actuals[4]
Operating costs (blasting, shoveling, and hauling coal and waste rock, processing raw coal, maintaining equipment and infrastructure, environmental management, reclamation and wages)	$51/tonne
Transportation costs (transporting coal 1,200 km from the Valley to ports and loading it onto ships destined for overseas customers)	$38/tonne
Capital costs (replacing aging equipment and infrastructure, developing areas of the mine to enable continued production; other investments in the business; and water quality management)	$30/tonne
Total average cost	**$119/tonne**

1.6.2.3 Effect of Water Quality Mitigation on Mine Economics

The mitigation measures considered under the Plan (see Chapter 6) will lead to an increase in two of the above cost categories:

- Capital costs will increase, as water treatment facilities, diversions or other measures are constructed and research and development into future mitigation options continues.
- Operating costs will increase, as water treatment projects are completed and require operation, and as some current mining practices are modified to improve water management.

These increases will reduce Teck's financial flexibility to maintain production and jobs in a low-price environment, and could also affect the global competitiveness of Elk Valley operations.

An additional impact is the reduction in potential tax and resource revenues for governments, including First Nations, from direct mining activities. Income taxes and the B.C. Mineral Tax are based on income. As costs go up, income is reduced, resulting in less tax income from direct mining activities.

The proposed water quality targets and implementation plan described in the Plan (Chapter 8) are designed to be protective of the environment and human health while taking economic factors into consideration, in order to support continued, sustainable mining in the Valley without affecting mining-related jobs and economic activity in the region.

[4]The average costs are for all of Teck's production including one mine outside of the Elk Valley. Capital costs include pre-stripping rock,but exclude new mine development.

Chapter 2
Regulatory Context

Chapter Overview

This chapter provides the legal and regulatory context under which the Plan was developed. It summarizes key federal and provincial legislation relevant to selenium, cadmium, nitrate and sulphate in water, and calcite formation, as well as water quality guidelines (WQGs) for the protection of various water uses.

Concordance with Ministerial Order and Terms of Reference

Chapter 2 satisfies Section D of Schedule C of Ministerial Order M113 and Section 3.2 and Section 3.8(a) of the Elk Valley Water Quality Plan Terms of Reference.

Highlights

- **Elk Valley Water Quality Plan developed under B.C.'s *Environmental Management Act*.** The Plan has been developed under an Order of the Minister of Environment via the B.C. *Environmental Management Act*.
- **British Columbian and Canadian legislation provides robust regulatory framework for the Elk Valley Water Quality Plan.** In addition to the *Environmental Management Act*, provincial legislation potentially relevant to the Plan includes the *Environmental Assessment Act*, the *Water Act*, the *Mines Act*, and the *Drinking Water Protection Act*. Potentially relevant federal legislation includes the *Canadian Environmental Assessment Act, 2012*, the *Canadian Environmental Protection Act, 1999*, the *Fisheries Act*, the *Species at Risk Act*, the *Migratory Birds Convention Act, 1994*, the *Canada Water Act* and the *International Boundary Waters Treaty Act*.
- **The Elk Valley Water Quality Plan will serve as a framework for future regulatory decisions.** Once approved, the Plan will provide a framework for decision-makers to consider in future regulatory applications for steelmaking coal mining in the Elk Valley.

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2.1 Introduction

The Plan falls under an Order of the Minister of Environment via the B.C. *Environmental Management Act*. As required by the Order and Section 3.2 of the Terms of Reference, this chapter summarizes the key pieces of legislation relevant to selenium, cadmium, nitrate and sulphate in water, and to calcite formation.

Under Canadian Constitutional law, responsibility for the environment is shared between federal and provincial jurisdictions. Both levels of government exercise regulatory jurisdiction over companies operating in Canada. In terms of the Plan, potentially relevant provincial legislation includes the *Environmental Management Act,* the *Environmental Assessment Act,* the *Water Act,* the *Mines Act,* and the *Drinking Water Protection Act*. Potentially relevant federal legislation includes the *Canadian Environmental Assessment Act, 2012*, the *Canadian Environmental Protection Act, 1999*, the *Fisheries Act,* the *Species at Risk Act,* the *Migratory Birds Convention Act, 1994*, the *Canada Water Act,* and the *International Boundary Waters Treaty Act*.

In addition to legislation, both levels of government have established water quality guidelines (WQGs) for the protection of various water uses, which are described in more detail in Section 2.4.

2.2 B.C. Legislation

2.2.1 Environmental Management Act (EMA)

The EMA prohibits the introduction of waste from prescribed activities into the B.C. environment unless the activity is authorized. Prescribed activities are authorized by a permit, approval, Code of Practice or a regulation. Under the Waste Discharge Regulation, coal mining is prescribed as an activity subject to these prohibitions in the EMA. All of Teck's operations in the Elk Valley have obtained the permits required under the EMA.

Under the Waste Discharge Regulation, the prohibition against the discharge of waste into the environment does not apply to the discharge of coarse coal refuse, waste rock or overburden that is managed in accordance with a permit issued under the *Mines Act*. However, the discharge of these materials is subject to the prohibition in the EMA against causing pollution.

Regulations under the EMA apply to various types of activities or wastes. For example, the EMA and the *Hazardous Waste Regulation* contain detailed requirements for the storage, treatment, handling, disposal and transport of hazardous waste.[1] Many of these requirements do not apply to mine tailings or waste rock facilities.[2]

The EMA and the *Contaminated Sites Regulation* (CSR) set out the requirements for the identification, investigation and remediation of contaminated sites in B.C. and establish the principles of liability that apply to contaminated sites. The EMA (section 68) and CSR provide the legislative basis for the Site Registry, a publicly accessible database containing information on the status of sites in B.C. relative to CSR requirements. The EMA specifies that a director may not issue a remediation order under the CSR requirements for the core area of a mine except where the land and water use is formally changed from those approved in the Mines Act permit.[3] The core area includes areas where waste rock and tailings are placed.[4]

[1] For the definition of hazardous waste, see the Hazardous Waste Regulation.
[2] Any discharge from the facilities would be subject to the EMA requirements discussed above.
[3] A remediation order under the CSR may also be issued at the request of the Chief Inspector of Mines.
[4] Orders may be issued under the pollution prevention and abatement provisions of the EMA with respect to the core area of a mine. The exemption only applies to CSR requirements.

The EMA also provides authority for the Minister of Environment, if considered advisable for purposes of environmental management, to issue an Order requiring development of an area-based management plan for a specific area, and to establish a process for the development of that plan. Under the EMA, if the Minister of Environment approves an area-based plan, the Minister, by order, may require persons making decisions under the EMA to consider the plan in making those decisions.

The EMA authorizes environmental protection officers to conduct compliance activities including the issuance of advisories, orders, warning letters and administrative monetary penalties. These measures are part of the compliance and enforcement hierarchy.The EMA is administered by the provincial Ministry of Environment (MOE), and thus its authority does not extend beyond the borders of B.C.

2.2.2 Environmental Assessment Act

Under the *Environmental Assessment Act,* the proponent of a "reviewable project" must obtain an environmental assessment certificate before proceeding with the project. To obtain a certificate, an assessment must be completed that typically addresses potential adverse environmental, economic, social, heritage and health effects, as well as any potential adverse effects on First Nations interests. A certificate may be issued only following successful completion of an environmental assessment. The proponent must comply with the terms and conditions of the environmental assessment certificate.

A "reviewable project" is specifically defined. A new coal mine that will have an annual production capacity of 250,000 tonnes or more is a reviewable project. A modification to an existing coal mine is a reviewable project if specific production capacity and land disturbance levels and areas are contemplated in the modification.

The *Environmental Assessment Act* states that provincial and municipal permits and approvals for a reviewable project may not be issued until an environmental assessment certificate is issued for the project. However, the Act allows for concurrent permitting. Section 23 states that if an environmental certificate is granted, the Minister responsible for the Act can require, by order, the issuance of specified approvals within a specified time. In the absence of such an order, the issuance of a certificate does not create an obligation on Government decision makers to issue authorizations under other enactments.

The *Environmental Assessment Act* falls under the jurisdiction of MOE, and is administered by the Environmental Assessment Office.

2.2.3 Water Act

The *Water Act* vests property and the right to the use and flow of all water in any stream in the provincial Crown, except to the extent private rights have been established under licences or approvals given under the *Act*. For example, a licence may permit diversion or use of water for the purpose specified in the licence.

The *Water Act* contains a number of provisions dealing with groundwater protection, including a prohibition against introducing, or causing or allowing the introduction of, any contaminant into a well in an amount or manner likely to cause a significant adverse impact on the quality of groundwater in the well or the existing uses made of the groundwater in the well.

The new *Water Sustainability Act* received Royal Assent on May 29, 2014. The *Act* is not yet in force, but will come into force over time by regulation. It is expected that the *Act* will begin to come into force in the spring of 2015. The new Act makes a number of changes to the management of provincial water resources, including:

- extending the provincial water license regime to groundwater used for anything other than domestic purposes;
- ensuring that environmental flow needs are considered in new water allocation decisions;
- authorizing Cabinet to establish water objectives for a watershed, stream or other area; and
- allowing for the development of water sustainability plans for specified areas.

The *Act* also prohibits the introduction of debris, contaminants and other matter into a stream or areas adjacent to a stream in a manner that would have a significant adverse impact on the stream or its users. This prohibition does not apply to a deposit authorized under the *Water Sustainability Act*, or another act, or to any prescribed activity.

The *Water Act and the Water Sustainability Act* are administered by the Ministry of Forests, Lands and Natural Resource Operations (FLNRO).

2.2.4 Mines Act

The *Mines Act* applies to all mines during exploration, development, construction, production, closure, and reclamation . Before starting any work in or about a mine, a permit must be obtained and a plan filed that outlines the details of the proposed work, a program for the conservation of cultural heritage resources, and measures for the protection and reclamation of land, watercourses and cultural heritage resources affected by the mine. Permit holders are required to provide reclamation security. Detailed projections of reclamation costs must be provided in an application for a *Mines Act* permit, including provisions for long-term monitoring, maintenance and mitigation of environmental impacts. All Teck operations in the Elk Valley have obtained the permits required under the *Mines Act*.

Historically, mine permit applications have been referred to long-standing, multi-agency Regional Mine Development Review Committees chaired by the Chief Inspector of Mines. Although these committees were inter-agency committees, their focus was the *Mines Act* permit process.

The Province recently made a number of administrative changes to the approval process for major mines. A new Guide to Coordinated Authorizations for Major Mines was released in December 2013. Under Section 9 of the *Mines Act*, the Chief Inspector of Mines is required to establish regional advisory committees to review applications for mine permits. Under this new coordinated authorization process, applications for major mines are referred to a project-specific Mine Review Committee (MRC) chaired by a government representative. The MRC coordinates and reviews all major authorizations for a mining project, including those required under the *Mines Act* and EMA. Members of the MRC include representatives of statutory decision-makers, local government and First Nations, as well as technical advisors from provincial and federal government agencies. At the end of the process, the MRC issues a recommendations report to statutory decision-makers, addressing all the major permit applications for the project.

Applicants for a *Mines Act* permit are generally required to advertise project proposals upon submission of the application and make information available for public review and comment. Additional consultation may be required.

The *Mines Act* is administered by the B.C. Ministry of Energy and Mines (MEM).

2.2.5 Drinking Water Protection Act (DWPA)

The DWPA sets out the requirements to ensure that drinking water operators provide their customers with safe water. It includes requirements for the approval of water system construction proposals, minimum treatment standards, and public notification of water quality problems. The legislation also contains a prohibition against the introduction of anything into a domestic water system, drinking water source, well recharge zone or an area adjacent to a drinking water source that will result or is likely to result in a health hazard. The DWPA is administered by health authorities and the Ministry of Health.

2.3 Federal Legislation

2.3.1 Canadian Environmental Assessment Act, 2012 (CEAA 2012)

Under CEAA 2012, designated projects must undergo an environmental assessment by the Canadian Environmental Assessment Agency, the National Energy Board or the Canadian Nuclear Safety Commission before the project can proceed. In some cases, the Agency may determine that an environmental assessment is not required for a designated project.

Designated projects include new coal mines with a production capacity of 3,000 tonnes/day or more, and the expansion of a coal mine that would increase the area of mine operations by 50% or more, or by 3,000 tonnes/day or more.

An assessment under CEAA 2012 focuses on environmental effects within areas of federal jurisdiction such as migratory birds, aquatic species, species at risk, federal lands and First Nations. At the conclusion of the assessment process, a decision statement is issued that includes the conditions with which the proponent must comply.

The Canadian Environmental Assessment Agency and the B.C. Environmental Assessment Office have entered into a Memorandum of Understanding that establishes the framework under which the provincial environmental assessment process may substitute for the federal assessment process. Substitution requests have been approved for several projects in B.C. to date, including mining projects. Where substitution is approved, both levels of government must still decide whether to approve the project.

2.3.2 Canadian Environmental Protection Act, 1999 (CEPA)

CEPA is one of the primary federal environmental statutes. It contains the legislative framework for the identification and regulation of toxic substances. It also addresses environmental and human health impacts of products of biotechnology, marine pollution, disposal at sea, vehicle, engine and equipment emissions, fuels, hazardous wastes and environmental emergencies.

Schedule 1 to CEPA contains a List of Toxic Substances that including inorganic cadmium compounds. Substances on the list may be subject to various management measures including regulations, and/or a requirement to develop a pollution prevention plan or environmental emergency plan. Some measures have been introduced that include inorganic cadmium compounds (e.g., Notice Requiring the Preparation and Implementation of Pollution Prevention Plans in Respect of Specified Toxic Substances Released from Base Metals Smelters and Refineries and Zinc Plants). However, to date, no specific provisions have been introduced for cadmium discharges from coal mining operations. Selenium, sulphate and nitrate are not listed in Schedule 1 to CEPA.

The *Canadian Environmental Protection Act* is administered by Environment Canada.

2.3.3 Fisheries Act

The *Fisheries Act* protects commercial, recreational and Aboriginal fisheries while safeguarding both fish and fish habitat. It prohibits the unauthorized deposit of any type of deleterious substance in water frequented by fish. "Deleterious substance" includes any substance that would degrade or alter water quality sufficiently to render it deleterious to fish or fish habitat. The Minister may authorize the deposit of a deleterious substance by regulation.

The *Fisheries Act* also prohibits any work, undertaking, or activity that results in serious harm to fish that are part of a commercial, recreational or First Nation fishery or to fish that support such a fishery. "Serious harm to fish" is defined as "the death of fish or any permanent alteration to, or destruction of, fish habitat." The Fisheries Protection Policy Statement indicates that the Department interprets "serious harm to fish" as including a

permanent alteration to fish habitat that is of a spatial scale, duration or intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds or as nursery, rearing or food supply areas, or for migration.

Projects expected to cause serious harm to fish require an authorization to proceed. The *Fisheries Act* sets out factors that must be considered in connection with an application for an authorization, including whether there are measures to avoid, mitigate or offset serious harm to fish. The Policy Statement indicates that any residual serious harm after avoidance and mitigation has been applied should be offset.

The *Fisheries Act* allows for agreements with the provinces for equivalency or delegation of administrative functions. In B.C., an interagency agreement provides for enforcement by the provincial Ministry of Environment.

Administration of the *Fisheries Act* is shared by the Department of Fisheries and Oceans and Environment Canada.

2.3.4 Species at Risk Act (SARA)

SARA identifies and categorizes any species considered at risk, and prohibits specific activities that may harm at-risk species and their habitat. Penalties for prohibited activities include fines and imprisonment. SARA generally applies only on federal lands. However, the protections for aquatic species and migratory birds apply to all lands and waters. Environment Canada is the lead federal agency responsible for administration of SARA. The Department of Fisheries and Oceans takes the lead on the protection of aquatic species that are at risk.

2.3.5 Migratory Birds Convention Act, 1994

The *Migratory Birds Convention Act* implements the Migratory Birds Convention. It prohibits the deposit of a substance that is harmful to migratory birds in waters or an area frequented by migratory birds, or in a place from which the substance may enter such waters or such an area. The *Act* also prohibits the deposit of a substance that, in combination with one more other substances, results in a substance that is harmful to migratory birds. Penalties for prohibited activities include fines and imprisonment. Environment Canada is the lead federal agency responsible for administration of the *Migratory Birds Convention Act*.

2.3.6 Transboundary Issues

The Canada-US border passes through many waterways. Mechanisms have been developed to facilitate cooperative management of these waters, including treaties and agreements, as well as more informal community-based and cross-border initiatives.

In Canada, the federal government leads national policy and engagement on issues that have an international component. Federal, provincial, and municipal governments in Canada have a history of consultation and coordination to meet Canada's obligations under international treaties and agreements. Two pieces of legislation address Canada's management of waters that cross international boundaries: the *Canada Water Act* (CWA) and the *International Boundary Waters Treaty Act (*IBWTA*)*.

The CWA is federal legislation that provides a framework for federal and provincial cooperation in the conservation, development, and management of Canada's water resources. This includes cooperation on water management programs that may encompass international or boundary waters and that are of significant national interest. A report to Parliament, describing activities conducted under the authority of the CWA, is published at the end of each fiscal year by Environment Canada. This report is a public document.

The IBWTA was enacted to implement the Canada-US International Boundary Waters Treaty of 1909 (Treaty). It establishes principles and outlines mechanisms to assist in the resolution of transboundary water quantity and quality disputes. The Treaty states that water shall not be polluted on one side of the border to an extent that results in harm to health or property on the other side. The International Joint Commission was created by the Treaty to hear disputes arising under the Treaty.

2.4 Water Quality Policy Context

This section summarizes key water policy statements and instruments of the governments of B.C. and Canada that relate to the establishment of water quality targets in the Plan. It includes a summary of the B.C. government policy related to water treatment technologies, and guidance on water quality monitoring.

2.4.1 B.C. Water Quality Policy Statements

Since 1985, MOE's policy has been to develop province-wide WQGs (formerly called water quality criteria) and site-specific water quality objectives (SSWQOs; see Section 2.4.3) for avoiding degradation, upgrading or protecting water quality for a designated use (MOE Policy 6.10.03.03, 1985).

The policy is in place for these reasons:

- to determine the quality of water in important waterways and to detect changes therein that may be significant to the management of the water resource
- to ensure that the quality of the aquatic resource is maintained
- to guide the issuance of permits, licenses and orders related to water quantity and quality
- to assist decision-makers planning for developments that could affect the aquatic resource.

2.4.2 B.C. Water Quality Guidelines

The MOE definition of a WQG is:

> *A maximum and/or minimum value for a physical, chemical or biological characteristic of water, sediment or biota, applicable province-wide, which should not be exceeded to prevent specified detrimental effects from occurring to a water use, including aquatic life, under specified environmental conditions. WQGs are science-based safe levels for physical, chemical, biological characteristics of water, biota or sediment, and thus do not account for social and economic factors. They are developed to protect various water uses, such as aquatic life, wildlife, agriculture, recreation/aesthetic, and source/drinking water. WQGs for the protection of aquatic life and wildlife are intended to protect the most sensitive species and most sensitive life stage indefinitely. As well, they consider all components of the aquatic ecosystems (algae, aquatic plants, invertebrates, amphibians, fish, etc.). For some substances, both a 30-day average (long-term guideline based on a minimum of 5 samples in a 30-day period) and a short-term maximum guideline (set to protect the most sensitive aquatic organism from lethal effects over short-term (96-h or less) exposures) are developed.*

WQGs are applicable province-wide and do not account for site-specific factors. B.C. guidelines are generally the basis for the derivation of site-specific water quality objectives, which take local circumstances into account. WQGs are not legally enforceable in B.C., but are approved by the Assistant Deputy Minister of MOE. Once approved, they become official policy that provides direction to those making decisions within MOE that affect water quality (MOE Policy 6.10.03.02, 1991). WQGs are considered in the development of allowable limits in water discharge permits, approvals, plans, or operating certificates.

B.C. WQG reports can be found at: http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html

The status of approved B.C. WQGs for the substances of concern under the Order is:

Nitrate: updated in 2009

Sulphate: updated in 2013

Cadmium: the working guideline is currently being updated

Selenium: updated in 2014

WQG derivation protocol can be found at: http://www.env.gov.bc.ca/wat/wq/pdf/wq-derivation.pdf

2.4.3 Site-Specific Water Quality Objectives

In B.C., SSWQOs protect the most sensitive water use at a particular site. Each applies to the site in question and any potentially affected waters downstream of the site, unless otherwise stated.

B.C.-approved WQGs are often adopted for the most sensitive water use as the preliminary WQO for each water quality variable for a site. At sites with atypical water quality characteristics or ecological receptors, the B.C.-approved WQGs may be modified to account for site-specific factors.

Certain conditions must be present before an approach other than direct adoption of the approved B.C. WQGs is considered. For example, any one of the following conditions could justify the development of a WQO that is different from the B.C.-approved WQGs:

- The natural background concentrations of a given variable exceed the B.C.-approved WQG.
- Site-specific circumstances increase or decrease toxicity of the contaminant(s) in question. When toxicity-modifying factors are present, WQOs are based on the natural background concentrations of these factors, not levels that have been altered due to human land use (e.g., water hardness).
- The dataset used to derive the B.C.-approved WQG includes taxonomic groups that do not occur, or do not have the potential to occur, within the water body in question.

Where existing water quality does not suit all desired water uses, and it is feasible to improve quality over time (e.g., legacy impacts from past land use), short-term objectives can be developed to stabilize water quality at a site while the long-term objectives represent the desired future condition (e.g., B.C. WQG levels).

Guidance for developing site-specific WQOs is at: http://www.env.gov.bc.ca/wat/wq/pdf/wqo_2013.pdf

2.4.4 Canadian Water Quality Guidelines

Guidelines issued by the Canadian Council of Ministers of the Environment (CCME) may be adopted by MOE as B.C. Working WQGs, and are considered in the development of approved B.C. WQGs. Regional factors in B.C. may necessitate the adjustment of CCME guidelines to suit provincial circumstances. It is MOE policy that B.C. WQGs take precedence over CCME guidelines.

The current B.C. WQG for cadmium is a Working WQG and is based on an Interim Canadian Water Quality Guideline (CCME 2005). The Interim Canadian Water Quality Guideline for cadmium is being revised and the draft B.C. Cadmium WQG is now posted for public comment.

2.5 Other Regulatory Tools

2.5.1 Manual for Reviewing Environmental Impact Assessments (EIAs)

The Manual for Reviewing Environmental Impact Assessments to Support Effluent Permitting provides guidance for reviewing and conducting EIAs for effluent permitting and waste management plans under the B.C. *Environmental Management Act*. It is intended to be used by EIA biologists and other MOE staff to ensure that a consistent province-wide approach is followed in reviewing EIA reports conducted as part of the waste discharge permitting process.

2.5.2 Site Performance Objective (SPO)

A Site Performance Objective (SPO) is an authorization limit imposed by the statutory decision maker which considers receiving environment information that is derived from scientific data with consideration of other factors. These factors are described in the Effluent Permitting Process: An Overview for Mine Project Applicants. In deriving an SPO, the level of risk is defined and documented. SPOs are set in consideration of the WQGs and/or water quality objectives (WQOs) and social and economic factors. SPOs have relevance to the area based plan because the Order refers to Water Quality Targets, which will be considered Site Performance Objectives if the plan gets approved by the Minister, and the targets, as defined within the Plan, are incorporated into permits or other authorizations.

The factors considered in a SPO decision are described in: http://www.env.gov.bc.ca/epd/industrial/mining pdf/effluent_permitting_guidance_doc_mining_proponents_apr2013.pdf

2.5.3 Drinking Water Guidelines

WQGs for source drinking water are developed by MOE through consultation with the B.C. Ministry of Health. Health Canada's Guidelines for Canadian Drinking Water Quality for chemical parameters are typically adopted by MOE to reduce risks to drinking water sources.

MOE has approved ambient WQGs for nitrate and sulphate in drinking water sources. The maximum acceptable concentration for nitrate is 10 mg/L (as N) (Nordin and Pommenz 1986). An aesthetic objective of 500 mg/L was adopted for sulphate (Singleton 2000). The current selenium guideline is 0.01 mg/L (Nagpal and Howell, 2001); however, Health Canada has proposed an updated guideline of 0.05 mg/L (Health Canada 2013). MOE has not formally adopted a cadmium source WQG; however, Health Canada's guideline (Health Canada 1986) will be adopted as a working guideline in B.C.

2.6 Other Guidance Tools

2.6.1 Determining Best Achievable Technology (BAT) Policy

This policy provides guidance for setting waste discharge standards by using BAT standards, and thus encourages significant reduction of waste discharges to the environment. In the policy, BAT "means the technology that can achieve the best waste discharge standards and that has been shown to be economically feasible."

2.6.2 B.C. Field Sampling Manual

The 2003 edition of the B.C. Field Sampling Manual sets out the sampling procedures, protocols and equipment that applicants are normally expected to use when doing monitoring required by MOE.

2.6.3 B.C. Laboratory Methods Manual (2009)

This policy identifies the approved laboratory methods to be followed by laboratories for B.C. clients in order to be acceptable for permit-related sampling. It is important to ensure the current version is used, since this manual is updated frequently.

2.6.4 Monitoring Guidance Document for Mine Proponents and Operators

MOE's Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators is designed to outline and define the baseline study requirements and information considerations necessary to propose a mineral development project in of B.C. The document describes minimum baseline requirements and associated acceptable methods and rationale, and provides sources of information and examples. The topics covered by this document include;

- air quality
- water quality and quantity (surface and groundwater)
- hydrology
- hydrogeology
- sediment quality
- aquatic life information requirements
- geological conditions.

Although developed specifically for the mining industry, much of the information on sampling methodologies and tools for impact assessment applies to other types of effluent permitting.

2.6.5 Guidelines for Designing a Monitoring Program and Interpreting Data (B.C.)

These two manuals present guidelines for designing a water quality program and interpreting water quality data in B.C. They cover the minimum requirements to ensure that a sampling program effectively addresses all concerns regarding potential impacts to a fresh water body and that data are reliable. This is accomplished through the development of a structured approach to program design, data collection, and data interpretation that can be widely applied. Given the variability of the natural conditions as well as man-made inputs, these manuals are limited to providing guidance rather than specific protocols.

Chapter 3
Consultation and Technical Advice

Chapter Overview

The development of the Plan included two processes for receiving and incorporating input from outside of Teck: the establishment of an independent Technical Advisory Committee (TAC) to provide scientific advice and review; and a consultation process with communities, First Nations and governments.

Concordance with Ministerial Order and Terms of Reference

Chapter 3 satisfies Section 2(c) of Schedule B and Schedule D of Ministerial Order M113 and Section 4.0, 5.1, 5.2, 5.4, and 5.5 and 5.9 of the Elk Valley Water Quality Plan Terms of Reference.

Highlights

- **Scientific advice from the TAC**: Teck received close to 700 pieces of science-based advice from the nine-member TAC, which included representatives of the provincial and federal governments, Ktunaxa Nation Council, US federal government, Montana state government, an independent third-party qualified scientist and Teck. Teck participated in over 200 hours of meetings with the TAC and sub-groups between September 2013 and July 2014. Annex A includes all TAC recommendations together with how Teck considered each recommendation.
- **Extensive multi-phase consultation**: Teck fulfilled the requirements of Ministerial Order M113 through consultation with the Ktunaxa First Nation, local government, the public, governments in Canada and the United States, and other stakeholders.
  - **Local government, stakeholders and the public**: Local governments, stakeholders and the public were consulted through a three-phase process. Opportunities included in-person meetings in Fernie, Sparwood and Elkford, and online consultation. Notification of the consultation phases was broad, including advertising and mailers to all households in the Elk Valley. In total, 213 people attended 11 meetings and open houses, and 164 pieces of written feedback were submitted.
  - **Ktunaxa First Nation**: The Ktunaxa First Nation was engaged through a consultation agreement and multi-phase consultation process that included numerous meetings with leadership and staff, five community presentations, and a mine site tour.
- **Input considered in development of the Plan**: Inputs received from the TAC and other entities was considered, along with socio-economic information, in the development of the Plan, as documented in Annex A (Advice Table) and Annex C.8 (Considerations Memo).
- **Consultation to continue**: Teck will continue to undertake consultation at key milestones during implementation of the Plan. Inputs will be considered in the adaptive management of the Plan.

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3.1 The Technical Advisory Committee

The TAC provided technical, science-based advice to Teck and shared this advice with the public during development of the Plan by guiding, reviewing and commenting on its various work packages and components. The advice focused on the science used in the development of the Plan. This included assessing and making recommendations on the scientific methodologies for development of the water-quality concentration targets and assessing potential aquatic health impacts of proposed targets. The Committee provided advice on existing scientific reports and literature relevant to the technical issues to be addressed in the Plan. It reviewed, assessed and made recommendations on the scientific and technical aspects of studies undertaken by Teck before and during development of the Plan.

The chair of the TAC attended six open houses and three small group meetings held during Phase 1 and Phase 2, providing TAC's perspective on the Plan process to attendees.

The goal of the TAC was to provide advice to Teck through consensus among members. Members presented and discussed advice at meetings. Advice was then organized into an advice table and incorporated in the official TAC meeting minutes. Teck reviewed all advice received from the TAC and responded on how each piece of advice was considered in the Plan. These responses are included in Annex A.

The committee included representatives from:

- B.C. Ministry of Environment (MOE) – chair
- B.C. Ministry of Energy and Mines (MEM)
- B.C. Environmental Assessment Office
- Environment Canada
- US Federal Government
- Montana State Government
- Ktunaxa Nation Council
- an independent third-party scientist selected by the TAC
- Teck.

Selection of the independent scientist was made by MOE with input from the TAC.

The TAC held seven scheduled meetings during the development of the Plan. In addition, working groups were established to focus on four key development topics: toxicology, human health, monitoring and Lake Koocanusa. In total, the TAC dedicated more than 200 hours to meetings and discussions on the Plan.

Agendas and meeting notes from TAC meetings are available at www.elkvalleytac.com.

3.2 Consultation

As required by the Order, Section 4.0 of the Terms of Reference for the Plan outlined requirements for consultation under which Teck would consult with, or notify as appropriate, the following groups identified in the Order:

- the public
- the Government of B.C.
- the Government of Canada
- local governments
- the US federal government and the State of Montana Department of Environmental Quality
- B.C. First Nations that assert interests in the Designated Area
- the Kootenai Tribe of Idaho, and the Confederated Salish and Kootenai Tribes
- environmental non-government organizations
- other resource companies including Coal Valley Resources, Crowsnest Pass Coal Mining, NWP Coal Canada, Centermount Coal and Centerpoint Resources.

In addition, the Terms of Reference directed a separate process for consultation on the Plan between Teck and the Ktunaxa Nation Council, described in Section 3.2.4

Teck undertook three phases of formal consultation during the 12-month period to develop the Plan, in which 213 individuals participated in meetings and public open houses, and 164 feedback forms were received.

In addition to notification of the general public through advertising and direct mail, Teck reached out specifically to the above-listed stakeholders to engage them in the consultation process. A dedicated website, www.teck.com/elkvalley, provided the public and stakeholders with access to all information and public materials related to consultation. Separate from the public consultation process, other outreach – including notification, bilateral meetings and group meetings – was conducted with a number of identified stakeholders, including the Ktunaxa Nation Council, B.C. Government, Government of Canada, US federal government, State of Montana, and the Kootenai Tribe of Idaho and the Confederated Salish and Kootenai Tribes.

Before the three formal rounds of consultation, Teck held three public information sessions in Elkford, Fernie and Sparwood, and in June-July 2013 introduced the Plan process at local events, including more than a dozen local community markets throughout the region. Teck also accepted feedback throughout the development period via the website, a toll-free feedback number and email.

Each round of consultation was facilitated by Kirk & Co., an independent consultant with extensive experience in public consultation:

- **Phase 1 (Oct. 28-Nov. 29, 2013):** In the first round, Teck provided information regarding the process to develop the Plan and sought input regarding current and potential water treatment and water quality management approaches. Teck also provided information on ongoing mitigation strategies and the supporting socioeconomic impact analysis.
- **Phase 2 (April 9-May 5, 2014):** During the second round, Teck provided an update on progress made in developing the Plan, including information about research into ecologically protective levels for the substances of concern. Input was sought regarding the short-, medium- and long-term approaches to be included in the Plan, and how communities and the public would like to be consulted about adaptive management of the Plan after it has been implemented.
- **Phase 3 (June 13-July 4, 2014):** In the final round, Teck provided draft Plan content on the Plan website, and sought public comment.

Feedback received through the consultation was summarized after each round by Kirk & Co. in a report that was posted on the public website. Following the final consultation round, all input from the three rounds was collected into a consideration report, detailing how key feedback – along with environmental, technical and financial information – was considered in the development of the final Plan (Annex C.8).

3.2.1 Phase 1 Consultation

Teck took a number of steps to notify the public and stakeholders listed in the Terms of Reference of the opportunity to participate in the Phase 1 consultation, including:

- placing newspaper, radio and online advertisements in local and regional media
- mailing approximately 8,500 postcard invitations to residences and businesses in the Elk Valley
- sending out approximately 300 emails
- making approximately 100 telephone calls to identified stakeholders.

Feedback was collected through an online feedback form, written feedback forms and through open houses and small group meetings.

The open houses and small group meetings, held in Elkford, Sparwood and Fernie, attracted 107 attendees and resulted in 94 feedback forms being submitted. Annex C.1 provides a detailed report on the notification undertaken, the materials and methods Teck used to facilitate information dissemination and consultation, and the feedback received.

3.2.1.1 Feedback Summary

Ninety-two per cent of Phase 1 consultation participants who provided feedback forms approved of the key steps in developing the Plan, with 4% disagreeing and the remainder expressing no opinion. A similar proportion (89%) reported that they somewhat or strongly agreed with current and future water treatment and quality management measures undertaken by Teck. Support for the scope of the Plan's socio-economic impact analysis was also at 89% among those providing feedback.

3.2.1.2 Key Themes

Many participants in the Phase 1 consultation expressed support for the proposed steps in developing the Plan. Some suggested that a broader water use plan be developed for the Elk Valley, including activities beyond mining. Some participants wanted to know what consideration had been given to testing well water, and some wanted to know how existing B.C. drinking water guidelines would be factored into the development of targets for the Plan. Participants also wanted to know more about the water treatment and water quality management options that Teck had proposed, and requested that Teck ensure monitoring and reporting of water quality once the Plan was completed. In general, participants recognized the importance of Teck's continued investment in research and development of the Plan, and were supportive of proposed mitigation measures.

The participants also generally recognized the economic importance of steelmaking coal mining in the Elk Valley and were in agreement with the proposed scope of the socio-economic impact analysis. Annex C.2 provides a detailed report on issues raised and comments provided by participants during Phase 1.

3.2.2 Phase 2 Consultation

Teck took a number of steps to notify the public and stakeholders listed in the Terms of Reference of the opportunity to participate in Phase 2 consultation, including: placing newspaper, radio and online advertisements in local and regional media; two mail-outs of approximately 8,500 postcard invitations each to residences and businesses in the Elk Valley; mailing approximately 8,500 newsletters with information on consultation; sending out approximately 300 emails; and, making follow-up telephone calls to identified stakeholders. Feedback was collected through an online feedback form, written feedback forms and through open houses.

The open houses in Elkford, Sparwood and Fernie attracted 84 attendees and resulted in 45 feedback forms being submitted. Annex C.3 provides a detailed report on the notifications given, the materials and methods Teck used to facilitate information dissemination and consultation, and the feedback received.

3.2.2.1 Feedback Summary

A high proportion of participants who provided feedback in the Phase 2 consultation period were supportive of the short-, medium- and long-term water quality approaches proposed by Teck. Participants were asked how they would prefer to be notified and consulted about ongoing monitoring and adaptive management of the Plan. Most respondents preferred to obtain information and provide feedback via a website (76.7%), direct notification (62.8%), and by attending a community information session (55.5%).

3.2.2.2 Key Themes

Annex C.4 provides a detailed report on issues raised and comments provided by participants during the Phase 2 consultation.

Some participants suggested that Mitigation measures proposed for the medium- and long-term also be considered as part of the short-term approach. Participants wanted to know more about the effects of selenium on aquatic life and how site-specific benchmarks are derived. Some asked how the potential for selenium in drinking water would be addressed through the Plan. Some participants wanted to know how other future industrial activity in the Elk Valley would be addressed within the context of the Plan; how drinking water quality is being addressed within the Plan; the geology of the areas being mined and how that relates to selenium release; and how long selenium would be released from waste rock piles. For a detailed report on issues raised and comments provided by participants during Phase 2 please refer to Annex C.4.

3.2.3 Phase 3 Consultation

Phase 3 consultation were primarily conducted online, with Teck making content from the draft Plan available at www.teck.com/elkvalley and collecting feedback online and through written submissions. Teck took a number of steps to notify and encourage the public and stakeholders listed in the Terms of Reference to participate in the Phase 3 consultation, including:

- placing newspaper, radio and online advertisements in local and regional media
- a mail-out of approximately 8,500 informational pamphlets to residences and businesses in the Elk Valley
- sending out approximately 460 emails
- making 25 telephone calls to identified stakeholders.

A group stakeholder feedback and discussion meeting was held on June 24, 2014, in Sparwood and Fernie. Notification was by emails and follow-up phone calls. Annex C.5 presents a discussion guide for the third phase of consultation.

The Phase 3 consultation resulted in 25 of pieces of written feedback being submitted, and 22 people participated in the feedback meeting. Annex C.6 provides a detailed report on the notification undertaken and the feedback received.

3.2.3.1 Key Themes

Participants at small group meetings were interested in how the Plan would address future industrial proposals, and whether they would have to meet the targets outlined in the Plan. Many were interested in Teck's plan for monitoring, including how often monitoring would be undertaken and whether results would be publicly available.

Several participants who provided submissions were in agreement with the Plan and water quality targets outlined in the Phase 3 discussion guide. Other respondents suggested that monitoring data should be provided to the BC government and the public at regular intervals. Several respondents were interested in how active water treatment facilities and other mitigation measures would be maintained following the end of mining activities, while others were supportive of Teck's leadership role in addressing water quality concerns and the amount of work that Teck has put into developing the Plan.

For a detailed report outlining issues and comments provided by Phase 3 consultation participants, please see Annex C.6.

3.2.4 Ktunaxa Nation Consultation

The Ktunaxa Nation Council (KNC) was consulted throughout the development of the Plan, and Teck is committed to continuing to consult and work with KNC leadership and staff throughout its implementation.

As outlined in the Terms of Reference, Teck consulted with the KNC in accordance with a KNC-Teck Elk Valley Water Quality Consultation Agreement, jointly developed pursuant to the existing KNC-Teck Consultation Protocol. Annex C.7 provides details on this agreement. Specific consultation included the following activities:

- KNC Community consultation meetings were held in February, April, June and July 2014, at which Teck provided information and received feedback on the Plan process, and at which the KNC's representative on the TAC provided information on the TAC process and perspective on the Plan development. Teck provided funding to facilitate staff preparation for, and staff and community members' participation in, these meetings.
- A two-day Ktunaxa Nation meeting was held on June 3-4, 2014, which included presentations and discussion of the Plan.
- KNC community members and staff participated in a tour of Teck's West Line Creek water treatment facility on June 16, 2014.
- KNC contracted MacDonald Environmental Sciences to provide technical advice and representation at the TAC. Teck provided capacity funding.
- KNC and band staff and leadership participated in the Plan consultation and development process. Teck provided capacity funding for this, and develop Ktunaxa-specific communication materials.
- KNC participated with Teck and the Government of B.C. in a Plan steering committee, which provided ongoing guidance and direction on the development of the Plan.

3.2.4.1 Feedback Summary

The following summarizes input received during KNC Community consultation meetings in February, April, June and July 2014.

KNC Community members were interested in the impact of increased levels of selenium on wildlife, fish, and plants, particularly those that are traditional foods of the Ktunaxa Nation. Some participants noted the traditional and spiritual uses of water in the area in which Teck is mining and expressed that they were participating in the consultation process to represent the interests of their children's children and all future generations of Ktunaxa Nation members. Consequently, some participants emphasized that Teck must take a longer-term, generational approach to the water treatment methods than it is considering and should move away from reliance on active water treatment and toward more passive water treatment methods. Some participants expressed frustration with past and present impacts of resource extraction, noting that Ktunaxa Nation members have and always will be present as protectors of the land in the Elk Valley, whereas industry has a short-term use for the land.

Several participants asked what assurances the Ktunaxa Nation has that Teck would not abandon its operations or responsibilities to manage water quality in the Elk Valley, including asking how budget limitations could affect the implementation of the Plan. Some participants wanted more information about Teck's implementation of the Plan and future monitoring activities and were interested to know how community members would receive updates regarding the status of Plan implementation and monitoring results. Many participants acknowledged Teck's leadership in consultation with the Ktunaxa Nation, appreciating the opportunity to meet directly with senior Teck staff on a regular basis.

Further information on the consultation undertaken and the feedback provided by the KNC can be found in Annex C.7. All feedback received from the KNC was also included in the consideration report, which describes how feedback was considered in the development and refinement of the Plan.

3.2.5 Other Specified Stakeholder Consultation

In addition to the general public consultation outlined above, additional steps were taken to ensure that specific stakeholder groups identified in the Terms of Reference were engaged and notified of opportunities to provide feedback on the development of the Plan.

All feedback received from these stakeholders was included in the consultation summaries produced for each round of consultation, as applicable, and in the consideration report, which describes how feedback was considered in the development and refinement of the Plan. For more information, see Annex C.8.

3.2.5.1 Local Government

Local governments within the Designated Area include the District of Sparwood, District of Elkford, City of Fernie and the Regional District of East Kootenay (Areas A and B). Consultation and engagement with each of these local governments took place through several avenues during the development of the Plan:

- Mayors and councillors from all Valley communities were directly invited by email and phone call to participate in all three phases of public consultation.
- Discussion Guides and related public materials for each round of public consultation were provided by email to councils and municipal staff.
- A number of mayors, councillors and regional district directors attended small group meetings and open houses Elkford, Sparwood and Fernie during Phase 1, 2 and 3, and provided feedback.
- A number of councillors and regional district directors participated in a tour of Teck's West Line Creek water treatment facility in November 2013.
- Letters of support for the Plan from local government can be found in Annex C.9.

3.2.5.1 Government of British Columbia

The Government of B.C. was consulted throughout development of the Plan. The departments Teck most frequently corresponded with were the Ministry of Environment (MOE), Ministry of Energy and Mines (MEM), Environmental Assessment Office (EAO), and Forests, Lands, and Natural Resource Operations (FLNRO). A number of forms of engagement were used, including:

- The TAC included members and alternate representatives from MOE, MEM, and EAO, who received regular updates and provided advice during the development of the Plan.
- Discussion Guides and information on each consultation round were disseminated to provincial government representatives at TAC meetings.
- Representatives from numerous government departments participated in tours of the Elk Valley operations and West Line Creek Water Treatment Facility during the Plan development period.

- Members of the Legislative Assembly attended information sessions, where Teck made presentations on the Plan.
- Regular bilateral and group meetings and information exchanges on specific aspects of Plan development took place throughout the process with BC government representatives.

3.2.5.1 Government of Canada

Teck provided the Government of Canada with regular updates throughout the development of the Plan. These updates occurred by way of formalized meetings and by way of direct outreach:

- The TAC included a member and alternate representative from Environment Canada, who participated in all TAC meetings and some subgroup meetings; received regular updates; and provided advice during development of the Plan.
- A number of in-person meetings in Ottawa took place with key departments including Environment Canada, Natural Resources Canada, Department of Fisheries and Oceans, and Foreign Affairs Trade and Development.
- A number of email and phone information exchanges took place in response to requests for information to Teck from federal government representatives.
- Discussion Guides and information on each consultation round were disseminated at TAC meetings to federal government representatives.

3.2.5.1 U.S. Government and the State of Montana Department of Environmental Quality

The Elk Valley watershed flows into Lake Koocanusa, a transboundary reservoir intersected by the B.C.-Montana border. The US State Department, Environment Protection Agency (EPA) and Government of Montana participated in and received updates on the development of the Plan through various channels:

- The TAC included a member and alternate representative from EPA Region 8 (Montana) and the U.S. Geological Survey who participated in all TAC meetings and some subgroup meetings.
- The Government of Montana Department of Environmental Quality (DEQ) was also represented on the TAC by a member and an alternate.
- In addition to the member and alternate representatives of the TAC, additional members of DEQ and EPA attended several TAC meetings as observers.
- A number of in-person meetings took place in Washington, DC with the offices of Senate and House Representatives of the State of Montana.
- Information updates and correspondence were exchanged with the State Department including with the Embassy of the United States in Ottawa, the consulate general in Vancouver, and the Office of Canadian Affairs in Washington, D.C.

3.2.5.1 Other B.C. First Nations that assert Interests in the Designated Area

The Shuswap Indian Band was identified as an additional B.C. First Nation asserting an interest in the Designated Area. Teck took steps to ensure the Shuswap had opportunities to participate and provide feedback during development of the Plan:

- The Shuswap were notified and invited by email to participate in all three phases of public consultation.
- The Shuswap were invited to participate in the stakeholder meeting during Phase 3.

3.2.5.1 Kootenai Tribe of Idaho and the Confederated Salish and Kootenai Tribes

The Kootenai Tribe of Idaho (KTOI) and the Confederated Salish and Kootenai Tribes (CSKT) received information and updates on the development of the Plan. Notification and engagement occurred through a number of avenues:

- In April 2014, Teck made a presentation on the Plan in a meeting with representatives of CSKT.
- Representatives from the KTOI and CSKT participated as observers at a number of TAC meetings.

3.2.5.1 Environmental Non-Governmental Organizations (ENGOs)

Wildsight and the Elk River Alliance (ERA) are ENGOs in the Designated Area with an identified interest in water quality issues. Consultation and engagement with these ENGOs took place through several avenues during the development of the Plan:

- ENGOs were invited by email and phone call to participate in all phases of public consultation.
- Discussion Guides and related public materials for each phase were emailed to ENGO staff.
- Representatives from Wildsight and the ERA attended small group meetings and open houses in Sparwood and Fernie during the Phase 1 and 2 consultation, and provided feedback.
- Representatives of Wildsight and the ERA attended the group stakeholder meeting as part of the Phase 3 consultation, and provided feedback.
- In December 2013, representatives of Wildsight participated in a tour of Teck's Line Creek Operations, including the West Line Creek water treatment facility.
- In May 2013, Teck and the ERA co-hosted a meeting for local fly-fishers and paddlers to discuss issues related to the Plan.

Teck notified other ENGOs by email of the opportunity to participate in consultation, including:

- the Yellowstone to Yukon Conservation Initiative (Y2Y)
- Sierra Club of B.C.
- Canadian Parks and Wilderness Society
- National Parks Conservation Association
- Headwaters Montana
- the Nature Conservancy of Canada
- the Nature Trust of B.C.
- the Kootenay River Network.

Teck participated in two water quality community information session hosted by the Kootenay River Network in Libby (June 2013) and Eureka Montana (August 2013).

3.2.5.1 Other Coal Companies

Coal Valley Resources, Crowsnest Pass Coal Mining, NWP Coal Canada, and Centermount Coal/Centerpoint Resources are identified in the Order as other coal companies with interests within the Designated Area. Consultation with these companies took place by means of several steps:

- Each was invited by email and phone call to participate in all three phases of public consultation.
- Registered letters were sent to all companies before Phase 2 consultation began, to ensure that they were aware of the opportunity to provide feedback.

- Teck made presentations or provided information directly to officials from Crowsnest Pass Coal Mining, Coal Valley Resources, and Centerpoint Resources.
- Letters of support for the Plan from other coal companies can be found in Annex C.9.

In addition, officials from CanAus Coal, which also has interests in the Designated Area, participated in the Phase 1 consultation and attended a one-on-one presentation by Teck.

3.3 Consideration of Consultation Feedback and Technical Advice

Annex C.8 is a Consideration Report that summarizes all the feedback Teck received during the consultation process and describes how that input has been considered, in conjunction with environmental, technical and financial information, in the development and refinement of the Plan.

Annex A comprises an Advice Table, as described at Section 3.1, that summarizes the technical advice received from the TAC and describes how it was considered in the development of the Plan.

3.4 Consultation During Implementation

As outlined in Section 4.2.2.1 of the Terms of Reference, during implementation of the Plan, Teck will report on progress and provide the above-named groups with opportunities to provide feedback at key milestones. This activity will use several avenues:

- Updates on Plan implementation will be posted as they become available, and ongoing feedback will be received and responded to through the Plan website.
- Submissions by mail, email or fax will be received and responded to on an ongoing basis.
- Throughout the Plan implementation period, a public feedback and information session will be advertised and held in at least one Elk Valley community annually.
- As necessary, bilateral or group meetings will be held to update and seek feedback from key groups.

Input received through consultation will be considered, along with environmental, technical and financial information, in the adaptive management and implementation of the Plan.

Chapter 4
Baseline Conditions

Chapter Overview

This chapter outlines current baseline conditions within the Designated Area relative to the protection of aquatic ecosystem and management of selenium, sulphate, nitrate and cadmium.

Concordance with Ministerial Order and Terms of Reference

Chapter 4 satisfies Section B1, B2, and B3 of Ministerial Order M113 and sections 3.4, 3.8(a) and 3.8(b) of the Elk Valley Water Quality Plan Terms of Reference. Human impacts are addressed in Chapter 5.

Highlights

- **Cadmium, nitrate, sulphate and selenium and other constituents were evaluated in the Designated Area.** Surface water quality data measurements have been collected over the past three years from locations through the area. Sediment samples have been collected since 2011.
- **Baseline conditions were examined for surface water quality, sediment quality and constituent concentrations in tissues of aquatic organisms:** These conditions, individually and cumulatively, determine the overall health of the aquatic environment and provide context for the development of the Plan.
- **Overall, biological monitoring results indicate that aquatic communities in the mainstem receiving environments appear to be healthy, with localized effects close to mine sites:**
  - Selenium and nitrate are the two constituents that most frequently exceed B.C. water quality guidelines in the Fording and Elk rivers; however, toxicity tests have not shown adverse effects on sensitive aquatic life.
  - Selenium is bio-accumulating in tissues of some biota in some areas to levels that may cause effects.
  - Benthic invertebrate community and fish population studies show little to no effects in the Fording River, Michel Creek and Elk River but invertebrate communities are affected in some tributaries directly influenced by mining.
- **Summary of monitoring in Lake Koocanusa:**
  - Water quality is well within B.C. WQGs for sulphate, nitrate and cadmium, and the selenium guideline is met in almost all (98%) water samples collected in Lake Koocanusa.
  - Data collected to date indicate that selenium in fish tissues is below levels that would harm fish populations.
- **Monitoring of water, sediment, fish and other biota will continue during Plan implementation.**

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4.1 Introduction

To provide context for the development of the Plan and management of Order constituents (cadmium, nitrate, sulphate, and selenium), Teck used available data to evaluate current baseline conditions within the Designated Area relative to Water Quality Guidelines (WQGs) and the protection of the aquatic ecosystem (e.g., sediment and biota evaluation relative to reference conditions, environmental quality guidelines and information in scientific literature). Calcite is evaluated and discussed in Chapter 7, while Chapter 5 evaluates baseline conditions in relation to the protection of human health and groundwater.

4.2 Management Units and Conceptual Site Model

To assist in the evaluation of current baseline conditions and identify where concentrations may be greater than WQGs, the Designated Area was divided into six management units (MUs, see Figure 4-1). Delineation of MUs is based on the location of Order Stations, and considers geographic features (e.g., confluence with major tributaries), and hydrodynamic characteristics (e.g., natural and/or artificial features). The six MUs in relation to the Order Stations are:

- MU-1 - Order Station FR4 (GH_FR1)
- MU-2 - Order Station FR5 (LC_LC5)
- MU-3 - Order Station ER1 (GH_ER1)
- MU-4 - Order Station ER2 (in the northern half – EV_ER4) and Order Station ER3 (at the southern limit, downstream of Michel Creek – EV_ER1)
- MU-5 - Order Station ER4 (RG_ELKORES)
- MU-6 - Order Station LK2 (RG_DSELK, RG_GRASMERE, and RG_BORDER).

Further to the above-listed MUs, and expanding upon the general influence diagram developed by the TAC on Oct. 29 and 30, 2013, a detailed conceptual site model (CSM) for the Designated Area was developed (Figure 4-2).

A CSM provides the framework within which a complex suite of chemical, physical, and biological processes and interactions can be systematically viewed in an organized manner. It considers sources of potential constituents of interest, physical-chemical processes that control chemical fate, and exposure pathways for relevant organisms (receptors) to evaluate current baseline conditions.

In developing a CSM, the first consideration is the different point and non-point sources that potentially release constituents to the environment. Once present in the aquatic environment, these constituents are transported within and among the various media by processes that result in a range of concentrations to which aquatic organisms are potentially exposed. Point and non-point sources of constituents within the Designated Area include activities such as mining, municipalities, agriculture, and forestry. As illustrated by Figure 4-2, constituents originating from Teck's coal mining operations may originate from waste rock, tailings, coarse coal rejects, and other mine-disturbed surfaces.

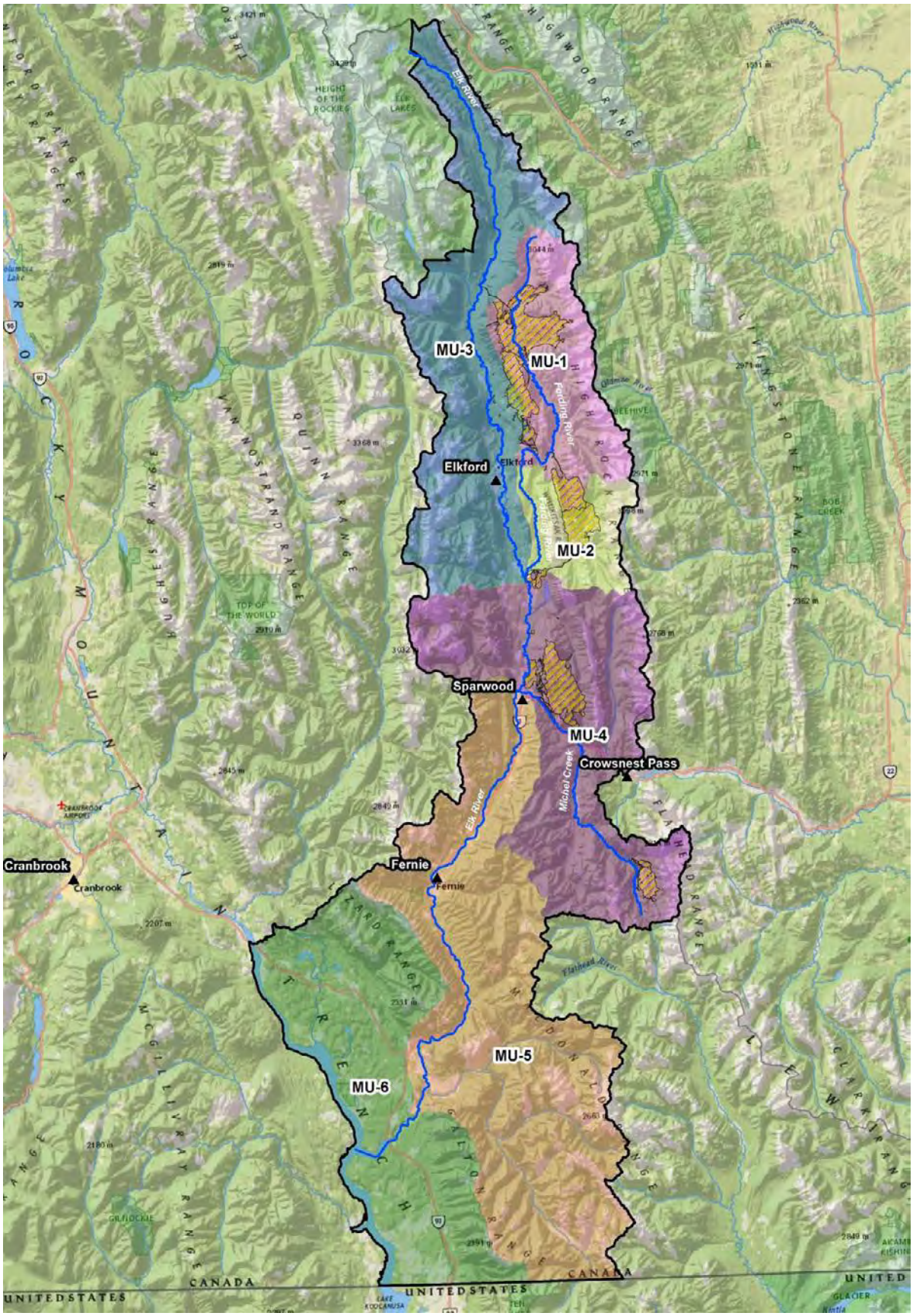


Figure 4-1. Management Units for the Designated Area.

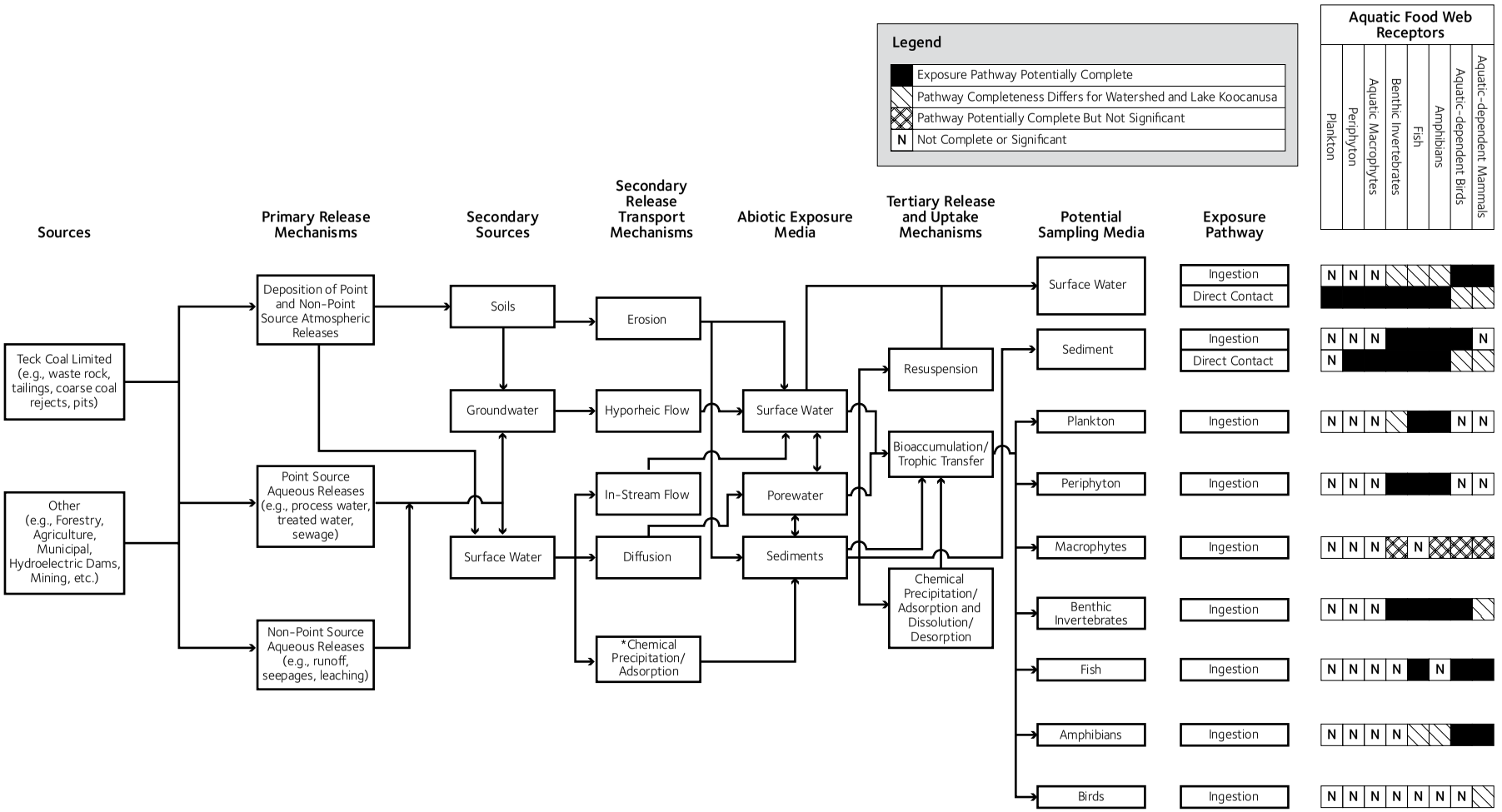


Figure 4-2. Conceptual site model for the designated area.

Note: "*" Chemical precipitation/adsorption within the Designated Area is inclusive of calcite formation and other relevant mine-related physical pathways (e.g. erosion/sediment transport, physical barriers (culverts, diversions), etc.). Details associated with calcite formation (e.g., conceptual site model) are presented in Chapter 7. Although the result of chemical reactions, calcite has the potential to act as a physical stressor which may adversely affect aquatic organisms due to changes in substrate structure. Other physical stressors that have the potential to adversely affect the aquatic environment either directly or indirectly include hydroelectric dams.

Receptor organisms have the potential to be exposed to constituents through ingestion of food (e.g., selenium bioaccumulation) or direct contact (e.g., surface water) (Figure 4-2). Receptor groups within the Designated Area include periphyton, aquatic macrophytes, benthic invertebrates, fish, amphibians, and birds and other aquatic-dependent wildlife.

Physical stressors in the Designated Area are also important. For instance, physical processes and environmental changes within Lake Koocanusa are affected by the operation of Libby Dam. Seasonal fluctuations of water elevations in the reservoir affect aquatic habitats and communities, either directly through disruption of spawning activity, or indirectly through the character of food webs or the quality and availability of habitat (Hardy and Paragamian 2013; Richards 1997; Crozier and Nordin 1983). The most direct effect is the dewatering of littoral habitats on species that depend on them for feeding or spawning (Richards 1997).

4.3 Existing Data

A large amount of environmental data has been collected in the Designated Area and Lake Koocanusa. These data include surface water quality, sediment quality, tissue residue concentrations, and evaluation of productivity and populations/communities in aquatic biota. A summary of current baseline conditions for each different type of data is presented below, and details are provided in Annex K.1.

4.3.1 Surface Water Quality

Water quality data were collected from 94 sampling locations throughout the Designated Area (Figure 4.3). These locations are identified as either 1) a mine-influenced tributary station, 2) a main stem receiving environment station (e.g., Fording and Elk rivers), or 3) a reference station. Figure 4.4 shows a schematic representation of the existing monitoring stations located within the Designated Area. More than 825,000 surface water quality data measurements for 73 constituents, collected over the past three years, were evaluated to assess baseline conditions.

The data were evaluated in a stepwise manner. First, maximum concentrations of respective constituents from mine-influenced tributary stations and main stem receiving stations were compared with long-term, sublethal-effect WQGs (the 30-day average value or the chronic criterion). If a long-term WQG was not available, then concentrations were compared with the short-term effect WQG (i.e., the maximum value or the acute criterion). If no individual sample for a constituent within the Designated Area was greater than its WQG, it was concluded that concentrations for that constituent do not exceed the WQG and the constituent was not evaluated further. It should be noted that for this first step and for constituents in which WQGs are hardness-based (e.g., cadmium and sulphate), a conservative average water hardness of 100 mg/L as CaCO3 was used.

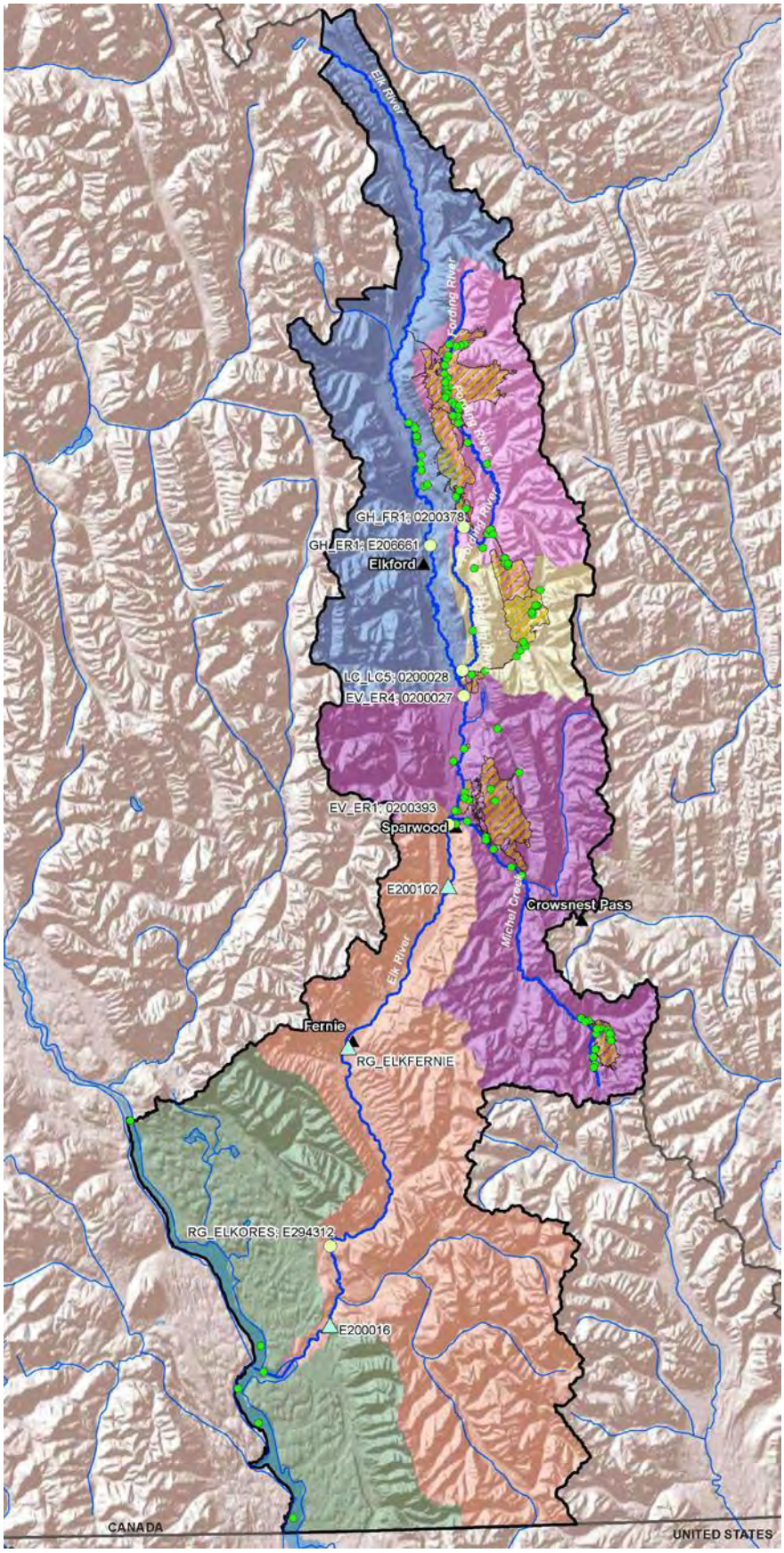


Figure 4-3. Surface Water Quality Monitoring Stations within the Designated Area.

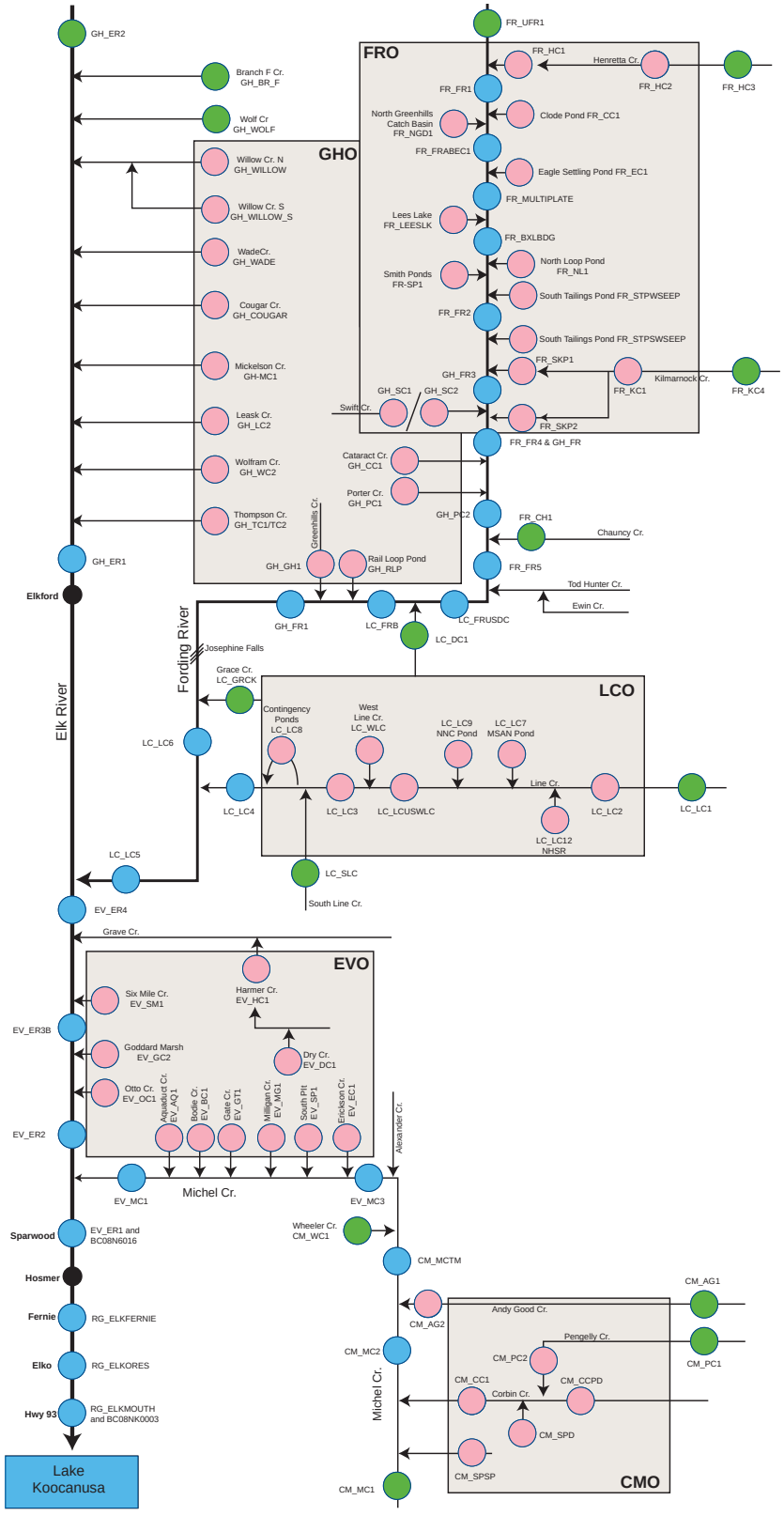


Figure 4-4. Schematic of Surface Water Quality Stations in the Designated Area.
Note: The green stations represent reference stations, the pink is for mine-influenced tributary stations and blue represents a main stem receiving environment station.

If an individual sample anywhere within the Designated Area exceeded a WQG, the constituent was further evaluated against reference (background) concentrations to see if the constituent is naturally elevated within the Designated Area. If more than 10% of sample concentrations at the location in question were greater than the 95th percentile of reference area (background) concentrations, the constituent was deemed to be sufficiently different from background, and likely the result of a point and/or non-point source. For the purpose of this evaluation, background surface water concentrations were determined as follows:

- Fording River, represented by sampling location FR_UFR1
- Elk River upstream of the confluence of the Fording, represented by GH_ER2
- Elk River downstream of the confluence of the Fording River, represented by the average of GH_ER2 and FR_UFR1
- Elk River downstream of the confluence of Michel Creek represented by the average of GH_ER2, FR_UFR1 and CM_MC1
- Tributary samples represented by the average of samples from reference tributaries in the same sub-watershed within the Designated Area
- The Kootenay River was used for Lake Koocanusa.
- Of the 73 constituents evaluated, 21 constituents were identified as having at least one sample greater than its WQG within the Designated Area, and were retained for further evaluation. These included:
- Elk and Fording Rivers: aluminum, ammonia, cadmium, copper, iron, nitrite, nitrate, selenium, sulphate, vanadium and zinc
- Lake Koocanusa: selenium
- Tributaries[1] (including Michel Creek): aluminum, ammonia, arsenic, barium, cadmium, cobalt, copper, iron, lead, lithium[2], manganese, nickel, nitrite, nitrate, selenium, silver, sulphate, thallium, uranium, vanadium and zinc.

All other water quality constituents are below WQGs throughout the Designated Area.

A number of WQGs depend upon parameters such as hardness (e.g., cadmium, sulphate), pH and temperature (ammonia), and chloride (nitrite). Therefore, the third and final step was to evaluate constituent concentrations based on location-specific parameters relative to the WQGs. Results for the Elk and Fording Rivers, Lake Koocanusa, and tributary stations are presented below.

[1] A significant portion of surface water samples presented herein as "tributaries" were collected at permitted discharge points, such as decants from settling ponds. As a result, these concentrations are considered to be conservative estimates for the purposes of evaluating current baseline conditions in tributaries.

[2] The lithium WQG is a working guideline intended to provide the best guidance that the Ministry can provide at this time. Because these estimates can be based on historic information or different derivation protocols, and are obtained from a number of different agencies, the Ministry acknowledges that such guidelines should be used with caution. Further review of the scientific literature identified that the working guideline is based on a secondary chronic value from Suter and Tsao (1996), and was derived from a limited number of studies using conservative assumptions. Since Suter and Tsao (1996), recent work has confirmed that chronic toxicity due to lithium in freshwaters occurs at concentrations greater than the working guideline and that the maximum lithium concentration in any sample from the Designated Area is below the chronic toxicity threshold reference value. A detailed discussion on this matter is presented within Annex K.1. It was therefore concluded that lithium surface water concentrations within the Designated Area will not adversely affect aquatic organisms and as such, lithium was not identified as exceeding the working guideline.

4.3.1.1 Elk and Fording Rivers

After adjusting guidelines to account for location-specific water quality parameters such as hardness, constituents identified as exceeding WQGs within the Fording and Elk rivers included aluminum, cadmium, copper, iron, nitrite, nitrate, selenium and vanadium. Exceedances of WQGs for metals in the Fording and Elk rivers are summarized in Tables 4-1 and 4-2, respectively. Selenium is the one metal/metalloid that routinely exceeds the WQG within the Fording River (Table 4-1). Cadmium (0.4%), copper (0.2%) and iron (2%) rarely exceed WQGs and are typically during spring freshet (high-flow events) and do not appear to be associated with a point source. Examples of the seasonal pattern are illustrated at location LC_FRDSDC; Fording River downstream of Dry Creek for total cadmium (Figure 4-5) and total iron (Figure 4-6). Similar data plots are available for all sampling locations within Annex K.1.

Table 4-1. Exceedances for total metals above chronic WQGs for the protection of aquatic life in the Fording River.

Location	Description	Cadmium	Copper	Iron	Selenium
FR_FR1	Fording River, downstream of Henretta Creek	0/48	0/49	0/49	53/53 (22)
FR_FR2	Fording River, upstream of Kilmarnock Creek	0/76	0/77	1/77 (2.9)	84/84 (26)
FR_FR5	Fording River Downstream of Chauncey Creek	0/44	0/44	0/44	44/44 (39)
FR_FRABEC1	Fording River, above EC1 outlet	0/41	0/41	0/41	48/48 (24)
GH_FR	Fording River, downstream of Swift Creek, upstream of Cataract Creek	0/89	0/89	2/88 (2.4)	109/109 (53)
GH_FR1	Fording River, downstream of Greenhills Creek	0/32	0/32	0/32	45/45 (35)
GH_FR3	Fording River, bridge above Swift Creek	0/30	0/30	0/30	43/43 (23)
GH_PC2	Fording River, 100 m below Porter Creek	1/28 (1.6)	0/28	0/28	51/52 (52)
LC_FRB	Fording River, U/S Sediment Pond Decant	0/18	0/18	1/18 (2.2)	18/18 (30)
LC_FRDSDC	Fording River, downstream of Dry Creek	1/30 (1.8)	0/30	2/30 (3.0)	30/30 (29)
LC_FRUSDC	Fording River, upstream of Dry Creek	0/37	0/37	2/37 (1.7)	37/37 (31)
LC_LC6	Fording River, upstream of Line Creek	0/29	0/29	1/29 (1.8)	29/29 (27)
LC_LC5	Fording River, downstream of Line Creek	0/39	1/39 (1.2)	2/39 (1.3)	39/39 (29)
	Sub-Total =	2/541	1/543	11/542	630/631
	Percent Observed to Exceed WQG =	0.4%	0.2%	2%	100%

Note: Results are reported as the number of observations greater than the WQG (numerator) by the number of observations at the sampling station (denominator). For those constituents where an exceedance of the guideline was observed, a hazard quotient using the maximum concentration was calculated and is presented in brackets.



Figure 4-5. Total Cadmium concentration as a function of time in the Fording River downstream of Dry Creek (LC_FRDSDC).

Note: The horizontal dashed red line is the chronic CCME WQG as determined at a water hardness of 100 mg/L CaCO3. The y-axis is on a logarithmic scale within units in micrograms per liter (µg/L). Less-than symbols are plotted at the analytical detection limit.

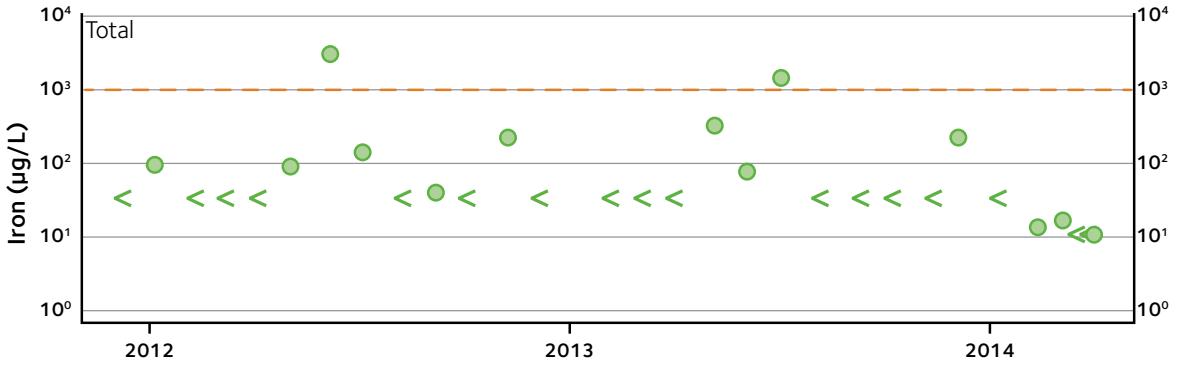


Figure 4-6. Total Iron concentration as a function of time in the Fording River downstream of Dry Creek (LC_FRDSDC).

Note: The dashed orange line is the chronic B.C. MOE WQG. The y-axis is on a log scale within units in µg/L. Less-than symbols are plotted at the analytical detection limit.

A summary of exceedances above WQGs for metals in the Elk River is presented in Table 4-2. As indicated by the frequency of samples exceeding the WQG, selenium (88%) routinely exceeds the WQG. As with the Fording River, high-flow events increase the potential for exceedances of other constituents such as cadmium, iron, and vanadium (see Figure 4-7 for an example). Temporal data plots for all sampling locations, including reference stations, are available Annex K.1.

Table 4-2. Exceedances for total metals above chronic WQGs for protection of aquatic life in the Elk River.

Location	Description	Aluminum[1]	Cadmium	Iron	Selenium	Vanadium
GH_ER1	Elk River Upstream of Boiven Creek	0/40	0/40	1/40 (1.1)	4/53 (1.1)	0/40
EV_ER1	Elk River Downstream of Michel Creek at C.P.R. Roadhouse	0/68	1/68 (2.2)	7/68 (5.8)	68/68 (7.2)	2/68 (2.9)
EV_ER2	Elk River upstream of Michel Creek	0/60	0/60	5/60 (2.5)	60/60 (8.4)	1/60 (1.1)
EV_ER3B	Elk River upstream of Lindsay Creek	0/68	1/68 (1.0)	4/68 (3.5)	68/68 (9.5)	3/68 (1.6)
EV_ER4	Elk River upstream of Grave Creek	0/67	0/67	6/67 (2.9)	67/67 (11)	1/67 (1.4)
RG_ELKFERNIE	Elk River at Fernie	0/9	0/9	0/9	9/9 (5.4)	0/9
RG_ELKORES	Elk River at Elko Reservoir	0/19	0/19	0/19	19/19 (6.4)	0/19
BC08NK0003	Elk River at Highway 93 Bridge	1/44 (2.2)	1/44 (1.0)	5/44 (2.6)	44/44 (3.2)	0/44
RG_ELKMOUTH	Elk River at the mouth	0/19	0/19	0/19	18/18 (4.0)	0/19
	Sub-Total =	1/394	3/394	28/394	357/406	7/394
	Percent Observed to Exceed WQG =	0.3%	0.8%	7%	88%	1.7%

Note: Results are reported as the number of observations greater than the WQG (numerator) by the number of observations at the sampling station (denominator). For those constituents where an exceedance of the guideline was observed, a hazard quotient using the maximum concentration was calculated and is presented in brackets.
Note [1]: The WQG for aluminum is based on the dissolved fraction (the fraction that passes through a 0.45 µm filter).



Figure 4-7. Total Iron concentration as a function of time in the Elk River upstream of Michel Creek (EV_ER2). Note: The dashed orange line is the chronic B.C. MOE WQG. The y-axis is on a log scale within units in µg/L. Less-than symbols are plotted at the analytical detection limit.

Nitrate also routinely exceeds WQGs within the Fording River, with a limited number of elevated nitrite levels observed downstream of Swift Creek. As illustrated within Table 4-3, nitrite concentrations within the Fording River are generally less than the WQG; with one sampling location (FR_FRABEC1; Fording River, above EC1 outlet) accounting for the majority of observed exceedances. As illustrated in Figure 4-8, there are limited data associated with this sampling location but there is an indication of a seasonal pattern. Data plots for all sampling locations are provided within Annex K.1.

Table 4-3. Exceedances for total nutrients above chronic WQGs for protection of aquatic life in the Fording River.

Location	Description	Nitrate as N	Nitrite as N
FR_FR1	Fording River, downstream of Henretta Creek	20/49 (3.7)	0/49
FR_FR2	Fording River, upstream of Kilmarnock Creek	64/77 (4.4)	0/77
FR_FR5	Fording River Downstream of Chauncey Creek	44/44 (7.8)	0/44
FR_FRABEC1	Fording River, above EC1 outlet	15/15 (3.1)	9/15 (2.0)
GH_FR	Fording River, downstream of Swift Creek, upstream of Cataract Creek	102/103 (6.2)	2/103 (1.1)
GH_FR1	Fording River, downstream of Greenhills Creek	47/47 (4.8)	0/47
GH_FR3	Fording River, bridge above Swift Creek	40/45 (4.5)	0/45
GH_PC2	Fording River, 100 m below Porter Creek	30/30 (9.9)	0/30
LC_FRB	Fording River, U/S Sediment Pond Decant	18/18 (5.5)	0/18
LC_FRDSDC	Fording River, downstream of Dry Creek	30/30 (6.0)	0/30
LC_FRUSDC	Fording River, downstream of Dry Creek	37/37 (5.6)	0/37
LC_LC6	Fording River, upstream of Line Creek	64/64 (5.0)	0/64
LC_LC5	Fording River, downstream of Line Creek	81/81 (4.8)	0/81
	Sub-Total =	592/640	11/640
	Percent Observed to Exceed WQG =	93%	2%

Note: Results are reported as the number of observations greater than the WQG (numerator) by the number of observations at the sampling station (denominator). For those constituents where an exceedance of the guideline was observed, a hazard quotient using the maximum concentration was calculated and is presented in brackets.

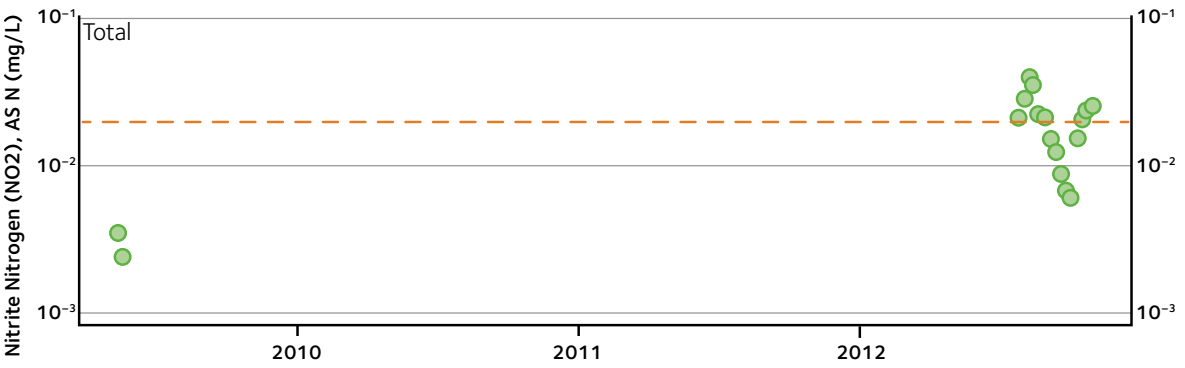


Figure 4-8. Nitrite concentration as a function of time in the Fording River above EC1 outlet (FR_FRABEC1). Note: The dashed orange line is the chronic B.C. MOE WQG. The y-axis is on a logarithmic scale within units in milligrams per liter as N (mg/L N).

The only nutrient to exceed WQGs in the Elk River with some frequency (15%) was nitrate (Table 4-4). Although nitrate concentrations are generally below WQGs within the Elk River, there is a trend of increasing concentrations, as illustrated at EV_ER4; Elk River upstream of Grave Creek (Figure 4-9).

Table 4-4. Summary of exceedances for total nutrients above chronic WQGs for the protection of aquatic life in the Elk River.

Location	Description	Nitrate as N	Nitrite as N
GH_ER1	Elk River Upstream of Boiven Creek	0/40	0/40
EV_ER1	Elk River Downstream of Michel Creek at C.P.R. Roadhouse	1/68 (1.1)	0/68
EV_ER2	Elk River upstream of Michel Creek	8/60 (1.3)	0/60
EV_ER3B	Elk River upstream of Lindsay Creek	19/68 (1.5)	0/68
EV_ER4	Elk River upstream of Grave Creek	32/67 (1.6)	0/67
RG_ELKFERNIE	Elk River at Fernie	0/9	0/9
RG_ELKORES	Elk River at Elko Reservoir	0/19	0/19
BC08NK0003	Elk River at Highway 93 Bridge	0/44	0/44
RG_ELKMOUTH	Elk River at the mouth	0/19	0/19
	Sub-Total =	60/394	0/394
	Percent Observed to Exceed WQG =	15%	0%

Note: Results are reported as the number of observations greater than the WQG (numerator) by the number of observations at the sampling station (denominator). For those constituents where an exceedance of the guideline was observed, a hazard quotient using the maximum concentration was calculated and is presented in brackets.

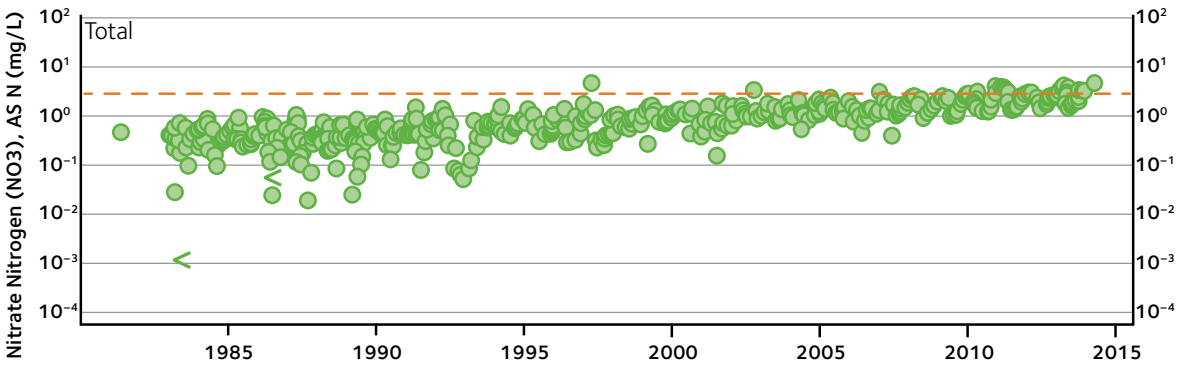


Figure 4-9. Nitrate concentration as a function of time in Elk River downstream of Grave Creek (EV_ER4). Note: The dashed orange line is the chronic B.C. MOE WQG. The y-axis is on a logarithmic scale within units illustrated in mg/L N. Less-than symbols are plotted at the analytical detection limit.

Based on surface water data collected from the Fording and Elk rivers, selenium and nitrate are the two constituents most frequently exceed WQGs, with the greatest proportion of exceedances occurring in the Fording River. To better understand if these concentrations are impacting sensitive aquatic receptors and in preparation of the Plan, a series of chronic toxicity tests were completed using surface water samples collected from the Elk River and Fording Rivers. Complete details and associated study designs associated with these

tests are presented in Chapter 8, and summarized in Annex K.1. They included: survival and growth of fathead minnows (*Pimephales promelas*), swim-up and fry development of rainbow trout (*Oncorhychus mykiss*), survival and reproduction of water fleas (*Ceriodaphnia dubia*), and survival and growth of a freshwater amphipod (*Hyalella azteca*). None of the tests resulted in effects on biota compared to organisms exposed to water collected upstream of mine influences.

4.3.1.2 Lake Koocanusa

Of the 7,151 surface water quality data measurements to date on over 40 constituents within the reservoir, selenium was the one constituent identified as exceeding a WQG or criteria. Specifically, three measurements exceed the B.C. MOE WQG (2 µg/L) and 23 exceed the 2014 draft U.S. Environmental Protection Agency (EPA) lentic criteria of 1.3 µg/L. A summary of selenium exceedances in the reservoir are presented in Table 4-5, with a summary for other water quality constituents presented in Annex K.2.

Table 4-5. Summary of exceedances for total selenium in Lake Koocanusa.

Location	Description	B.C. MOE WQG	EPA criterion
RG_WARDB	Lake Koocanusa downstream of Kootenay River; B.C.	0/10	0/10
RG_EASTARM	Lake Koocanusa near the mouth of Elk River; B.C.	2/14 (2.3)	9/14 (3.6)
RG_USELK	Lake Koocanusa Upstream of the Elk River; B.C.	1/14 (1.4)	1/14 (2.2)
RG_DSELK	Lake Koocanusa 1st station downstream of Elk River; B.C.	0/15	1/15 (1.1)
RG_GRASMERE	Lake Koocanusa 2nd station downstream of Elk River; B.C.	0/13	4/13 (1.5)
RG_BORDER	Lake Koocanusa 3rd station downstream of Elk River; B.C.	0/13	4/13 (1.0)
K01KOOCL01	Lake Koocanusa at International Boundary; MT	0/16	3/16 (1.2)
K01KOOCL02	Lake Koocanusa near Dodge Creek mouth; MT	0/2	0/2
K01KOOCL03	Lake Koocanusa - Tenmile shoreline; MT	0/14	1/14 (1.1)
K01KOOCL04	Lake Koocanusa in Forebay (Libby Dam); MT	0/14	0/14
	Sub-Total =	3/125	23/125
	Percent Observed to Exceed =	2%	18%

Note: Results are reported as the number of observations greater than the WQG (numerator) by the number of observations at the sampling station (denominator). A hazard quotient using the maximum concentration was calculated and is presented in brackets.

4.3.1.1 Tributaries

In tributaries, concentrations higher than WQGs were found in some samples for aluminum, ammonia, arsenic, barium, cadmium, cobalt, copper, iron, lead, manganese, nickel, nitrite, nitrate, selenium, silver, sulphate, thallium, uranium, vanadium and zinc. Given the large number of tributaries, the following discussion presents a summary of results on a Management Unit basis.

Management Unit 1: Upon considering location-specific water quality parameters such as hardness, constituents identified as sometimes exceeding WQGs within tributaries of MU-1 include barium, cadmium, cobalt, copper, iron, nitrite, nitrate, selenium, sulphate, uranium, vanadium and zinc. A summary of exceedances relative to WQGs for metals is presented in Table 4-6. As indicated by the above results, selenium is the one

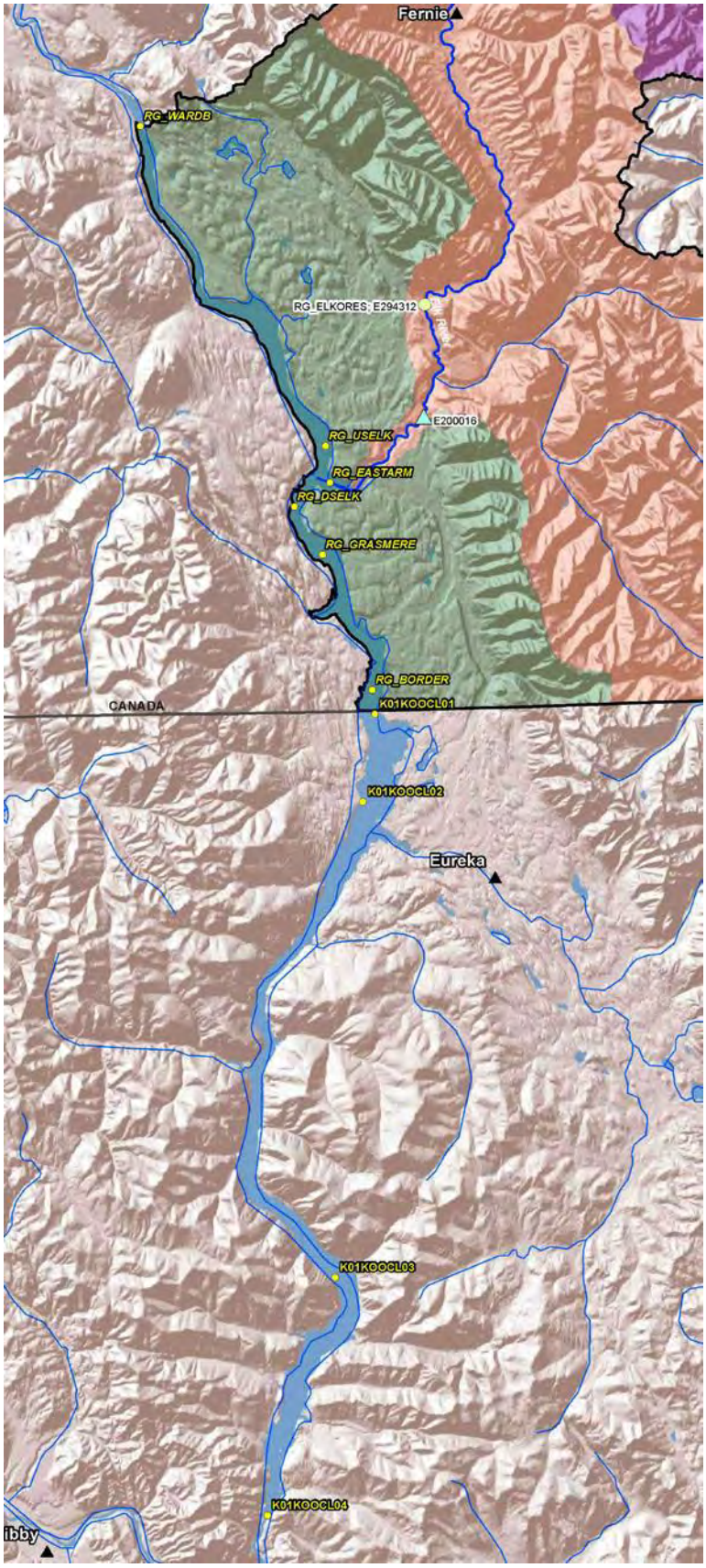


Figure 4-10. Lake Koocanusa surface water sampling locations.

metal that routinely exceeds the WQG within tributaries of MU-1 (96% of the time); while other constituents rarely exceed WQGs.

Exceedances of other constituents are associated with seasonal variability, with the exception of uranium. Three locations demonstrate minimal seasonal variability in total uranium concentrations: 1) decant from Eagle settling pond (FR_EC1), 2) Cataract Creek sediment pond decant (GH_CC1), and 3) Swift Creek pond bypass (GH_SC2). As illustrated in Figure 4-11, total uranium concentrations at these three locations are fairly consistent over time, with lower concentrations observed in spring. Data plots for all constituents and at all sampling locations are available in Annex K.1.

Table 4-6. Exceedances for total metals above chronic WQGs for protection of aquatic life in tributaries of MU-1.

Location	Description	Barium	Cadmium	Cobalt	Copper	Iron	Selenium	Uranium	Vanadium	Zinc
FR_CC1	Decant from Clode sediment pond	2/74 (2.9)	4/74 (2.6)	6/74 (1.5)	0/73	0/73	74/74 (89)	0/74	0/74	0/74
FR_EC1	Decant from eagle settling pond	0/82	0/81	2/82 (1.1)	0/82	0/82	88/88 (205)	63/82 (2.2)	0/82	0/82
FR_HC1	Henretta Creek, upstream of Fording River	0/67	0/66	0/67	0/67	0/67	67/67 (22)	0/67	0/67	0/67
FR_HC2	Henretta Cr. U/S of McMillan Cr.	0/65	0/65	0/65	0/65	0/65	65/65 (25)	0/65	0/65	0/65
FR_LEESLK	Lees Lake, south of a spoil	0/10	0/10	0/10	0/10	0/10	10/10 (34)	0/10	0/10	0/10
FR_MULTIPLATE	Fording River, multi plate culvert Greenhills access road	0/44	0/44	0/44	0/44	0/44	51/51 (29)	0/44	0/44	0/44
FR_NGD1	North Greenhills diversion ditch	0/67	0/66	0/67	1/67 (35)	0/67	67/67 (26)	0/67	0/67	0/67
FR_NL1	Decant from north loop sedimentation pond	0/4	0/4	0/4	0/4	0/4	4/4 (20)	0/4	0/4	1/4 (1.3)
FR_SKP1	Decant from S Kilmarnock Sediment Pond-Phs 1	0/20	2/20 (1.3)	0/20	0/20	0/20	20/20 (132)	0/20	0/20	0/20
FR_SKP2	Decant from S Kilmarnock Sediment Pond-Phs 2	0/16	2/16 (1.4)	0/16	0/16	0/16	16/16 (50)	0/16	0/16	0/16
FR_STPWSEEP	South tailings pond south west seep	0/27	7/22 (1.7)	0/27	0/27	0/27	0/29	0/22	0/22	0/22
FR_SP1	Smith Pond decant	0/66	0/66	0/66	0/66	0/66	64/66 (38)	0/66	0/66	0/66
GH_CC1	Cataract Creek sediment pond decant	0/39	0/39	0/39	0/39	0/39	52/52 (357)	32/39 (1.3)	0/39	0/39
GH_GH1	Greenhills Creek sediment pond decant	0/39	0/39	0/39	0/39	4/39 (2.9)	52/52 (93)	0/39	4/39 (1.9)	0/39
GH_PC1	Porter Creek sediment pond decant	0/38	0/38	0/38	0/38	0/38	51/51 (63)	0/38	0/38	0/38
GH_RLP	Rail Loop Sediment Pond Decant	0/29	0/29	0/29	0/29	0/29	30/30 (7.6)	0/29	10/29 (3.3)	0/29
GH_SC1	Swift Creek sediment pond decant	0/11	0/11	0/11	0/11	0/11	22/22 (303)	1/11 (1.0)	0/11	0/11
GH_SC2	Swift Creek pond bypass	0/27	0/27	0/27	0/27	0/27	29/29 (429)	23/27 (1.3)	0/27	0/27
	Sub-Total =	2/725	15/717	8/725	1/725	4/725	762/793	119/720	14/720	1/720
	Percent Observed to Exceed WQG =	0.3%	2.1%	1.1%	0.1%	0.6%	96%	16.5%	1.9%	0.1%

Note: Results are reported as the number of observations greater than the WQG (numerator) by the number of observations at the sampling station (denominator). For those constituents where an exceedance of the guideline was observed, a hazard quotient using the maximum concentration was calculated and is presented in brackets.

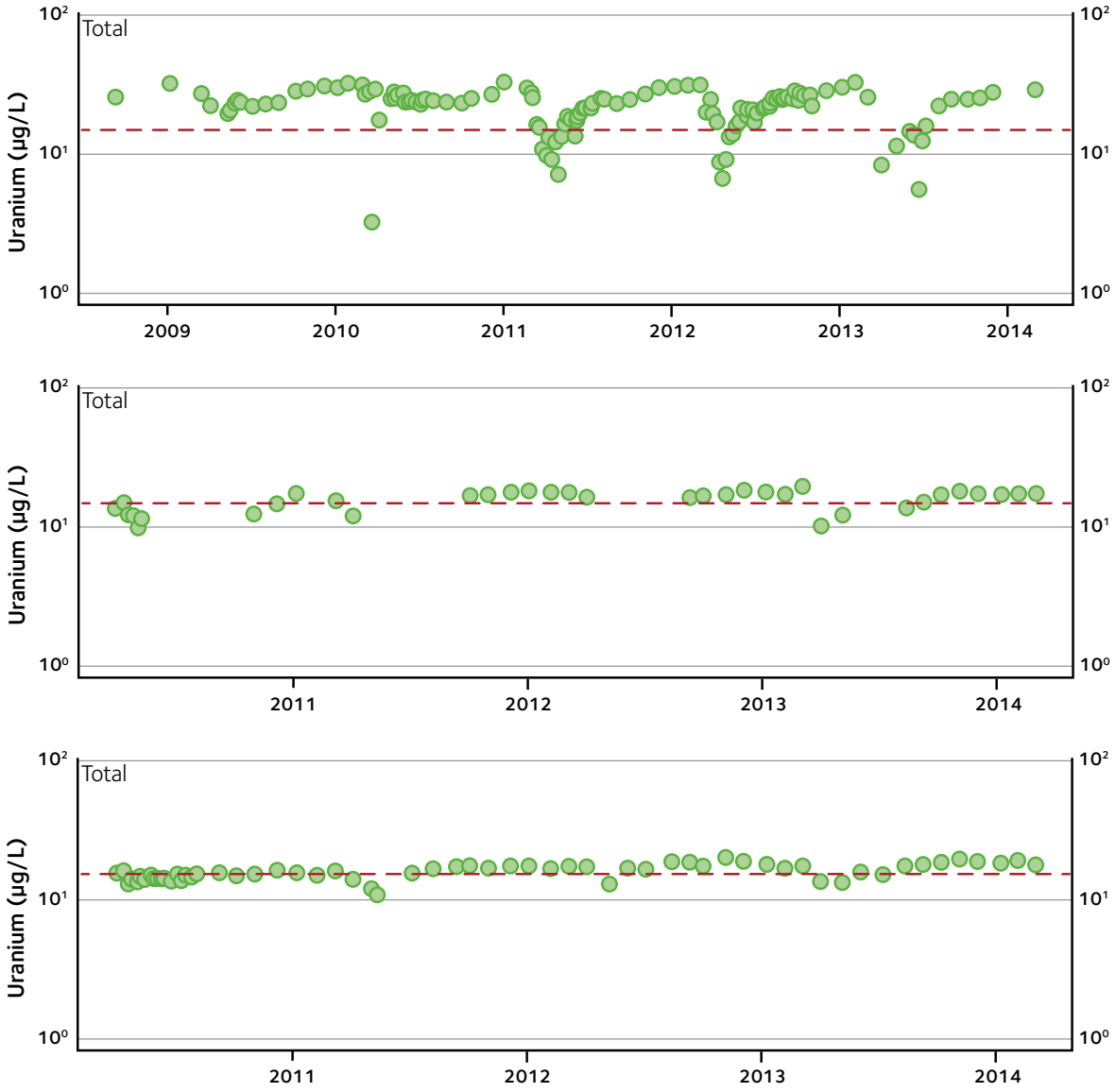


Figure 4-11. Uranium concentration at Eagle settling pond decant (top panel), Cataract Creek sediment pond decant (middle panel), and Swift Creek pond bypass (bottom panel). Note: The dashed red line is the chronic CCME WQG.

Sulphate and nitrogen exceedances are summarized in Table 4-7. As with the main stem of the Fording River, nitrate (60%) exceeds the WQG most frequently in tributaries of MU-1, followed by sulphate (36%). Consistent with other constituents, concentrations tend to vary seasonally with highest concentrations observed during low-flow conditions. However, there are exceptions where concentrations have decreased or plateaued. Examples are nitrate at the decant from Eagle settling pond (FR_EC1; Figure 4-12) and sulphate at the decant from Cataract Creek sediment pond decant (GH_CC1; Figure 4-13). Nitrate concentrations at the decant from Eagle settling pond are consistently above the chronic WQG but appear to be declining since 1995 (Figure 4-12); while sulphate concentrations at the decant from Cataract Creek sediment pond decant appear to demonstrate low variability since 2010 (Figure 4-13).

Table 4-7. Exceedances for total sulphate and nutrients above chronic WQGs for protection of aquatic life in tributaries of MU-1.

Location	Description	Nitrate as N	Nitrite as N	Sulphate
FR_CC1	Decant from Clode sediment pond	73/73 (15)	46/73 (11.5)	1/74 (1.1)
FR_EC1	Decant from eagle settling pond	81/81 (20)	0/81	79/82 (4.5)
FR_HC1	Henretta Creek, upstream of Fording River	47/67 (3.6)	1/67 (1.4)	0/67
FR_HC2	Henretta Cr. U/S of McMillan Cr.	41/65 (3.4)	0/65	0/65
FR_LEESLK	Lees Lake, south of a spoil	5/10 (1.7)	0/10	7/10 (1.8)
FR_MULTIPLATE	Fording River, multi plate culvert Greenhills access road	17/17 (4.4)	9/17 (1.9)	0/17
FR_NGD1	North Greenhills diversion ditch	0/67	1/67 (1.2)	0/67
FR_NL1	Decant from north loop sedimentation pond	4/4 (4.8)	0/4	0/4
FR_SKP1	Decant from S Kilmarnock Sediment Pond-Phs 1	21/21 (41)	6/21 (2.4)	4/21 (1.7)
FR_SKP2	Decant from S Kilmarnock Sediment Pond-Phs 2	16/16 (16)	3/16 (2.3)	0/16
FR_STPSWSEEP	South tailings pond south west seep	12/27 (6.9)	0/27	8/27 (1.2)
FR_STPWSEEP	South tailings pond south west seep	7/22 (4.6)	0/22	6/22 (1.2)
FR_SP1	Smith Pond decant	0/66	1/66 (1.4)	11/67 (1.2)
GH_CC1	Cataract Creek sediment pond decant	53/54 (13.2)	0/54	56/57 (4.2)
GH_GH1	Greenhills Creek sediment pond decant	34/54 (2.2)	0/54	36/57 (1.9)
GH_PC1	Porter Creek sediment pond decant	1/53 (1.9)	0/53	26/56 (1.6)
GH_RLP	Rail Loop Sediment Pond Decant	4/32 (1.3)	31/32 (16)	0/33
GH_SC1	Swift Creek sediment pond decant	22/22 (15.6)	2/22 (1.4)	21/22 (3.4)
GH_SC2	Swift Creek pond bypass	31/31 (23)	0/31	34/34 (4.4)
	Sub-Total =	469/782	119/782	289/798
	Percent Observed to Exceed WQG =	60%	13%	36%

Note: Results are reported as the number of observations greater than the WQG (numerator) by the number of observations at the sampling station (denominator). For those constituents where an exceedance of the guideline was observed, a hazard quotient using the maximum concentration was calculated and is presented in brackets.

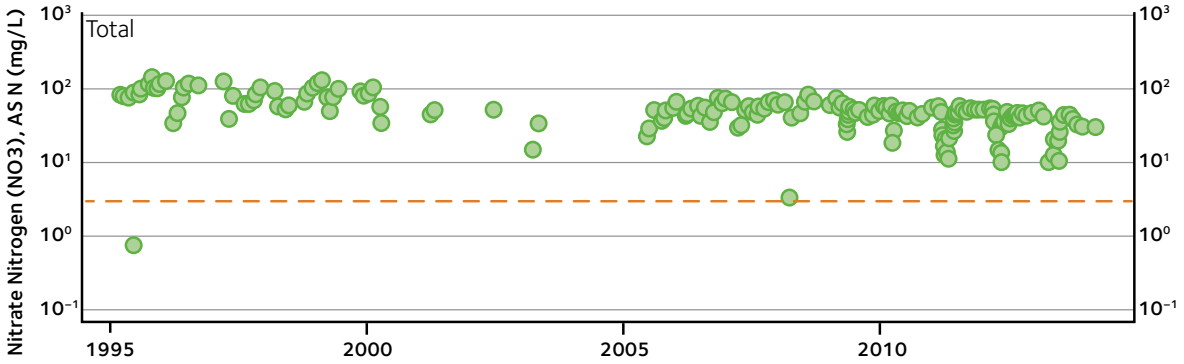


Figure 4-12. Nitrate concentration as a function of time at Eagle settling pond decant (FR_EC1).
Note: The dashed orange line is the chronic B.C. MOE WQG. The y-axis is on a log scale within units of mg/L N.



Figure 4-13. Sulphate concentration as a function of time at Cataract Creek sediment pond decant (GH_CC1). Note: The dashed orange line is the chronic B.C. MOE WQG plotted at 309 mg/L for moderately soft/hard to hard waters (76-180 mg/L as CaCO3). The y-axis is illustrated on a log scale within units of mg/L.

Constituents most frequently exceeding WQGs in tributaries within MU-1include selenium (96% of samples), nitrate (60% of samples), and sulphate (36% of samples). Other constituents exceed WQGs less frequently, and are largely associated with two sampling locations (the decant from Eagle settling pond, FR_EC1; and the decant from Cataract Creek sediment pond decant, GH_CC1). Specifically these two locations represent 80% and 47% of the observed exceedances for uranium and sulphate within the management unit.

Management Unit 2: Upon considering location-specific water quality parameters such as hardness, constituents identified as exceeding WQGs in tributaries of MU-2 include: cadmium, copper, nitrate, selenium, and sulphate. A summary of exceedances relative to WQGs for is presented in Table 4-8.

Table 4-8. Summary of exceedances above chronic WQGs for protection of aquatic life in tributaries of Management Unit 2.

Location	Description	Cadmium	Copper	Nitrate as N	Selenium	Sulphate
LC_LC2	Line Creek upstream of rock drain	0/43	0/43	0/84	36/43 (10)	0/84
LC_LC4	Line Creek, upstream of process plant	1/81 (1.2)	1/81 (1.1)	72/81 (6.1)	81/81 (35)	0/81
LC_WLC	West Line Creek	28/83 (2.5)	0/83	83/83 (14)	83/83 (346)	70/83 (3.0)
	Sub-Total =	29/207	1/207	155/248	200/207	70/248
	Percent Observed to Exceed WQG =	14%	0.5%	63%	97%	28%

Note: Results are reported as the number of observations greater than the WQG (numerator) by the number of observations at the sampling station (denominator). For those constituents where an exceedance of the guideline was observed, a hazard quotient using the maximum concentration was calculated and is presented in brackets.

Consistent with other water quality data, selenium and nitrate are the two constituents that routinely exceed WQGs within MU-2; with West Line Creek having the highest observed concentrations. Based on data collected within West Line Creek, concentrations for selenium and nitrate are greater than WQGs but as illustrated within Figure 4-14.

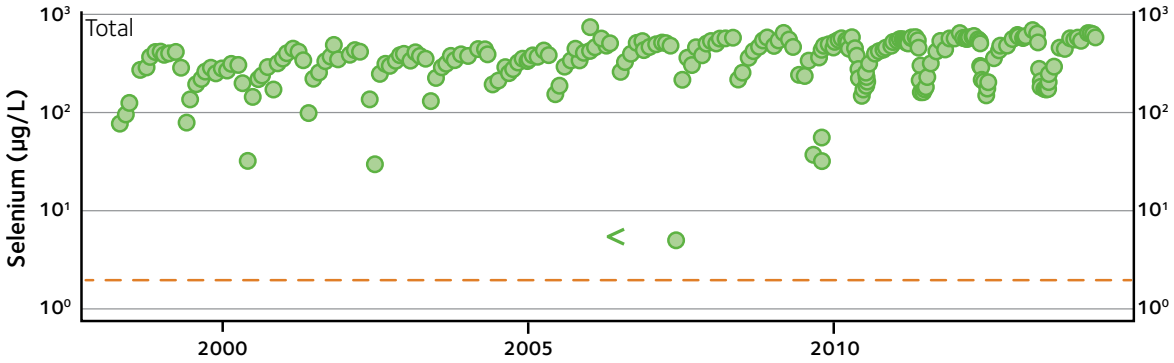


Figure 4-14. Selenium concentration as a function of time at West Line Creek (LC_WLC). Note: The dashed orange line is the chronic B.C. MOE WQG. The y-axis is on a log scale within units of µg/L. Less-than symbols are plotted at the analytical detection limit.

Management Unit 3: Considering location-specific water quality parameters such as hardness, constituents identified as exceeding WQGs within tributaries of MU-3 include aluminum, ammonia, arsenic, cadmium, cobalt, copper, iron, nitrate, nitrite, selenium, silver, sulphate, and vanadium. Exceedances of WQGs for metals are summarized in Table 4-9.

Selenium (52% >WQG) is the constituent with the greatest number of observations in excess of the WQG. Other constituents exceed their respective WQGs infrequently, with exceedances largely associated with one sampling location (Wolfram Creek upstream of the settling pond; GH_WC2). This sampling location accounts for all recorded observations in which arsenic and copper concentrations are greater than WQGs. It also accounts for 90%, 50%, and 56% of the observed exceedances in cobalt, iron, and vanadium.

Table 4-9. Exceedances for total metals above chronic WQGs for protection of aquatic life in tributaries of MU-3.

Location	Description	Aluminum[1]	Arsenic	Cadmium	Cobalt	Copper	Iron	Selenium	Silver	Vanadium
GH_ WILLOW_S	Willow Creek South	4/6 (2.8)	0/6	0/6	0/6	0/6	0/6	1/6 (1.7)	0/6	0/6
GH_WILLOW	Willow Creek North	0/31	0/31	0/31	0/31	0/31	0/31	7/55 (1.1)	0/31	0/31
GH_WADE	Wade Creek	0/21	0/21	0/21	0/21	0/21	3/21 (2.7)	1/32 (1.0)	0/21	1/21 (1.3)
GH_COUGAR	Cougar Creek	0/10	0/10	1/10 (1.1)	0/10	0/10	0/10	0/17	1/10 (1.8)	0/10
GH_MC1	Mickelson Cr. Above Elk River	0/23	0/23	1/23 (1.6)	0/23	0/23	0/23	9/36 (4.3)	0/23	0/23
GH_LC2	Leask Cr. U/S Pond inflow	0/24	0/24	1/24 (1.1)	1/24 (1.1)	0/24	3/24 (3.8)	34/34 (43)	0/24	2/24 (1.7)
GH_WC2	Wolfram Cr. U/S Pond inflow	0/28	1/28 (1.3)	2/28 (1.9)	9/28 (5.6)	1/28 (1.2)	7/28 (16)	40/40 (57)	1/28 (1.7)	5/28 (4.0)
GH_WC1	Wolfram Cr. Sediment Pond Decant	0/1	0/1	0/1	0/1	0/1	1/1 (2.1)	2/2 (16)	0/1	1/1 (1.4)
GH_TC1	Thompson Cr. At Bridge (pond bypass)	0/30	0/30	0/30	0/30	0/30	0/30	43/43 (81)	0/30	0/30
	Sub-Total =	4/174	1/174	5/174	10/174	1/174	14/174	137/265	2/174	9/174
	Percent Observed to Exceed WQG =	2%	0.6%	3%	6%	0.6%	8%	52%	1%	5%

Note: Results are reported as the number of observations greater than the WQG (numerator) by the number of observations at the sampling station (denominator). For those constituents where an exceedance of the guideline was observed, a hazard quotient using the maximum concentration was calculated and is presented in brackets.
Note[1]: The WQG for aluminum is based on the dissolved fraction (the fraction that passes through a 0.45 µm filter).

Exceedances of major cations and nutrients are shown in Table 4-10. Nitrate is the nutrient most frequently in excess of the WQG in tributaries (46% of samples). Other constituents rarely exceed their respective WQGs. As with metals exceeding WQGs within MU-3, Wolfram Creek upstream of the settling pond (GH_WC2) accounts for the majority of observed exceedances of inorganic nitrogen and sulfate guidelines. This one location accounts for 100%, 75%, and 57% of WQG exceedances recorded for ammonia, nitrite, and sulphate, respectively.

Table 4-10. Exceedances for total sulphate and nutrients above chronic WQGs for the protection of aquatic life in tributaries of MU-3.

Location	Description	Ammonia as N	Nitrite as N	Nitrate as N	Sulphate
GH_ WILLOW_S	Willow Creek South	0/7	0/6	0/6	0/7
GH_WILLOW	Willow Creek North	0/56	0/55	0/55	0/56
GH_WADE	Wade Creek	0/33	0/32	0/32	0/33
GH_COUGAR	Cougar Creek	0/18	0/17	0/17	0/18
GH_MC1	Mickelson Cr. Above Elk River	0/37	0/36	0/36	0/37
GH_LC2	Leask Cr. U/S Pond inflow	0/35	3/34 (2.0)	34/34 (20)	0/35
GH_WC2	Wolfram Cr. U/S Pond inflow	6/42 (3.6)	9/40 (8.7)	40/40 (13)	13/42 (1.4)
GH_WC1	Wolfram Cr. Sediment Pond Decant	0/2	0/2	2/2 (4.1)	0/2
GH_TC1	Thompson Cr. Bridge (pond bypass)	0/46	0/43	42/43 (7.2)	23/46 (1.7)
	Sub-Total =	6/276	12/265	118/265	36/276
	Percent Observed to Exceed WQG =	2%	5%	46%	13%

Note: Results are reported as the number of observations greater than the WQG (numerator) by the number of observations at the sampling station (denominator). For those constituents where an exceedance of the guideline was observed, a hazard quotient using the maximum concentration was calculated and is presented in brackets.

Management Unit 4: Considering location specific water quality parameters such as hardness, constituents identified as exceeding WQGs within tributaries of MU-4 include aluminum, ammonia, arsenic, cadmium, cobalt, copper, iron, nickel, nitrate, nitrite, selenium, silver, sulphate, thallium, uranium, and vanadium. Exceedances of WQGs for metals are summarized in Table 4-11.

Table 4-11. Exceedances for total metals above chronic WQGs for protection of aquatic life in tributaries of MU-4.

Location	Description	Aluminum[1]	Arsenic	Cadmium	Cobalt	Copper	Iron	Nickel	Selenium	Silver	Thallium	Uranium	Vanadium
EV_HC1	Harmer Creek Dam Spillway	0/62	0/62	0/62	0/62	0/62	0/62	0/62	62/62 (20)	0/62	0/62	0/62	0/62
EV_SM1	Six Mine Pond Decant	0/49	0/49	1/49 (1.0)	0/49	2/49 (1.1)	8/49 (7.3)	0/49	28/49 (1.7)	1/49 (1.8)	0/49	0/49	5/49 (4.3)
EV_GC2	Goddard Creek Sedimentation Pond Decant	0/80	0/80	1/80 (1.0)	0/80	0/80	3/80 (2.2)	0/80	80/80 (30)	0/80	0/80	0/80	1/80 (1.2)
EV_OC1	Otto Creek Near Mouth	0/63	0/63	1/63 (1.3)	0/63	0/63	3/63 (4.4)	0/63	25/63 (2.4)	0/63	0/63	0/63	0/63
CM_SPSP	7 Pit Pond Decant	0/19	0/19	0/19	0/19	0/19	2/19 (7.1)	0/19	0/19	0/19	0/19	0/19	1/19 (2.1)
CM_WD	West Ditch	10/27 (11)	0/28	8/28 (1.7)	9/28 (17)	0/28	9/28 (2.7)	8/28 (1.3)	28/28 (12)	0/28	0/28	0/28	0/28
CM_SPD	Main Pond Decant	0/49	2/49 (8.8)	2/49 (4.2)	49/49 (13)	2/49 (3.8)	0/49	10/49 (1.2)	49/49 (8.0)	2/49 (10)	2/49 (1.9)	0/49	2/49 (16)
CM_CC1	Corbin Cr. D/S CMO	0/96	0/96	2/96 (2.7)	49/96 (6.7)	0/96	0/96	0/96	95/95 (9.7)	0/96	2/96 (1.1)	0/96	0/96
CM_MC2	Michel Creek D/S CMO near Andy Goode Cr. Junction	0/82	0/82	0/82	2/82 (1.4)	0/82	8/82 (3.1)	0/82	81/81 (4.9)	0/82	0/82	0/82	0/82
CM_MCTM	Michel Creek Below Tent Mountain	0/42	0/42	0/42	0/42	0/42	0/42	0/42	35/42 (2.2)	0/42	0/42	0/42	0/42
EV_MC3	Michel Creek upstream of Erickson Creek	0/67	0/67	0/67	0/67	0/67	0/67	0/67	1/67 (1.3)	0/67	0/67	0/67	0/67
EV_EC1	Erickson Creek at Mouth	0/67	0/67	0/67	0/67	0/67	0/67	0/67	67/67 (65)	0/67	0/67	0/67	0/67
EV_SP1	South Pit Pond Decant	0/53	0/53	7/53 (2.4)	0/53	0/53	0/53	0/53	52/53 (156)	1/53 (1.8)	0/53	3/53 (1.1)	1/53 (1.7)
EV_MG1	Milligan Pond Decant	0/47	0/47	0/47	0/47	0/47	0/47	0/47	47/47 (72)	0/47	0/47	0/47	0/47
EV_GT1	Gate Creek Sedimentation Pond Decant	0/39	0/39	0/39	0/39	0/39	0/39	0/39	39/39 (149)	0/39	0/39	0/39	1/39 (1.7)
EV_BC1	Bodie Creek Sedimentation Pond Decant	0/67	0/67	0/67	0/67	0/67	0/67	0/67	67/67 (252)	0/67	0/67	0/67	0/67
EV_MC1	Michel Creek at Highway 43 Bridge	0/66	0/66	1/66 (2.4)	0/66	0/66	0/66	0/66	66/66 (7.8)	0/66	0/66	0/66	3/66 (2.6)
	Sub-Total =	10/976	2/976	23/976	109/976	4/976	33/976	18/976	822/974	4/976	4/976	3/976	14/976
	% Observed to Exceed WQG =	1%	0.2%	2%	11%	0.4%	3%	2%	84%	0.4%	0.4%	0.3%	1%

Note: Results are reported as the number of observations greater than the WQG (numerator) by the number of observations at the sampling station (denominator). For those constituents where an exceedance of the guideline was observed, a hazard quotient using the maximum concentration was calculated and is presented in brackets.
Note[1]: The WQG for aluminum is based on the dissolved fraction (the fraction that passes through a 0.45 µm filter).

Selenium has the greatest number of observations in excess of WQGs (84% of the samples). With the exception of cobalt, other constituents rarely exceeded WQGs and those infrequent exceedances are associated with seasonal flows (see Annex K.1). Two sampling stations (CM_CC1 and CM_SPD) account for 90% of the observed cobalt exceedances. As illustrated by Figure 4-15, cobalt concentrations at these two localized stations do not appear to be associated with a strong seasonal pattern. The elevated cobalt concentrations are localized within MU-4.

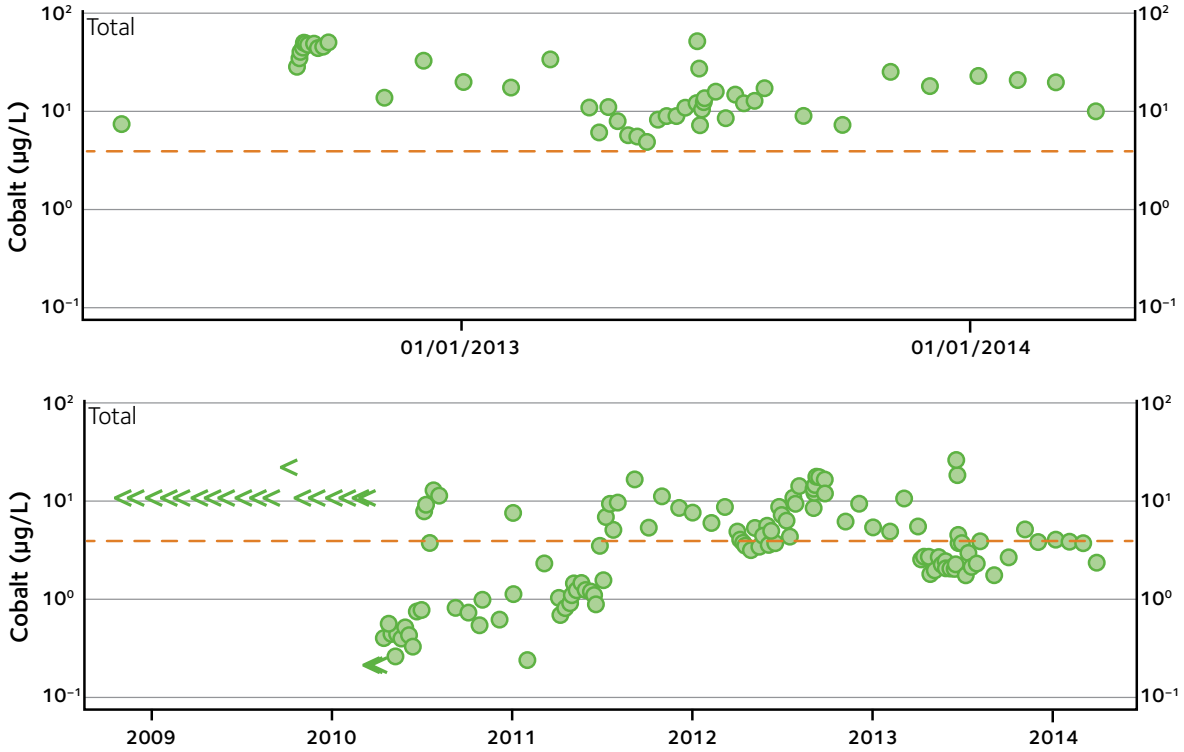


Figure 4-15. Cobalt concentration as a function of time at Main Pond Decant, "CM_SPD" (top panel), and at Corbin Cr. D/S CMO, "CM_CC1" (bottom panel). Note: The dashed orange line is the chronic B.C. MOE WQG. The y-axis is illustrated on a log scale within units of µg/L. Less than symbols are plotted at the analytical detection limit.

Unlike other management units where nitrate concentrations have typically exceeded WQGs less frequently than selenium, MU-4 uniquely exhibits more frequent exceedance of the sulphate WQG.

Corbin Creek (CM_CC1), Erickson Creek (EV_EC1), Bodie Creek (EV_BC1), and the South Pit decant (EV_SP1) account for approximately 79% of the elevated sulphate concentrations observed within MU-4 (Table 4-12, Figure 4-16). Data plots for all sampling stations are available in Annex K.1.

Table 4-12. Exceedances for total sulphate and nutrients above chronic WQGs for protection of aquatic life in tributaries of MU-4.

Location	Description	Ammonia as N	Nitrite as N	Nitrate as N	Sulphate
EV_HC1	Harmer Creek Dam Spillway	0/62	0/62	0/62	0/62
EV_SM1	Six Mine Pond Decant	0/49	0/49	0/49	0/49
EV_GC2	Goddard Creek Sedimentation Pond Decant	0/70	0/70	8/70	0/70
EV_OC1	Otto Creek Near Mouth	0/63	0/63	0/63	0/63
CM_SPSP	7 Pit Pond Decant	0/39	0/35	0/35	0/38
CM_WD	West Ditch	0/31	1/28 (1.4)	3/28 (3.4)	28/29 (2.6)
CM_SPD	Main Pond Decant	0/54	4/50 (2.0)	37/50 (5.2)	43/53 (2.1)
CM_CC1	Corbin Cr. D/S CMO	0/101	8/97 (2.3)	62/97 (2.8)	66/100 (1.6)
CM_MC2	Michel Creek D/S CMO near Andy Goode Cr. Junction	0/88	1/84 (1.1)	3/84 (1.3)	0/87
CM_MCTM	Michel Creek Below Tent Mountain	0/45	0/42	0/42	0/43
EV_MC3	Michel Creek upstream of Erickson Creek	0/67	0/67	0/66	0/67
EV_EC1	Erickson Creek at Mouth	0/67	0/67	67/67 (4.3)	67/67 (1.7)
EV_SP1	South Pit Pond Decant	0/53	1/53 (2.0)	52/53 (4.4)	52/53 (2.3)
EV_MG1	Milligan Pond Decant	1/47 (1.1)	3/47 (2.9)	0/47	16/47 (1.3)
EV_GT1	Gate Creek Sedimentation Pond Decant	0/39	0/39	39/39 (12)	35/39 (2.8)
EV_BC1	Bodie Creek Sedimentation Pond Decant	0/67	4/67 (1.1)	67/67 (31)	65/67 (2.6)
EV_MC1	Michel Creek at Highway 43 Bridge	0/66	0/66	0/66	0/66
	Sub-Total =	1/1008	22/986	338/985	372/933
	Percent Observed to Exceed WQG =	0.1%	2%	34%	40%

Note: Results are reported as the number of observations greater than the WQG (numerator) by the number of observations at the sampling station (denominator). For those constituents where an exceedance of the guideline was observed, a hazard quotient using the maximum concentration was calculated and is presented in brackets.

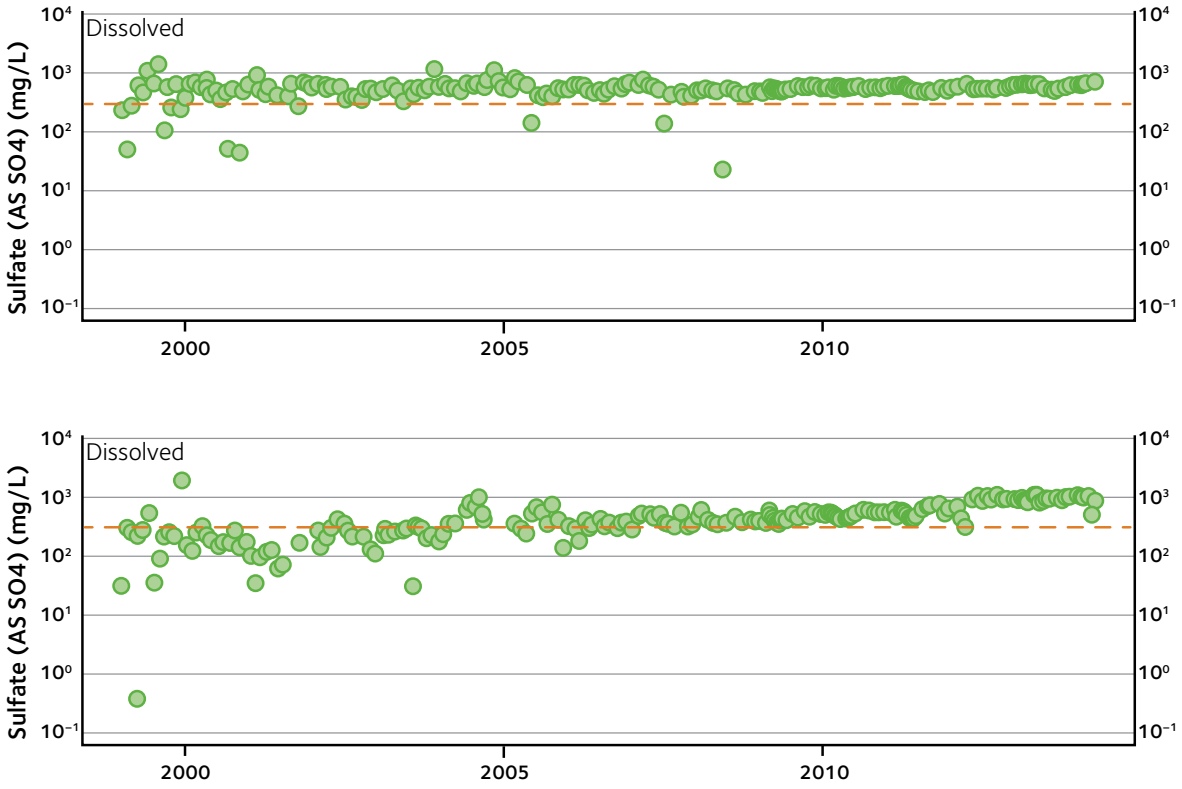


Figure 4-16. Sulphate concentrations as a function of time at Erikson Creek, "EV_EC1" (top panel), and at Bodie Creek Sedimentation Pond Decant, "EV_BC1" (bottom panel). Note: The dashed orange line is the chronic B.C. MOE WQG, plotted at 309 mg/L for moderately soft/hard to hard waters (76-180 mg/L as CaCO3). The y-axis is on a log scale within units of mg/L.

Management Unit 5: No tributaries were identified within MU-5 as exceeding WQGs.

4.3.2 Sediment

Surface sediment data were collected from sampling locations throughout the Designated Area. These locations include: 1) mine-influenced (exposed) locations, 2) mine workings (e.g., settling ponds), and 3) reference locations. More than 350 sediment samples, analyzed for over 50 constituents, have been collected since 2011 and were used to assess current baseline conditions. Given that sediment samples collected within mine works (e.g. settling ponds) do not reflect ambient environmental conditions, they were not evaluated for the purpose of assessing baseline conditions. Sediment data associated with settling ponds are reported in Annex K.1.

Sediment data collected within the receiving environment were evaluated in a stepwise manner. In the first step, concentrations of respective constituents from exposed locations were compared to lower- and upper-sediment quality guidelines (SQGs), specifically:

Lower-SQGs

- Lowest Effects Level (LEL): the concentration at which most benthic organisms are unaffected.
- Threshold Effect Level (TEL) ≈ Interim Sediment Quality Guideline (ISQG): the concentration below which adverse biological effects are not expected to occur.

Sediments collected within Lake Koocanusa were also screened against the Threshold Effects Concentration (TEC; MacDonald et al. 2000). The TEC represents the geometric mean of SQGs identified at concentrations below which harmful effects on sediment-dwelling organisms are not expected. TECs considered in this consensus-based approach include TELs (Smith et al. 1996; US EPA 1996), effect-range low values (ERLs; Long and Morgan 1991), LELs (Persaud et al. 1993), and minimal-effect thresholds and sediment quality advisory levels.

Upper-SQGs

- Probable Effects Level (PEL): the concentration above which adverse effects are expected to occur frequently.
- Severe Effects Level (SEL): the concentration above which most benthic organisms are expected to be impaired.

As with to lower-SQGs, sediment data collected within Lake Koocanusa were also screened against the Probable Effects Concentration (PEC; MacDonald et al. 2000). The PEC represents the geometric mean of SQGs identified at concentrations above which harmful effects on sediment-dwelling organisms are expected to occur frequently. PECs considered in this consensus-based approach include PELs (Smith et al. 1996; US EPA 1996), effect range median values (ERMs; Long and Morgan 1991), SELs (Persaud et al. 1993), and toxic effect thresholds.

In the first step of the evaluation, maximum concentrations for the whole sediment fraction (≤1 mm)[3] were compared with lower-SQGs. If no individual sample exceeded its lower-SQG (e.g., LEL, TEL, ISQG, or TEC), it was concluded that concentrations for that constituent did not exceed a guideline and as such, were not evaluated further.

If one sample exceeded the lower-SQG, the second step in the evaluation was to compare sediment concentrations with the upper-SQGs (e.g., PEL, SEL, or PEC). Samples that exceeded the upper-SQG were identified as having the potential to adversely affect sediment-dwelling organisms. Constituents with concentrations between the lower- and upper-SQGs were considered to have uncertain potential effects to benthic organisms. In both cases, these constituents and those for which there are no SQGs were carried forward to the third step of the analysis.

In the third step, sediment constituent concentrations were evaluated against reference samples. If more than 10% of sample concentrations at the location in question were greater than the 95th percentile of reference area (background) concentrations, it was concluded that the constituent was elevated relative to background levels, and likely the result of activities/discharges within the Designated Area.

4.3.2.1 Management Units 1-5 (Elk River Watershed)

A summary of the results for MU-1 through MU-5 (Elk River Watershed) and Lake Koocanusa are presented herein, with supporting data and associated screening steps presented in Annex K.

Constituents exceeding the lower-SQG and likely associated with point or non-point discharges include metals (arsenic, cadmium, copper, iron, manganese, nickel, selenium and zinc) and polycyclic aromatic hydrocarbons (phenanthrene and pyrene). Although identified as exceeding SQGs, elevated analytical detection limits for the polycyclic aromatic hydrocarbons at some locations introduces uncertainty for these two constituents. Of these 10 constituents, copper and iron were infrequently detected at concentrations above the lower-SQG (i.e., in

[3] Instances where only the <63 µm fraction was available; data were evaluated in the same manner as for whole sediment fractions.

<10% of the samples). Copper exceeded the lower-SQG in only one sample (sampling location MI16), and iron exceeded the lower-SQG in only two samples (locations MI16 and NGC1).

Exceedances relative to SQGs in MUs-1 to MU-5 are summarized in Table 4-13 for constituents with exceedances in >10% of samples (i.e., excluding copper and iron). Four metal constituents listed in Table 4-12 had concentrations exceeding their upper-SQG, at the following locations:

- Cadmium: 5 of 5 samples at Upper Lake Mountain Creek (LAK2); 5 of 5 samples near the mouth of Swift Creek (SWI1), and 1 of 5 samples at Michel Creek Wetland (MI16)
- Nickel: 5 of 5 samples near the mouth of Swift Creek (SWI1)
- Zinc: 3 of 5 samples near the mouth of Swift Creek (SWI1).

These results indicate that potential impacts on sediment-dwelling organisms at those locations. As previously noted, there are uncertainties associated with the polycyclic aromatic hydrocarbon data due to elevated analytic detection limits.

In addition to bulk sediment chemistry, sediment toxicity tests were conducted on samples from the Fording River Oxbow (FO10), Goddard Marsh (GO13), and Elko Reservoir (ELKO). Tests evaluating potential effects on growth and survival were conducted using *Hyalella azteca* (a freshwater amphipod), and *Chironomus riparius* (a freshwater chironomid). When compared with laboratory control and reference-area samples, no adverse effects were observed in samples collected from the Fording River Oxbow or Elko Reservoir. At Goddard Marsh, three of five samples showed slightly impaired survival of freshwater chironomids compared to controls (i.e., ~76% survival compared with 98-100% survival in the controls). No adverse effects were observed in freshwater amphipods for these same samples. Given the incongruent toxicity tests results, it is uncertain if the reduction in survival at Goddard Marsh is due to metals contamination or other non-constituent factors (e.g., grain size).

4.3.2.2 Lake Koocanusa

To date, 90 sediment samples have been collected within the reservoir, extending down to the forebay of Libby Dam. Although SQGs are applicable to the whole sediment fraction (<2 mm or <1 mm), all data (including the <63 µm fraction) were compared with SQGs. Results of the analysis and comparison identified the following constituents as exceeding the lower-SQG: arsenic, cadmium, iron, manganese, and nickel. All other constituents were less than the lower-SQG.

Table 4-13. Sediment exceedances above sediment quality guidelines in MU-1 through MU-5.

MU	Sample location	Arsenic		Cadmium		Manganese		Nickel		Selenium		Zinc		Phenanthrene		Pyrene	
		Lower-SQG	Upper-SQG	Lower-SQG	Upper-SQG	Lower-SQG	Upper-SQG	Lower-SQG	Upper-SQG	Lower-SQG	Upper-SQG	Lower-SQG	Upper-SQG	Lower-SQG	Upper-SQG	Lower-SQG	Upper-SQG
1	CC1	--	--	--	--	--	--	--	--	--	--	--	--	5/5	3/5	3/5	0/5
	FMUCK	0/3	0/3	3/3	0/3	1/3	0/3	3/3	0/3	2/3	na	0/3	0/3	3/3	2/3	2/3	0/3
	FO10	0/5	0/5	5/5	0/5	0/5	0/5	5/5	0/5	5/5	na	0/5	0/5	5/5	5/5	3/5	0/5
	FOR3	--	--	--	--	--	--	--	--	--	--	--	--	5/5	4/5	3/5	0/5
	FOX1	0/5	0/5	5/5	0/5	0/5	0/5	4/5	0/5	5/5	na	0/5	0/5	5/5	3/5	0/5	0/5
	FR d/s DRCK	--	--	--	--	--	--	--	--	--	--	--	--	5/5	0/5	0/5	0/5
	FR u/s DRCK	--	--	--	--	--	--	--	--	--	--	--	--	5/5	3/5	0/5	0/5
	FR4	--	--	--	--	--	--	--	--	--	--	--	--	5/5	1/5	0/5	0/5
	FR4a	--	--	--	--	--	--	--	--	--	--	--	--	5/5	3/5	1/5	0/5
	FR5	--	--	--	--	--	--	--	--	--	--	--	--	5/5	2/5	0/5	0/5
	HE27	0/3	0/3	2/3	0/3	0/3	0/3	2/3	0/3	0/3	na	0/3	0/3	3/3	3/3	1/3	0/3
	HEN1	0/5	0/5	5/5	0/5	0/5	0/5	5/5	0/5	4/5	na	0/5	0/5	5/5	5/5	2/5	0/5
	KC4	--	--	--	--	--	--	--	--	--	--	--	--	5/5	0/5	1/5	0/5
	LAK1	--	--	--	--	--	--	--	--	--	--	--	--	5/5	5/5	0/5	0/5
	LAK2	0/5	0/5	5/5	5/5	0/5	0/5	5/5	0/5	5/5	na	5/5	0/5	5/5	4/5	4/5	0/5
	SWI1	0/5	0/5	5/5	5/5	0/5	0/5	5/5	5/5	5/5	na	5/5	3/5	5/5	5/5	3/5	0/5
2	LC3	--	--	--	--	--	--	--	--	--	--	--	--	2/2	1/2	1/2	0/2
	LC5	--	--	--	--	--	--	--	--	--	--	--	--	5/5	2/5	2/5	0/5
3	ER2	0/5	0/5	0/5	0/5	0/5	0/5	0/5	0/5	0/5	na	0/5	0/5	5/5	0/5	0/5	0/5
	EROU	5/5	0/5	5/5	0/5	5/5	0/5	5/5	0/5	0/5	na	1/5	0/5	5/5	0/5	0/5	0/5
4	ELWDGC	1/3	0/3	3/3	0/3	3/3	0/3	3/3	0/3	0/3	na	0/3	0/3	3/3	0/3	0/3	0/3
	ER4	--	--	--	--	--	--	--	--	--	--	--	--	4/5	0/5	0/5	0/5
	GO13	3/5	0/5	5/5	0/5	5/5	0/5	5/5	0/5	4/5	na	2/5	0/5	5/5	5/5	5/5	0/5
	MI16	3/5	0/5	5/5	1/5	1/5	0/5	5/5	0/5	4/5	na	3/5	0/5	5/5	3/5	4/5	0/5
	MIWW	1/3	0/3	3/3	0/3	0/3	0/3	3/3	0/3	0/3	na	0/3	0/3	3/3	2/3	3/3	0/3
5	ELK1	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10	na	0/10	0/10	9/10	0/10	0/10	0/10
	ELK2	0/5	0/5	4/5	0/5	0/5	0/5	2/5	0/5	1/5	na	0/5	0/5	5/5	0/5	0/5	0/5
	ELKO	0/5	0/5	5/5	0/5	0/5	0/5	4/5	0/5	0/5	na	0/5	0/5	5/5	0/5	4/5	0/5
	ER1	0/5	0/5	4/5	0/5	0/5	0/5	2/5	0/5	0/5	na	0/5	0/5	5/5	0/5	0/5	0/5
	EROL	1/5	0/5	5/5	0/5	1/5	0/5	4/5	0/5	1/5	na	0/5	0/5	5/5	1/5	4/5	0/5
	ERWSF	1/3	0/3	3/3	0/3	1/3	0/3	3/3	0/3	0/3	na	0/3	0/3	3/3	0/3	3/3	0/3
	SPW	0/3	0/3	3/3	0/3	3/3	0/3	3/3	0/3	3/3	na	0/3	0/3	3/3	0/3	0/3	0/3
	Sub-Total =	15/93	0/93	75/93	11/93	20/93	0/93	68/93	5/93	39/93	na	16/93	3/93	148/150	62/150	49/150	0/150
	Percent Observed to Exceed SQG =	16%	0%	81%	12%	22%	0%	73%	5%	42%	na	17%	3%	99%	41%	33%	0%

Note: Results are reported as the number of observations greater than the SQG (numerator) by the number of observations at the sampling station (denominator).
Note: Lower-SQGs include: Lowest Effects Level (LEL), Threshold Effects Level (TEL), and/or Interim Sediment Quality Guideline (ISQG). Upper SQGs include: Probable Effects Level (PEL) and/or Severe Effects Level (SEL).
Note: "--" = not analyzed, na = no guideline.
Note: Arsenic SQGs (Lower = 5.9 µg/g; Upper = 17 µg/g); Cadmium SQGs (Lower = 0.6 µg/g; Upper = 3.5 µg/g); Manganese SQGs (Lower = 460 µg/g; Upper = 1100 µg/g); Nickel SQGs (Lower = 16 µg/g; Upper = 75 µg/g); Selenium SQGs (Lower = 2 µg/g); Zinc SQGs (Lower = 123 µg/g; Upper = 315 µg/g); Phenanthrene SQGs (Lower = 0.0419 µg/g; Upper = 0.515 µg/g); and Pyrene SQGs (Lower = 0.053 µg/g; Upper = 0.875 µg/g).
Note: Exceedances of Phenanthrene and Pyrene are based on qualified data (i.e., non-detects). Given that analytical detection limits for these constituents were above the SQGs, results are uncertain.

Samples exceeding the lower-SQG were compared to the upper-SQG, to evaluate the potential for impacts on sediment-dwelling organisms. No constituents were identified as exceeding their respective upper-SQGs. Exceedances relative to SQGs are summarized in Table 414, and a graphical summary of the data is presented in Annex K.2.

4.3.3 Periphyton Productivity

Measurement of periphyton chlorophyll-a was initiated in 2012 and 2013 in several areas of the Elk River watershed, to examine differences between mine-exposed and reference areas (Annex K.1). Higher chlorophyll-a concentrations were observed in some near-field mine-exposed areas, compared to reference areas. With the exception of two samples that included bryophytes (not typically considered part of the periphyton community), and one sample from the Fording River where calcite deposition was evident, all chlorophyll-a concentrations were well below the WQG of 100 mg/m^2.

4.3.4 Benthic Invertebrate Community Health

A detailed assessment of benthic invertebrate community health in mine-exposed areas relative to reference areas was conducted in 2012 (Minnow 2014). Community samples were collected in September 2012 from 36 reference and 56 mine-exposed lotic areas, for assessment of potential mine-related effects on community composition. Reference areas were selected to represent a range of natural habitat characteristics exhibited by mine-exposed areas, such as elevation, stream size, catchment area, and catchment gradient, to ensure that each mine-exposed area could be matched with, and statistically compared to, a sub-set of reference areas with similar natural habitat characteristics. The reference areas were situated in the Elk River watershed upstream of mining inputs, and also in the upper Kootenay River watershed (B.C.) and in the Oldman River watershed (Alberta), where man-made disturbances were negligible[4].

Using methods established in the scientific literature, community characteristics for each mine-exposed area was statistically compared to the characteristics reflected by the sub-group of reference areas with most similar habitat characteristics. Adverse effects were concluded for 20 mine-exposed areas, most of which were in mine-influenced tributaries near mine sources (Table 4.15). Adverse effects were generally reflected as reductions in the combined proportion of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) (i.e., EPT), or the proportion of Ephemeroptera alone; these groups (particularly mayflies and stoneflies) dominated the invertebrate communities in reference areas, as well as mine-exposed areas that were considered to be in reference condition. Eighty-six per cent of the main stem receiving environments sampled had communities consistent with reference areas, including all areas sampled along the Elk River.

[4] Detailed analyses of reference area data, completed in consultation with technical experts from BCMOE, identified that benthic invertebrate community characteristics were most strongly influenced by natural habitat characteristics and were not measurably influenced by the small amount of historical forestry activity in some reference watersheds (Minnow 2014).

Table 4-14. Summary of sediment exceedances above Sediment Quality Guidelines for the protection of aquatic life in Lake Koocanusa.[1]

Location	Description	Arsenic		Cadmium		Iron		Manganese		Nickel	
		Lower-SQG	Upper-SQG	Lower-SQG	Upper-SQG	Lower-SQG	Upper-SQG	Lower-SQG	Upper-SQG	Lower-SQG	Upper-SQG
Transect 1	South of Kootenay mouth	0/7	0/7	0/7	0/7	2/7	0/7	2/7	0/7	0/7	0/7
Transect 2	North of Elk River mouth	0/12	0/12	0/12	0/12	12/12	0/12	10/12	0/12	5/12	0/12
Transect 3	South of Elk River mouth	0/7	0/7	0/7	0/7	2/7	0/7	2/7	0/7	0/7	0/7
Transect 4		0/12	0/12	2/12	0/12	9/12	0/12	10/12	0/12	5/12	0/12
Transect 5		0/6	0/6	0/6	0/6	3/6	0/6	4/6	0/6	0/6	0/6
Transect 6		0/5	0/5	0/5	0/5	0/5	0/5	2/5	0/5	0/6	0/5
Transect 7		0/5	0/5	0/5	0/5	3/5	0/5	5/5	0/5	0/6	0/5
K01KOOCL01	International Boundary	2/9	0/9	0/9	0/9	0/8	0/8	--	--	--	--
K01KOOCL02	Near Dodge Creek mouth	0/1	0/1	0/1	0/1	--	--	--	--	--	--
K01KOOCL03	Tenmile	3/8	0/8	0/8	0/8	0/8	0/8	--	--	--	--
K01KOOCL04	Forebay	1/8	0/8	0/8	0/8	0/8	0/8	--	--	--	--
	Sub-Total =	6/80	0/80	2/80	0/80	31/78	0/78	35/54	0/54	10/56	0/56
	Percent Observed to Exceed SQG =	8%	0%	3%	0%	39%	0%	65%	0%	18%	0%

Note: Results are reported as the number of observations greater than the SQG (numerator) by the number of observations at the sampling station (denominator).
Note: Lower-SQGs include: Lowest Effects Level (LEL), Threshold Effect Level (TEL), Interim Sediment Quality Guideline (ISQG), and/or Threshold Effects Concentration (TEC). Upper SQGs include: Probable Effects Level (PEL), Severe Effects Level (SEL), and/or Probable Effects Concentration (PEC).
Note: Transects 1 through 7 were collected in British Columbia, K01KOOCL01 through K01KOOCL04 were collected in Montana.
Note: "--" = not analyzed.
Note: Sediments collected in Montana are the <63 µm fraction.
Note: Arsenic SQGs (Lower = 9.8 µg/g; Upper = 33 µg/g); Cadmium SQGs (Lower = 0.99 µg/g; Upper = 5.0 µg/g); Iron SQGs (Lower = 21,200 µg/g; Upper = 43,766 µg/g); Manganese SQGs (Lower = 460 µg/g; Upper = 1100 µg/g); and Nickel SQGs (Lower = 22.7 µg/g; Upper = 48.6 µg/g).

Table 4-15. Effects on benthic invertebrate health in mine-exposed areas.

MU	Area code	Area description	Area type	Adversely affected based on statistical comparisons of community endpoints to habitat-matched reference areas?	Percent ephemeroptera (mayflies), plecoptera (stoneflies), trichoptera (caddisflies)[1]	Percent ephemeroptera (mayflies)[1]
1	FODHE	Fording d/s Henretta	Mainstem receiver	No	95	81
	FOUNGD	Fording u/s NGD	Mainstem receiver	No	79	60
	MP1	Fording Multiplate d/s Eagle Ponds	Mainstem receiver	Potentially	64	57
	FOUSH	Fording u/s Shandley Creek	Mainstem receiver	No	79	70
	FOUKI	Fording u/s Kilmarnock Creek	Mainstem receiver	No	84	75
	FOBKS	Fording between Kilmarnock & Swift	Mainstem receiver	No	79	70
	FOBSC	Fording d/s Swift, u/s Cataract	Mainstem receiver	Yes	63	49
	FOBCP	Fording between Cataract & Porter	Mainstem receiver	No	84	73
	FODPO	Fording d/s Porter, u/s Chauncey	Mainstem receiver	No	73	34
	FO22	Fording u/s Chauncey Creek	Mainstem receiver	Potentially	56	30
	FOUEW	Fording d/s Chauncey, u/s Ewin	Mainstem receiver	No	80	52
	FO28	Fording u/s Dry Creek	Mainstem receiver	No	93	61
	FO29	Fording d/s Dry, u/s GHO & Hwy Bridge	Mainstem receiver	Yes	59	51
	FODGH	Fording River d/s GHO	Mainstem receiver	No	88	59
	HENFO	Henretta u/s confluence with Fording	Mine-influenced tributary	No	82	61
	NGD1	Lower Lake Mountain Creek	Mine-influenced tributary	No	71	59
	KICK	Kilmarnock u/s road crossing near mouth	Mine-influenced tributary	Yes	8	3
	SWCK	Swift Creek near mouth	Mine-influenced tributary	Yes	65	1
	CACK	Cataract Creek near mouth	Mine-influenced tributary	Yes	2	0
	POCK	Porter Creek near mouth	Mine-influenced tributary	Yes	39	0
	GHCKU	Greenhills Creek u/s of settling pond	Mine-influenced tributary	Yes	7	5
	GHCKD	Greenhills Creek d/s of settling pond	Mine-influenced tributary	Yes	3	0
2	FO9	Fording d/s Josephine falls, u/s Grace & Line	Mainstem receiver	No	80	48
	FOUL	Fording d/s Grace, u/s Line	Mainstem receiver	Potentially	84	29
	LI8	Line Creek d/s LCO	Mainstem receiver	Potentially	72	28
	FO23	Fording d/s Line Creek	Mainstem receiver	No	76	29
	LILC3	Line d/s West Line, u/s South Line	Mine-influenced tributary	Yes	8	2
	LIDSL	Upper Line Creek, d/s South Line	Mine-influenced tributary	Yes	49	32
3	EL20	Elk River d/s Thompson & GHO	Mainstem receiver	No	93	48
	ELUEL	Elk River u/s Elkford	Mainstem receiver	No	94	58
	ELDEL	Elk River d/s Elkford sewage ponds	Mainstem receiver	No	93	48
	ELUFO	Elk River just u/s Fording	Mainstem receiver	No	71	36
	WOCK	Wolfram d/s pond	Mine-influenced tributary	Yes	12	2
	THCK	Thompson d/s pond	Mine-influenced tributary	Yes	68	1

MU	Area code	Area description	Area type	Adversely affected based on statistical comparisons of community endpoints to habitat-matched reference areas?	Percent ephemeroptera (mayflies), plecoptera (stoneflies), trichoptera (caddisflies)[1]	Percent ephemeroptera (mayflies)[1]
4	EL19	Elk River d/s Fording, u/s Grave	Mainstem receiver	No	92	63
	ELDGR	Elk River d/s Grave	Mainstem receiver	No	88	47
	ELUSP	Elk d/s Otto, u/s Sparwood & Michel	Mainstem receiver	No	85	58
	MIUCO	Michel u/s Corbin Creek	Mainstem receiver	No	87	46
	MIDCO	Michel d/s Corbin, u/s Andy Good	Mainstem receiver	Yes	58	28
	MIDAG	Michel d/s Andy Good	Mainstem receiver	No	86	63
	MI5	Michel d/s CMO	Mainstem receiver	No	71	43
	MI3	Michel u/s Erickson Creek	Mainstem receiver	No	82	51
	MI2	Michel Creek d/s EVO.	Mainstem receiver	Yes	52	16
	HACKUS	Harmer Creek u/s Harmer Pond	Mine-influenced tributary	No	76	32
	HACKDS	Harmer d/s Pond near mouth at Grave	Mine-influenced tributary	Yes	46	30
	GRCK	Grave Creek d/s Harmer	Mine-influenced tributary	No	81	53
	GRDS	Grave Creek near mouth at Elk	Mine-influenced tributary	Yes	61	29
	OCNM	Otto Creek near mouth	Mine-influenced tributary	Yes	38	13
	COCK	Corbin Creek near Mouth	Mine-influenced tributary	Yes	44	3
	ERCK	Erickson at CPR main line near mouth	Mine-influenced tributary	Yes	93	6
	BOCK	Bodie Creek d/s Bodie Pond	Mine-influenced tributary	Yes	28	1
5	EL1	Elk d/s Sparwood & Michel	Mainstem receiver	No	79	44
	ELUFE	Elk u/s Fernie	Mainstem receiver	No	74	51
	ELDFE	Elk d/s Fernie	Mainstem receiver	No	81	59
	ELELKO	Elk River u/s Elko	Mainstem receiver	No	85	54
	ELH93	Elk River u/s Hwy 93 Bridge	Mainstem receiver	No	77	46
Reference Areas		**36 areas negligibly disturbed by mining or other man-made influences**	**Summary statistics, All reference areas combined[2]**	**Minimum**	64	12
				5th Percentile	71	31
				Mean	86	49
				95th Percentile	97	67
				Maximum	97	82

Note[1]: Values less than the 5th percentile or less than the minimum of the combined reference areas are shaded light blue or dark blue, respectively. Also see footnote #2.
Note[2]: For general comparative purposes, summary statistics are presented for all reference areas combined, but each mine-exposed areas was statistically compared with a sub-group of reference areas based on similar habitat characteristics. Details are presented in Minnow (2014).

4.3.5 Fish Populations

Westslope cutthroat trout is commonly found in lotic and lentic habitats throughout the Elk River watershed and is the only fish species present in the Fording River upstream of Josephine Falls. In addition to cutthroat trout, bull trout (*Salvelinus confluentus*) and mountain whitefish (*Prosopium williamsoni*) are native to the Elk River basin, although they are usually only found in the main stem and in lower reaches of larger tributaries such as the Fording River, Line Creek, Alexander Creek, and Michel Creek (Wilkinson 2009; Robinson 2011). Rainbow trout (*Oncorhynchus mykiss*) is a non-native species that generally resides in lakes but spawns in adjacent streams; it was introduced to the Elk River basin through stocking programs at Grave Lake and Summit Lake and possibly other locations (Wilkinson 2009). Eastern brook trout (*Salvelinus fontinalis*) is another non-native species; it occurs mostly in the Michel Creek basin, although isolated populations also occur in beaver ponds along the Elk River up to Forsyth Creek (Wilkinson 2009; Robinson 2011). There are also patchy distributions of several other species, such as longnose sucker (*Catostomus catostomus*) and longnose dace (*Rhinichthys cataractae*), which mainly occupy slow-flowing side channels, oxbows, ponds, and lakes at lower elevations along or near the Elk River downstream of Elkford (Robinson 2011; LePage 2013).

Based on this knowledge, cutthroat trout has been identified as a representative species for monitoring mine-related effects on fish in lotic areas of the Elk River watershed. Longnose sucker was identified as a suitable species for monitoring mine-related influences in lentic habitats. In addition to understanding population dynamics, identifying and tracking the health of fish (e.g., growth, condition, abnormalities) is important for assessing fish population status. Fish population monitoring requires multiple years of study to understand and quantify basic population characteristics and begin to comprehend potential changes over time and relationships to stressors (e.g., mining, angling, extreme weather events). Cutthroat trout and longnose sucker studies were initiated in 2012 and 2013 to collect baseline data to inform the development of future monitoring (e.g., RAEMP) and assess appropriate monitoring endpoints, and determine what the most effective monitoring methods are to evaluate mine-related influences on population characteristics and fish health.

A multi-year study (2012-2015, inclusive) of cutthroat trout in the upper Fording River watershed is underway to assess population status, seasonal movements, and habitat use, which will inform mine mitigation and fish habitat management decisions (Cope et al. 2014). Unlike the lower Fording River and the remainder of the Elk River watershed, WCT in the upper Fording River are isolated from confounding factors (e.g., angling, competition from other fish species, hybridization, potential effects related to agricultural development) that could affect population stability and fish health. Literature on Population Viability Analyses (PVA) and Recovery Potential Assessments for WCT has shown that a viable population can range between 470 and 4,600 adults (Cope et al. 2014), depending on the methodology used. Also, between 9 and 28 km of stream is required to maintain an isolated population. To date, monitoring of fry, juveniles, sub-adults, and adults indicates that the westslope cutthroat trout population of the upper Fording River is stable at about 3,000 adults having access to 57.6 km of habitat. Based on Fulton's condition indices, Upper Fording River Westslope Cutthroat trout also appear to be robust and exhibit low rates of deformities.

In 2013, a study of longnose sucker presence/absence, abundance (density), and health was initiated at a variety of lentic areas to inform the design of the RAEMP. No differences in biomass, growth rates and body condition were found among the areas studied (Robinson and Arnett 2014). Of the 13 areas surveyed, eight were recommended for future monitoring based on high densities of LSU and the ability to isolate, and thus quantitatively monitor, populations for density determination.

4.3.6 Tissue Concentrations in Receptors (Bioaccumulation)

Baseline conditions within tissues of periphyton, invertebrates, fish (whole body, muscle, ovary/gonad), amphibians (egg masses), and birds eggs were evaluated by completing a screening-level ecological risk assessment (SLERA). A copy of the SLERA is provided in Annex K.1. The first step of the SLERA was to compare the available provincial or federal CCME tissue guidelines to the tissue-specific 95th percentile concentration of pooled reference tissue data[5]. If provincial or federal guidelines were not available, screening-level dietary effect threshold toxicity reference values (TRVs) were used. This step was completed to determine if the available tissue guidelines and TRVs were appropriately conservative to evaluate the Designated Area relative to the reference areas. If the tissue-specific 95th percentile reference concentration of a given constituent was greater than the available guideline or TRV, then the reference concentration was selected as the screening value used in the SLERA.

As a conservative[6] second step, constituents[7] were evaluated based on a comparison of the maximum tissue concentration to the screening value selected in the first step. Results identified the following constituents as exceeding a guideline, TRV, or 95th percentile reference concentration (whichever was greater) in at least one sample within the Designated Area: aluminum, arsenic, barium, cadmium, chromium, cobalt, copper, manganese, mercury, nickel, selenium, vanadium, and zinc. As these constituents had at least one concentration from an exposed sampling location greater than the 95th percentile of the reference tissue type, they were considered the potential result of a point or not-point source. Constituents for which sample concentrations fell below the 95th percentile reference concentrations were not associated with a point or non-point source, and as such were not evaluated further.

The next step in the evaluation involved calculating an exposure-point concentration. Exposure-point concentrations representative of MU populations were calculated as the 95th percentile for constituent concentrations in respective tissue types (periphyton, invertebrate, fish [whole body and muscle], amphibian egg masses, and bird egg tissue). The 95th percentile concentrations for each MU were then compared with dietary- and tissue-based screening values (as applicable to each constituent), to evaluate prey-tissue-specific and MU-specific hazard quotients (HQs) for each receptor. Hazard quotients were not calculated for prey-tissue types for which the maximum detected concentration did not exceed the corresponding dietary or tissue screening value. A summary of results is shown in Table 4-16. Shaded cells identify constituents for which the tissue-specific 95th percentile concentration did not exceed the corresponding screening value. Nine of the 13 COIs identified in the second step of the SLERA had MU-specific HQs greater than 1.0 for at least one tissue type in at least one MU.

For each MU with a 95th percentile HQ greater than 1.0, station-specific HQs were calculated based on the maximum concentration at each station within that MU. Station-specific maximum HQs were not calculated when constituent concentrations within an MU were less than the screening value. As shown in Table 4-16, MU-1 and MU-5 had the greatest frequency of tissue- and MU-specific 95th percentile concentrations that exceeded the respective screening value. Selenium had the greatest frequency of MU-specific HQs > 1.0 among all tissue types and all receptors except mammals (Table 4-16). Further details of the MU-specific and station-specific evaluations are provided in Annex K.1.

[5] To facilitate comparisons between exposed and reference locations in each MU, reference data were pooled per tissue type. Summary statistics, including the mean, median, minimum, maximum, and 95th percentile concentration of each constituent, were calculated and are presented in Annex K.1.

[6] Tissue guidelines are based on the average concentration and not a maximum concentration. For instance, the chronic dietary guideline to protect fish and aquatic-dependent wildlife is 4 µg/g selenium (dry weight) measured as the mean concentration of at least eight replicate (composite) tissue samples representing invertebrate or other prey species. Therefore the approach used to evaluate current baseline conditions with the maximum concentration is anticipated to be conservative.

[7] Constituents evaluated included: aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, cesium, chlorine, chromium, cobalt, copper, gallium, iron, lead, lithium, magnesium, manganese mercury, molybdenum, nickel, phosphorous, potassium, rhenium, rubidium, selenium, silicon, silver, sodium, strontium sulfur, tellurium, thallium, thorium, tin, titanium, uranium, vanadium, yttrium, zinc, and zirconium.

Table 4-16. Number of samples that exceed a chronic dietary tissue guideline or toxicity reference value and have a concentration greater than the 95th percentile of reference conditions.

COI	Tissue type	Receptor LOE	95th percentile hazard quotients					
			MU-1	MU-2	MU-3	MU-4	MU-5	L. Koocanusa
Cadmium	invertebrates	fish diet	0.82	1.1	0.32	0.48	0.40	0.47
Chromium	invertebrates	fish diet	3.4	0.52	0.51	2.0	2.1	2.3
		bird diet	2.5	0.42	0.6	1.6	2	1.2
	fish (WB/muscle)	fish diet	2.6	0.98	0.48	3.2	1.7	2.1
	amphibian egg mass	fish diet	2.5	--	--	0.50	2.7	1.1
Copper	invertebrates	bird diet	0.91	1.4	1.3	1.2	1.1	0.76
Manganese	periphyton	invertebrate diet	0.93	0.27	0.93	0.41	3.1	0.25
Mercury	invertebrates	fish diet	1.4	0.66	1.3	0.78	1.2	0.32
		bird diet	1.7	0.79	1.6	0.94	1.5	0.38
	fish (WB/muscle)	fish diet	0.27	1.8	--	0.7	0.98	3.3
		bird diet	0.27	3.8	--	1.5	2.0	6.8
		mammal diet	0.20	1.4	--	0.52	0.73	2.4
Nickel	periphyton	invertebrate diet	1.7	0.74	3.3	0.49	0.27	2.6
Selenium	periphyton	amphibian diet	2.4	3.6	4.3	2.8	1.1	0.73
	invertebrates	invertebrate tissue	2.1	1.9	2.2	1.6	1.2	0.55
		fish diet	2.5	2.3	2.6	1.9	1.4	0.65
		amphibian diet	3.4	3.0	3.5	2.6	1.9	0.87
		bird diet	1.9	1.7	1.9	1.4	1.0	0.48
	fish (reproductive)	fish egg	2.5	1.3	0.44	1.7	1.5	0.42
	fish (WB/muscle)	fish diet	3.8	1.2	1.1	4.2	1.3	0.46
		bird diet	2.8	0.87	0.78	3.1	0.92	0.34
	amphibian egg mass	fish diet	1.3	0.95	--	1.4	1.5	0.41
		bird diet	0.97	0.69	--	1.0	1.1	0.30
	bird eggs	bird egg	1.9	1.7	2.9	1.5	0.63	0.63
Vadium	amphibian egg mass	fish diet	1.2	--	--	1.2	0.088	1.0
Zinc	periphyton	invertebrate diet	5.8	1.6	1.7	0.49	0.51	0.43
	invertebrates	bird diet	0.71	0.99	0.79	0.89	1.2	0.86

Note: Results are reported quotient of the 95th percentile concentration of each MU (numerator) and the applicable screening value (denominator), which was the tissue guideline, toxicity reference value, or 95th percentile reference concentration (whichever was greater).
1. Note: WB = whole body, LOE = line of evidence, "—" = not analyzed (no exposed data available)

Selenium was the only constituent identified as a primary tissue constituent of potential concern for aquatic biota (see Annex K.1). Manganese, nickel, and zinc exposure concentrations in periphyton exceeded effects-based thresholds for herbivorous invertebrates in at least one MU. Specifically, an HQ of 1.3 was calculated for manganese in MU-5, HQs of 2.2 and 2.4 were calculated for nickel in MU-3 and Lake Koocanusa respectively; and an HQ of 2.4 was calculated in MU-1 for zinc. In consideration of the conservative nature of the dietary-effect thresholds for these trace elements, their lack of tissue-based effects, and that calculated exceedances were spatially limited, it is not anticipated that these are tissue constituents of potential concern within the Designated Area.

Tissue selenium concentrations within the Designated Area, however, routinely approached or exceeded an HQ of 1, and the scientific literature recognizes the potential for reproductive effects due to elevated selenium tissue concentrations. HQs for selenium (HQ_{Se}) as calculated for fish ovary/egg based on the 95th percentile by MU are as follows:

- MU-1: HQSe = 2.5
- MU-2: HQSe = 1.3
- MU-3: HQSe = 0.4
- MU-4: HQSe = 1.7
- MU-5: HQSe = 1.5
- Lake Koocanusa: HQSe = 0.6.

As indicated by the above results, with the exception of MU-3 and Lake Koocanusa, calculated HQs for selenium in fish ovary/egg tissues generally exceed 1 indicating the potential for adverse effects. Additional analyses were completed and are summarized for Lake Koocanusa in Section 4.3.6.1.

4.3.6.1 Lake Koocanusa – Fish Tissue

Selenium concentrations measured in fish (whole body/muscle) tissues within Lake Koocanusa are presented within Table 4-17. To date 10 fish species have been sampled, five of which (longnose sucker, mountain whitefish, peamouth chub, rainbow trout and westslope cutthroat trout) have had individuals with tissue concentrations greater than the B.C. WQG (4 mg/kg dw). Of those five species, one mountain whitefish sample was identified as also exceeding the 2014 draft EPA criterion (whole body = 8.1 mg/kg dw).

For the five fish species identified as exceeding the B.C. WQG, the frequency of exceedances are as follows: westslope cutthroat trout (70% of samples), longnose sucker (56% of samples), mountain whitefish (50% of samples), peamouth chub (19% of samples), and rainbow trout (4% of samples); refer to Table 4-18.

Burbot fish tissue data have been reported (see Table 4-17), however desiccation during sample storage, prior to analysis, introduces sufficient uncertainty to render the data uninterpretable. As a result, although summary statistics have been presented, these data cannot be meaningfully evaluated against guidelines or criterion. In addition to selenium, the fish tissue residue guideline (0.033µg/g ww) to protect wildlife from mercury toxicity was exceeded. Given that mercury is typically a concern from a human health perspective, an analysis for human health is described in Chapter 5 based on the mercury fish tissue water quality guideline from Health Canada of 0.5µg/g wet weight (as approved by BCMOE).

Unlike fish whole body/muscle tissue data, ovary selenium samples collected within the reservoir are limited. As noted within the BC WQG, the chronic egg/ovary tissue guideline (11 mg/kg dw) is based on the mean concentration of at least eight samples. Therefore, although 8 fish species have been sampled for reproductive tissues (ovary/gonads), only 50% have sufficient data to compare against the guideline. As indicated within Table 4-18, insufficient data (sample size (N) = <8) to compare against the BC WQG are available for largescale sucker, mountain whitefish, rainbow trout, and westslope cutthroat trout. As a result, the summary statistics

and evaluation against the WQG for these four species should be considered qualitative. Only data collected from peamouth chub can be directly compared to the BC WQG due to sufficient sample size (N = 81 samples).

Of the 81 peamouth chub samples collected to date, 11 samples (14%) were identified as exceeding the BC WQG, see Table 4-19. Although the other fish species have insufficient data to be compared against the BC WQG they were compared to the draft EPA criteria. Comparing tissue concentrations against the draft EPA criteria identifies exceedances for mountain whitefish (3 out of 7 samples; 43%), westslope cutthroat trout (1 out of 7 samples; 14%), and peamouth chub (2 out of 81 samples; 2%). No other fish species exceeded the EPA criteria.

Table 4-17. Summary of fish tissue selenium concentrations (mg/kg dry weight) in Lake Koocanusa

Species	Year	Tissue	N	Min	Max	Average	Std.Dev.	Samples exceeding criteria					
								B.C. WQG		EPA (KY)		EPA Draft	
Bull trout (BT)													
	2007	Muscle	19	1.1	2.0	1.7	0.24	0	0%	0	0%	0	0%
	2008	Muscle	39	0.1	2.0	1.7	0.35	0	0%	0	0%	0	0%
	2013	Muscle	34	2.0	4.0	2.7	0.56	0	0%	0	0%	0	0%
Kokanee (KKN)													
	2007	Muscle	20	1.3	2.1	1.7	0.23	0	0%	0	0%	0	0%
	2008	Muscle	60	1.3	2.4	1.8	0.24	0	0%	0	0%	0	0%
		Whole	20	1.9	3.2	2.5	0.28	0	0%	0	0%	0	0%
	2013	Muscle	37	1.6	2.8	2.2	0.29	0	0%	0	0%	0	0%
Longnose sucker (LNS)													
	2007	Muscle	14	2.5	5.1	3.5	0.77	4	29%	0	0%	0	0%
	2008	Muscle	28	2.5	5.1	3.5	0.75	8	29%	0	0%	0	0%
	2013	Muscle	32	1.5	6.8	5.5	1.0	30	94%	0	0%	0	0%
Largescale sucker (LSS)													
	2009	Whole	10	1.9	2.9	2.4	0.32	0	0%	0	0%	0	0%
Mountain whitefish (MWF)													
	2007	Muscle	2	2.0	2.9	2.5	0.64	0	0%	0	0%	0	0%
	2008	Muscle	4	2.0	2.9	2.5	0.52	0	0%	0	0%	0	0%
	2009	Whole	10	2.1	16	6.5	3.7	9	90%	1	10%	1	10%
	2012	Muscle	6	2.7	4.6	3.4	0.79	2	33%	0	0%	0	0%
Northern pikeminnow (NPM)													
	2007	Muscle	20	1.0	1.9	1.3	0.27	0	0%	0	0%	0	0%
	2008	Muscle	40	1.0	1.9	1.3	0.27	0	0%	0	0%	0	0%
	2013	Muscle	44	1.3	3.7	2.1	0.60	0	0%	0	0%	0	0%
Peamouth chub (PMC)													
	2007	Muscle	20	1.7	4.6	2.9	0.82	3	15%	0	0%	0	0%
	2008	Muscle	50	1.7	6.4	3.0	0.99	9	18%	0	0%	0	0%
		Whole	10	2.4	4.2	3.4	0.54	1	10%	0	0%	0	0%
	2009	Whole	10	1.5	3.3	2.3	0.56	0	0%	0	0%	0	0%
	2013	Muscle	48	1.7	8.4	3.6	1.5	13	27%	0	0%	0	0%
Rainbow trout (RBT)													
	2007	Muscle	2	1.5	1.6	1.6	0.071	0	0%	0	0%	0	0%
	2008	Muscle	4	1.5	1.6	1.6	0.058	0	0%	0	0%	0	0%
	2013	Muscle	17	1.9	4.1	2.6	0.56	1	6%	0	0%	0	0%
Westslope cutthroat trout (WCT)													
	2009	Whole	10	2.8	7.7	5.4	1.4	9	90%	0	0%	0	0%
	2012	Muscle	5	3.5	5.3	4.6	0.77	4	80%	0	0%	0	0%
	2013	Muscle	8	1.4	6.1	3.9	1.5	3	38%	0	0%	0	0%
Burbot biopsy (BRB)[a]													
	2013	*Muscle*	*56*	*0.72*	*8.1*	*4.0*	*1.7*	*na*	*na*	*na*	*na*	*na*	*na*
Total (excludes BRB)		Whole	70					19	27%	1	1%	1	1%
		Muscle	553					77	14%	0	0%	0	0%
		Grand Total =	**623**					96	15%	1	0.2%	1	0.2%

Note[a]: - Burbot biopsy concentrations are estimated due to uncertainties associated with moisture content and sample desiccation.

Table 4-18. Summary of fish reproductive tissue selenium concentrations (mg/kg dry weight) in Lake Koocanusa.

Species	Year	Tissue	N	Min	Max	Average	Samples Exceeding Criteria					
							BC WQG		EPA (KY)		EPA Draft	
Kokanee (KKN)												
	2008	Gonads	40	2.9	4.9	3.7	0	0%	0	0%	0	0%
		Ovary	18	2.8	4.8	3.8	0	0%	0	0%	0	0%
	2013	Gonads	28	3.1	5.6	4.2	0	0%	0	0%	0	0%
Longnose sucker (LNS)												
	2008	Gonads	8	4.0	5.6	4.8	0	0%	0	0%	0	0%
	2013	Gonads	1	6.9	6.9	6.9	0	0%	0	0%	0	0%
Largescale sucker (LSS)												
	2009	Ovary	1	3.9	3.9	3.9	0	0%	0	0%	0	0%
Mountain whitefish (MWF)												
	2009	Ovary	1	13	13	13	1	100%	0	0%	0	0%
	2012	Ovary	6	8.9	24	17	5	83%	3	50%	3	50%
Northern pikeminnow (NPM)												
	2008	Gonads	36	2.5	5.9	3.6	0	0%	0	0%	0	0%
	2013	Gonads	24	2.4	8.1	3.9	0	0%	0	0%	0	0%
Peamouth chub (PMC)												
	2008	Gonads	40	4.0	12	7.3	4	10%	0	0%	0	0%
		Ovary	10	5.0	11	7.8	1	10%	0	0%	0	0%
	2013	Gonads	31	5.4	22	9.1	6	19%	1	3%	2	6%
Rainbow trout (RBT)												
	2013	Gonads	2	4.7	4.8	4.7	0	0%	0	0%	0	0%
Westslope cutthroat trout (WCT)												
	2009	Ovary	6	6.7	17	11	3	50%	0	0%	1	17%
	2013	Gonads	1	10	10	10	0	0%	0	0%	0	0%
	Total	Ovary	42				7	17%	3	7%	3	7%
		Gonad	211				10	5%	1	0%	2	1%
		Grand Total =	**253**				17	7%	4	2%	5	2%

4.4 Cumulative Impacts on Environmental Quality

The previous sections of this chapter outline, on a medium-specific basis, the frequency and location of constituent concentrations that exceed WQGs, SQGs, and dietary guidelines. This section considers the various lines of evidence collected within each Management Unit to comment on the aquatic environmental health of the Designated Area. Lines of evidence considered are water quality (Section 4.3.1), sediment quality (Section 4.3.2), tissue concentrations (Section 4.3.3) and benthic invertebrate community structure (Annex K.1).

- 2013 water quality data were summarized using the Canadian water quality index (WQI), which takes into account the total number of analytes being considered and the number and magnitude of exceedances of guidelines or alternative benchmarks at each sampling location. Guidelines that depend on other water quality factors (e.g., hardness) were applied using sample-specific values. The WQI User Manual (CCME 2001) states that the specific variables, objectives, and time period used in the index may vary from region to region, depending on local conditions and issues. Consistent with this, site-specific (Elk Valley) benchmarks were used for selenium, nitrate, and sulphate to make the results more realistic than generic guidelines with respect to potential effects.
- 2011 and 2013 sediment quality was summarized using the Canadian sediment quality index. High sediment quality guidelines were used because the low sediment guidelines are within the range of reference area concentrations for most analytes.
- As identified within Annex K.1, selenium is the only mine-related constituent that bioaccumulates in tissues of aquatic and aquatic-dependent biota at concentrations of potential concern. Therefore, selenium hazard quotients were evaluated for resident/sessile (periphyton, benthic invertebrate) and mobile (fish, amphibians, birds) species.
- Benthic invertebrate community health was evaluated using data collected in 2012 (Minnow 2014) Criteria used to categorize the health of communities were derived from a review of the ranges of two endpoints (combined Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies] [EPT], as well as percent Ephemeroptera alone) in reference areas, as well as mine-influenced areas determined by detailed statistical comparisons to be within reference condition (see Table 4-15).

Results of the 2012 benthic invertebrate community assessment are considered to be a particularly important line of evidence of aquatic environmental quality at each location, because the organisms integrate the cumulative effects of exposure to multiple stressors over time and their sessile behavior means that they are excellent indicators of localized conditions. Comparison of the various lines of evidenced showed that where benthic invertebrate quality was within reference conditions, WQI results were typically also good or fair, there was little or no calcite, and invertebrate tissue selenium concentrations were below levels associated with effects on the invertebrates themselves as well as to consumers (fish or birds). Likewise, areas with affected benthic invertebrate communities were typically associated with poorer water quality and/or the presence of calcite.

4.4.1 Management Units 1 through 5

Lotic Areas: Aquatic environmental quality was evaluated for 15 reference areas, 20 discharge tributaries, and 36 main stem areas within the Elk River watershed. Benthic invertebrate communities were adversely affected within 65% of mine-influenced tributaries. It is important to remember that data collection activities conducted to date within the Designated Area were not designed to evaluate its overall environmental health. Rather, they have focused on tributaries known to have elevated concentrations of mine-related constituents. Examples of such tributaries include:

- Kilmarnock, Swift, Cataract, Porter, and Greenhills Creeks in MU-1
- Line Creek downstream of the rock drain and West Line Creek in MU-2
- Wolfram and Thompson Creeks in MU-3
- Otto, Corbin, Erickson, and Bodie Creeks in MU-4.

These tributaries tend to have elevated concentrations of mine-related substances (e.g., reduced WQI scores) and/or visible calcite deposits. They also contribute most of the mine-related loads of selenium, nitrate, and sulphate to the watershed.

All reference areas were considered to have healthy benthic invertebrate communities, good water quality, and little to no calcite deposition. Similarly, 86% of all areas along the main stem of the Elk River, Fording River, Line Creek, and Michel Creek have healthy benthic invertebrate communities, including all areas along the Elk River.

Elevated tissue selenium concentrations and associated HQs were observed in almost half of the 61 lotic areas for which tissue data are available. Some of these were fish captured in reference areas uninfluenced by mining, which is evidence that the tissues of mobile vertebrate species do not always reflect conditions in the area of capture.

Off-Channel Areas: Invertebrate or vertebrate tissue concentrations greater than toxicity reference values (e.g., HQ>1) were observed in about 35% of off-channel habitats evaluated, excluding reference areas and mine settling ponds. The highest HQs among all MUs were observed at the Fording River Oxbow (MU-1) and Goddard Marsh (MU-4).

4.4.2 Lake Koocanusa

Surface water quality, sediment quality and constituent concentrations in aquatic organism tissues have been monitored at multiple locations throughout the reservoir. To date selenium is the one constituent that has been identified within the reservoir to exceed guidelines and requires continued monitoring.

4.5 Summary

Selenium and nitrate concentrations in surface waters of the Elk River watershed are routinely elevated above water quality guidelines and are increasing in many areas. In addition, there is evidence that selenium is bio-accumulating in tissues (e.g., benthic invertebrates, fish) to levels that may adversely affect aquatic receptors in some areas. To date, biological monitoring programs in the Designated Area do not indicate that regional effects are occurring. Localized effects observed close to point sources (e.g., change in benthic community structure within tributaries) have however been observed. Therefore for the purposes of the Plan and based on the evaluation of current baseline conditions, efforts should focus on reducing selenium and nitrate to concentrations that will protect of aquatic life.

As indicated by the evaluation of current baseline data, there are a limited number of data gaps and uncertainties associated with certain medium and constituents. For instance, elevated analytical detection limits (e.g., polycyclic aromatic hydrocarbons) for sediment samples introduces uncertainties associated with comparison to guidelines. Similarly ongoing studies (e.g., westslope cutthroat trout fisheries study) when complete will help address such data gaps/uncertainties (refer to Annex K.1).

Chapter 5

Assessment of Protection of Human Health and Groundwater

Chapter Overview

This chapter outlines results of the assessment of potential impacts of water quality on human health and how the Plan addresses this topic. It also summarizes the results of a regional drinking water evaluation and sampling program.

Concordance with Ministerial Order and Terms of Reference

Chapter 5 satisfies Section B.1 and B.2 of Schedule C of Ministerial Order M113 and sections 3.4 and 3.8(a) and 3.8(b) of the Elk Valley Water Quality Plan Terms of Reference.

Highlights

- **Comprehensive two-phase approach to evaluate potential effects on human health.** Current baseline water quality was first assessed by comparing concentrations in surface water, sediment, fish tissue and groundwater to provincial guidelines. Any constituents that exceeded guidelines, and those for which no guideline is available, were analyzed in a second phase. In the second phase, estimates of average concentrations were compared to conservative health-protective benchmarks for each pathway (e.g., swimming, incidental ingestion, eating fish or drinking groundwater).
- **No unacceptable human health risks identified based on current water quality.** Teck undertook extensive studies of the effects of current water quality on human health, including testing of groundwater wells. Results show no unacceptable human health risks associated with current concentrations of constituents in water, sediment or fish.
- **Surface water quality management will protect groundwater for drinking water in floodplain areas.** Groundwater is intrinsically tied to surface water in parts of the Elk Valley. Reducing and managing surface water levels of selenium, cadmium, nitrate and sulphate through implementation of the Plan will also provide ongoing protection of human health and groundwater within the populated areas of the Elk Valley.

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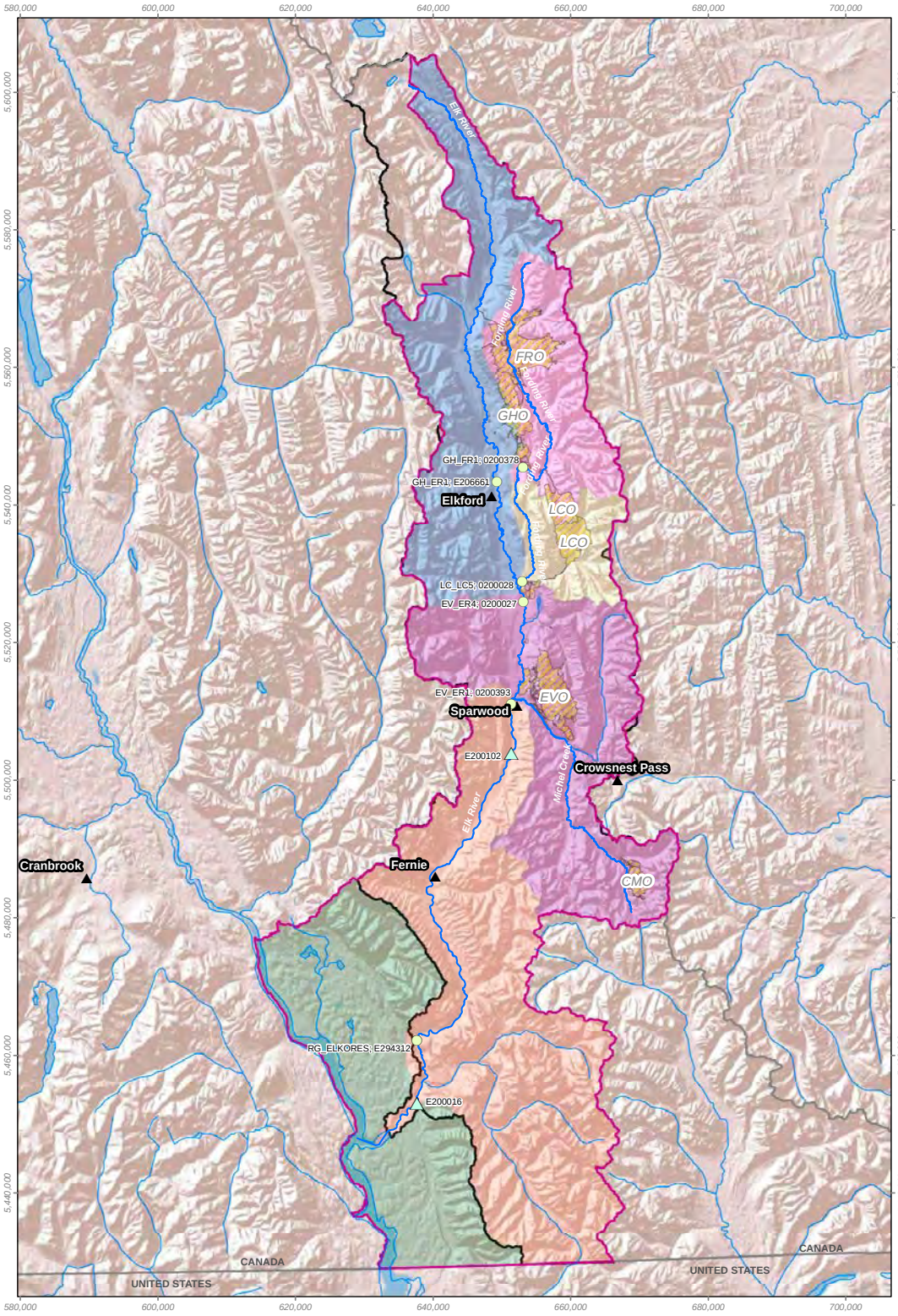
5.1 Introduction

Protection of human health and groundwater are important objectives of the Plan. The Plan's Terms of Reference describes two phases to evaluate these objectives: an assessment of current baseline conditions (ToR Section 3.4), and an effects assessment for constituents shown to exceed guidelines (ToR Section 3.8). This chapter outlines the methods and results of the assessment of baseline conditions from the perspective of human health, assesses potential human health impacts, and summarizes a regional groundwater study. Separate detailed reports on human health evaluation and regional groundwater are provided in Annex L.

5.1.1 Human Health Assessment and Protection

The four constituents specified in the Order, as well as other constituents in specified environmental media, were examined to identify those that may present a risk to human health under current conditions for pertinent exposure pathways. The first phase consisted of comparing the maximum reported constituent concentrations in each management unit (MU) with provincial guidelines for water quality, sediment and fish concentrations. (See Figure 5-1 for the geographical definition of each MU). During the second phase, pathway-specific benchmark values were derived for constituents shown to exceed guidelines during the assessment of current baseline conditions. The benchmark values were compared with upper confidence limits on mean concentrations by MU. Risk analyses were conducted for constituents exceeding the pathway-specific values.

- Sulphate and nitrate are evaluated in surface water and groundwater. During the current baseline evaluation, nitrate was found to exceed the guideline in surface water in MU-1 and MU-2, but not in groundwater. Sulphate exceeded the guideline once among hundreds of surface water samples and one groundwater well sample exceeded the guideline. The second phase of analysis showed that neither constituent posed a health risk in either surface water or groundwater.
- Cadmium and selenium were evaluated in surface water, groundwater, sediment and fish. During the current baseline evaluation, selenium was found to exceed the guidelines in MUs 1, 2, 4, and 5 for surface water, in MUs 4 and 5 for groundwater, in MUs 1 and 4 for sediment, and in MUs 1, 2, 4, and 6 for fish. Cadmium exceeded the guideline in fish tissue in MUs 3 and 4. In no cases were current baseline conditions associated with health risks when the second phase of analysis was conducted.
- The same was true for other constituents evaluated. During the first phase of baseline evaluation, some constituents exceeded guidelines, but in no case were current baseline conditions found to pose health risks during the second phase of analysis.



Map 2.1-3 Teck Mining Operations in the Elk Valley

Figure 5-1. Management units within the Designated Area.

5.1.2 Groundwater Assessment and Protection

A regional evaluation was completed to identify groundwater used for drinking water that may be affected by mining activity in the Elk Valley. A total of 91 locations were sampled to assess drinking water quality. The majority of the locations sampled (79) were private groundwater wells. Additional samples were collected from Elkford and Sparwood municipal wells, groundwater wells with multiple users (e.g., mobile home parks), and six surface water points of diversion (springs/creeks). These data were incorporated into the human health evaluation. In no case was groundwater quality found to pose unacceptable health risks.

Two possible localized transport pathways for potential mining-influenced constituents in groundwater were identified: source release to upland groundwater, and surface water recharge from the Elk River in the floodplain. Shallow groundwater (i.e., <15 m below grade) in the Elk River floodplain has a higher degree of hydraulic connectivity to the Elk River than does deep groundwater, resulting in a greater potential for shallow groundwater to be influenced by constituents in the Elk River. In particular, shallow groundwater in floodplain areas hydraulically downgradient of a meander may receive a higher component of surface water recharge. Surface water recharge to groundwater also appears to be higher where river gradients are higher.

Given that current baseline conditions do not present human health risks and groundwater is intrinsically tied to surface water quality in parts of the Elk River, reducing and managing surface water concentrations of Order constituents will ensure that human health and groundwater for drinking are protected within the populated areas of the Elk Valley (floodplains).[1]

[1] Individual mining operations are developing groundwater monitoring networks and monitoring programs to improve understanding of groundwater at an operational (local) level. Results of these investigations will be used to help improve Teck's understanding of local groundwater for potential mitigation scenarios.

5.2 Approach to Evaluation

A two-phase approach was used for the human health evaluation (Figure 5-2). During the first phase, current baseline water quality was assessed by comparing constituent concentrations in surface water, sediment, fish tissue and groundwater to guideline values. Constituents that exceeded guideline values, as well as constituents for which no guideline values were available, were subjected to a more detailed effects assessment during the second phase.

An influence diagram was created to summarize potential causal relationships between concentrations of the constituents of potential concern and the values the Plan is seeking to protect. For human health, drinking water and fish consumption (selenium-specific) are identified as the two receptor pathways most relevant to selenium, sulphate, nitrate, and cadmium.

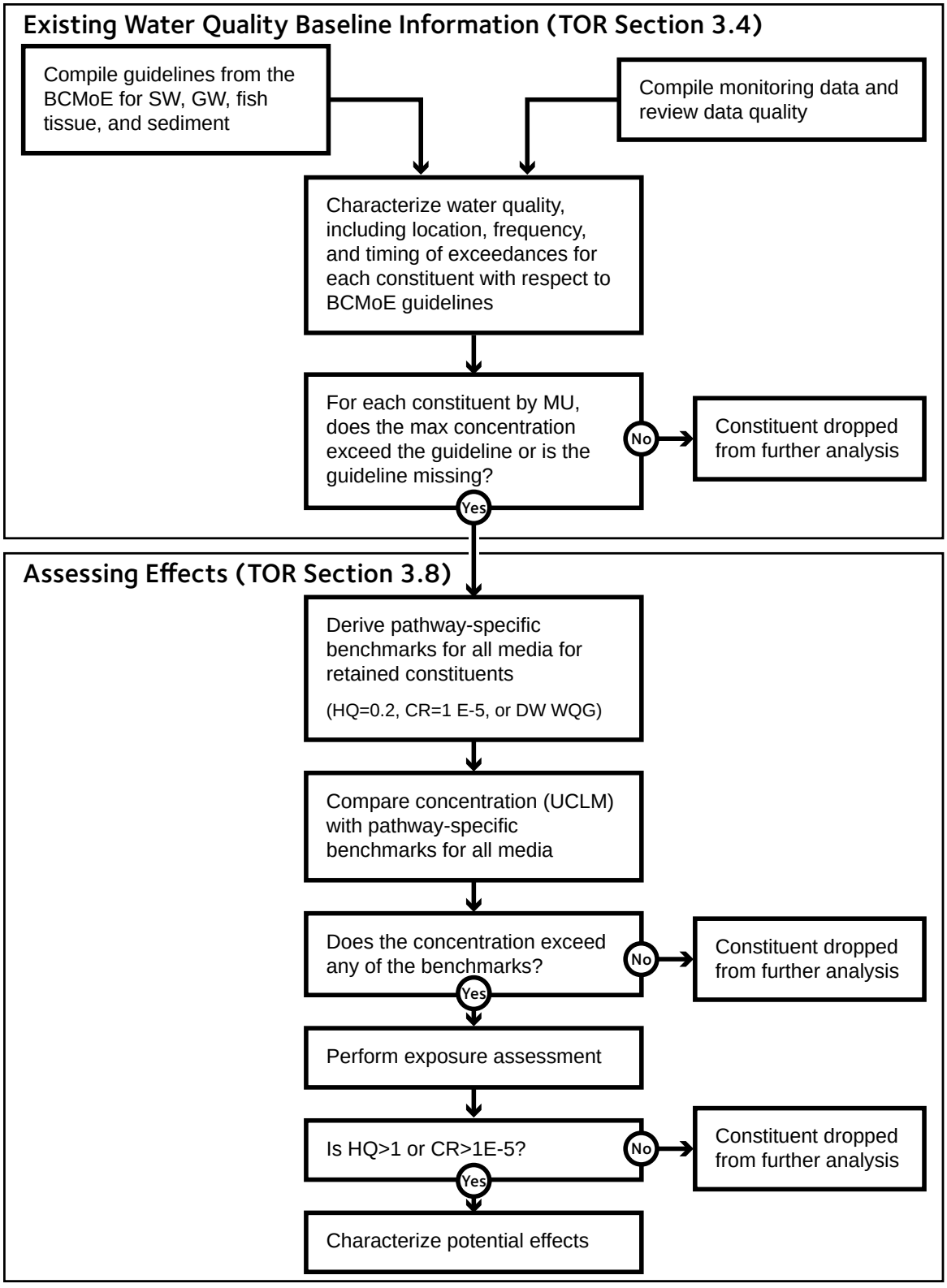
The human health evaluation considered additional constituents beyond the four specified in the Order, and additional exposure pathways beyond drinking water and fish consumption. Surface water, sediment, and fish tissue data collected during 2011-2013 were the primary focus of the evaluation. While all analytical parameters were considered, only those deemed pertinent to assessing potential health risks were included in this evaluation. Details of constituent selection are provided in Annex L.3.

Surface water quality data (total and dissolved) are available for 44 inorganic and nine organic constituents pertinent to assessing potential human health risk.[2] Sediment data are available for 33 inorganic constituents and 17 organic compounds.[3] Fish tissue data from muscle and whole-body samples are available for 40 inorganic constituents. Groundwater samples collected during 2014 were analyzed for 10 inorganic constituents, including the Order constituents.[4]

In the first phase of the evaluation, current baseline water quality was assessed by comparing concentrations of constituents in surface water, sediment, fish, and groundwater within each MU with human health protective guidelines based on the pathway with greatest exposure potential for each exposure medium (e.g., drinking water guidelines were applied to surface water and groundwater). Constituents exceeding the guidelines on any sampling date were carried through to the second phase for assessment of potential effects.

In the second phase of evaluation, estimates of average constituent concentrations[5] were compared with health-protective pathway-specific benchmarks. Average concentrations, additive exposures and potential other interactive effects were considered to identify constituents and exposure pathways requiring more detailed assessment of potential adverse health effects.

[2] Some parameters are indicators of general water conditions (e.g., pH, hardness, total dissolved solids) and others are collected only to support ecological analyses. Parameters that may affect water potability are briefly summarized in the human health risk evaluation.
[3] Only bulk sediment samples were included in this analysis. Additional fine fraction data were collected primarily to support ecological effects analyses.
[4] Analytical data for groundwater include water hardness and alkalinity in addition to chemical analytes.
[5] The upper confidence limits of the mean were used as a conservative estimate of mean concentrations.



B.C. MOE – British Columbia Ministry of the Environment; SW – surface water; GW – groundwater; MU – Management unit; HQ – Hazard Quotient; CR – Cancer Risk; DW – Drinking water; WQG – Water quality guideline; UCLM – Upper confidence limit of the mean.

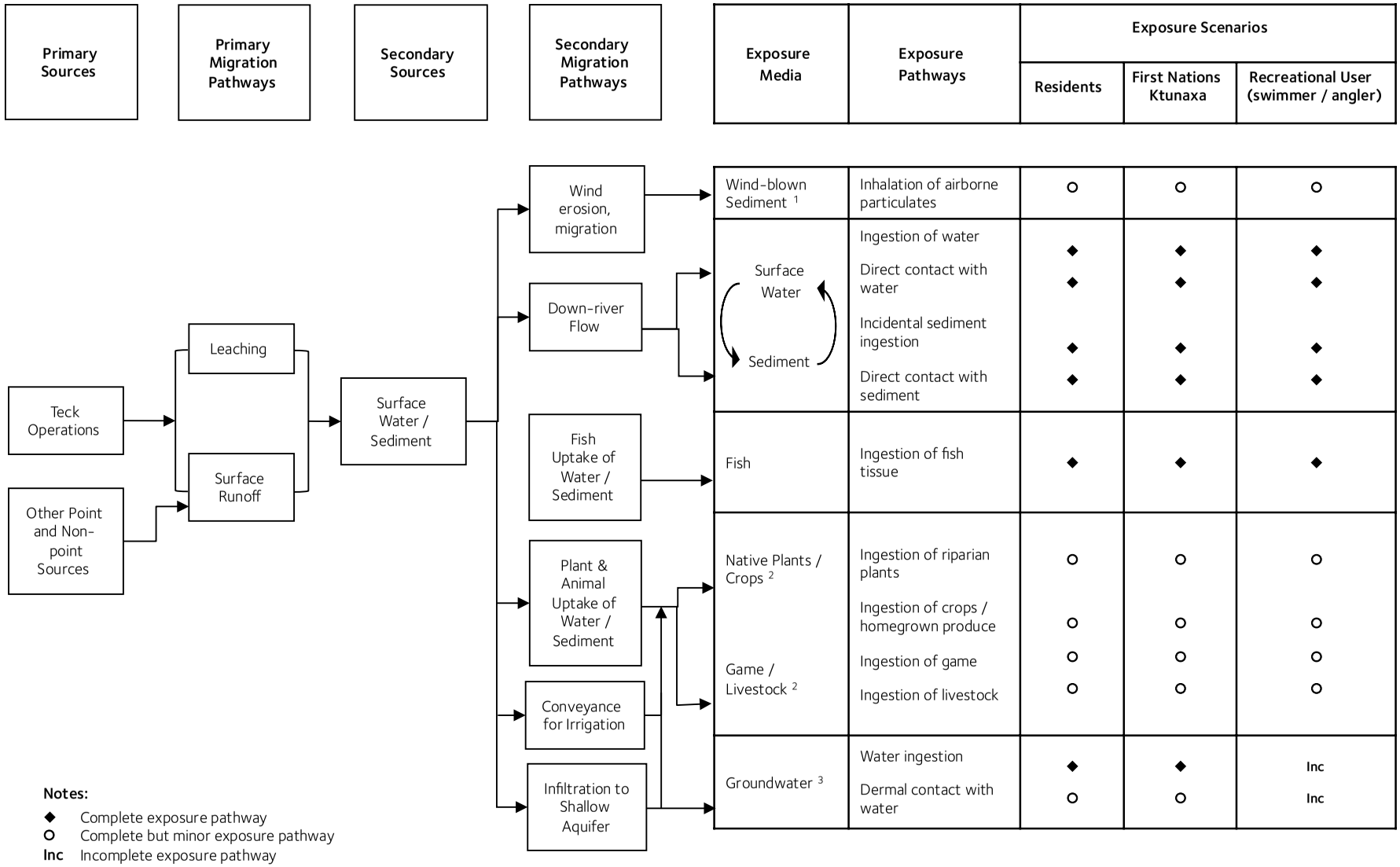
Figure 5-2. Evaluation of constituents of interest to address human health.

5.3 Human Health Conceptual Site Model

The Elk Valley setting for Teck operations provides the basis for assumptions regarding use of the waterbodies identified in the Order, including who relies on a watershed and how it is accessed. The conceptual site model (CSM) used to guide the evaluation is based on a review of land, surface water, and groundwater uses within the Designated Area. Information on residential, commercial, industrial, agricultural, subsistence, and recreational uses and activities form the basis for identifying exposure pathways and exposure parameters needed to quantify exposures and risk. Constituent sources, transport, and exposure pathways are depicted in the CSM schematic diagram (Figure 5-3).

Once released to surface water, constituents may dissolve or adsorb to suspended sediment, which may ultimately settle to the river bottom. In addition to surface water, constituents may occur in groundwater when a hydraulic connection is present. A hydraulic connection is most likely to occur where groundwater wells are in the floodplain, or where wells draw sufficient water from the Elk River to create a hydraulic gradient (SNC-Lavalin 2014).

People may come into contact with constituents in receiving surface waters, or where groundwater is removed in locations influenced by surface water, through the pathways shown in the schematic CSM (Figure 5-3) and in the artist's rendering (Figure 5-4). Primary exposure pathways include surface water, sediment, fish, and groundwater. Surface water and groundwater may be used as domestic water supplies. Residents, including members of First Nations, and tourists may directly contact constituents in surface water and/or sediment within the Designated Area while pursing leisure activities (e.g., swimming, fishing, floating), harvesting, or performing other traditional activities in the rivers. Both incidental ingestion and skin contact with water and sediment are primary exposure pathways. Consumption of terrestrial plants and animals that may consume surface water (either from the river or when used for irrigation) are secondary exposure pathways, because people contact the constituents indirectly, only through the plants and animals who have taken them up, rather than directly contacting constituents in water, sediment or fish.



Exposure Media	Exposure Pathways	Exposure Scenarios: Residents	Exposure Scenarios: First Nations Ktunaxa	Exposure Scenarios: Recreational User (swimmer / angler)
Wind-blown Sediment [1]	Inhalation of airborne particulates	O	O	O
Surface Water / Sediment	Ingestion of water	◆	◆	◆
	Direct contact with water	◆	◆	◆
	Incidental sediment ingestion	◆	◆	◆
	Direct contact with sediment	◆	◆	◆
Fish	Ingestion of fish tissue	◆	◆	◆
Native Plants / Crops [2]	Ingestion of riparian plants	O	O	O
	Ingestion of crops / homegrown produce	O	O	O
Game / Livestock [2]	Ingestion of game	O	O	O
	Ingestion of livestock	O	O	O
Groundwater [3]	Water ingestion	◆	◆	Inc
	Dermal contact with water	O	O	Inc

Notes:

◆ Complete exposure pathway
O Complete but minor exposure pathway
Inc Incomplete exposure pathway

1. Exposed sediment in Lake Koocanusa during low-water periods may be subject to wind erosion and subsequent inhalation by recreational visitors to the reservoir but this pathway is considered minor relative to direct sediment contact while swimming.
2. Plant and animal uptake of surface water/sediment may occur but exposure via tissue ingestion is considered a minor exposure pathway relative to fish ingestion.
3. Surface water infiltration to shallow aquifer is limited to areas where wells are located within Elk River floodplain.

Figure 5-3. Human health assessment conceptual site model.

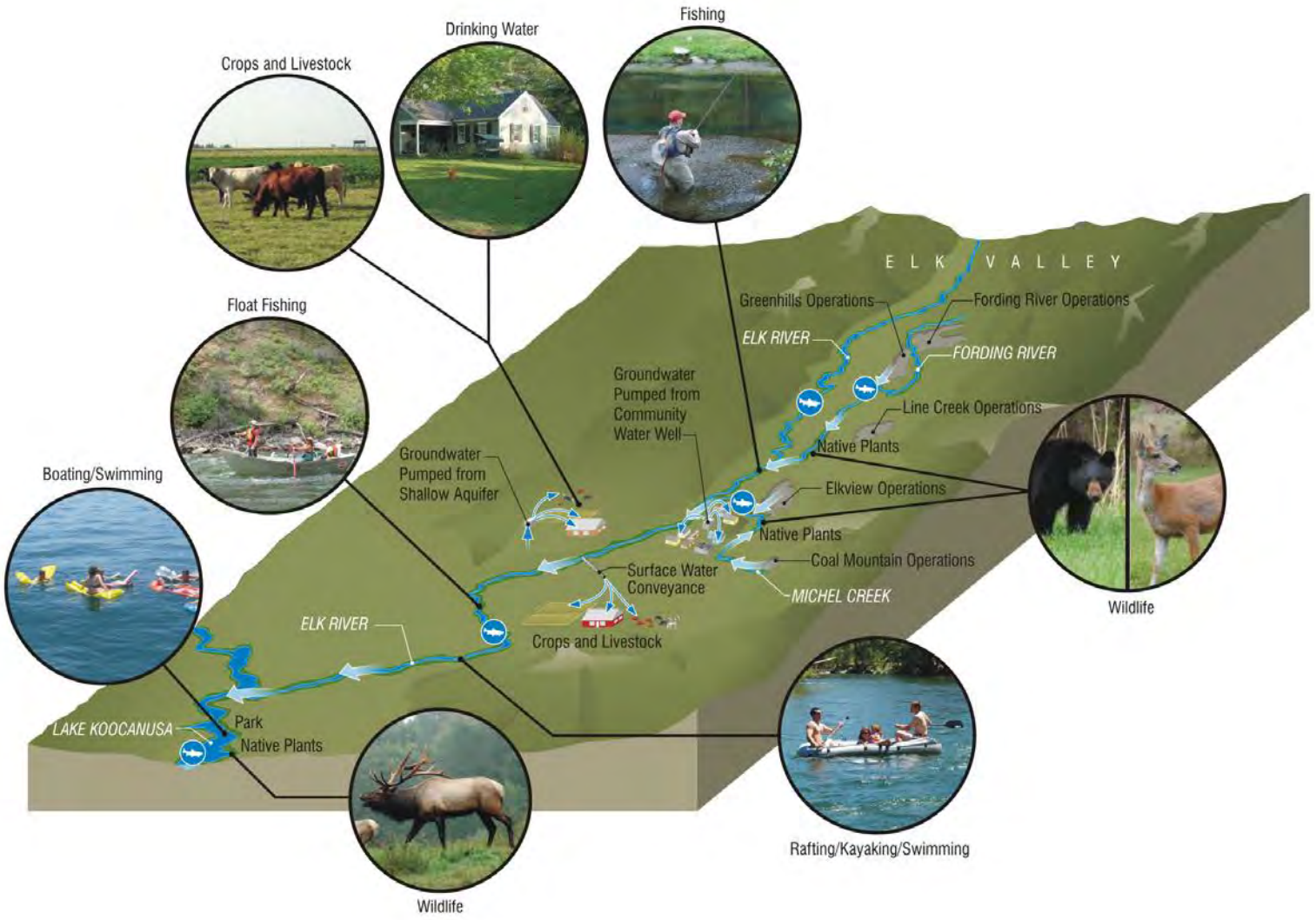


Figure 5-4. Human health assessment graphic conceptual site model representation.

5.4 Current Baseline Assessment

Current baseline data were organized by MU and exposure medium (e.g., surface water, groundwater, fish tissue, sediment). The maximum concentration identified for each recent data set (collected within the last three years) was compared to the selected numeric human health guideline, using a hierarchy recommended by the British Columbia MOE and the project team.[6] The baseline assessment used human health protective guidelines based on the most intensive possible contact or exposure pathway. For example, guidelines for drinking surface water are generally more stringent than guidelines for recreational use of surface water. Similarly, guidelines for incidental ingestion of residential soil are generally more protective than guidelines for periodic recreational contact with sediments. The goal in compiling guidelines for the baseline review was to identify all constituents that may need further assessment. Therefore, surface water and groundwater data were compared with drinking water guidelines, and fish tissue data were compared with fish consumption guidelines. Sediment data were compared with residential soil guidelines that assume daily exposure. Constituents that did not exceed their respective guidelines were not considered further. Constituents that exceeded their respective guidelines, or lacked guidelines, were further evaluated.

5.4.1 Surface Water

Surface water was tested for 44 inorganic constituents, of which 33 have guideline values. For those 33 constituents, 21 fell within the guidelines. Guideline values were not available for 11 inorganic constituents. Additionally, nine organic constituents were analyzed in surface water, eight of which had guideline values. Results are summarized in Table 5-1.

Most surface water guidelines are based on the total fraction of the constituent. Aluminum was the exception, with a guideline based on the dissolved fraction. Nevertheless, the maximum concentration for both total and dissolved fractions was compared with the guideline values. For bromide and sulphate, only dissolved data are available; the maximum of the dissolved fraction was compared to the guideline.

Table 5-2 summarizes constituents exceeding guidelines for total and dissolved concentrations that were carried forward for surface water. The subsequent discussion of surface water screening results focuses on total concentrations, for consistency with the basis for guideline values, except as noted above for aluminum, bromide, and sulphate. Comparison of dissolved concentrations to guideline values intended for "total" concentrations did not result in additional constituents being retained for further analysis.

[6] B.C. MOE provided or pre-approved most guideline values used in the evaluation. Details of guideline values and the selection process are provided in the appended human health evaluation report.

Table 5-1. Summary of surface water screening results.[a]

Constituents carried to effects assessment		
	Inorganic	**Organic**
Constituents Exceeding Guideline	Aluminum, Arsenic, Beryllium, Bromide, Cobalt, Iron, Magnesium, Manganese, **Nitrate (as N)**, **Selenium, Sulphate,** Vanadium	None
Constituents Lacking Guideline	Bismuth, Calcium, Phosphate, Phosphorus, Potassium, Silica, Silicate (Dissolved), Silicon, Sulfide, Sulphur, Titanium	Phenanthrene
Constituents not carried to effects assessment		
	Inorganic	**Organic**
Constituents Not Exceeding Guidelines	Antimony, Barium, Boron, **Cadmium**, Chloride, Chromium, Copper, Fluoride, Lead, Lithium, Mercury, Molybdenum, Nickel, Nitrite (as N), Silver, Sodium, Strontium, Thallium, Tin, Uranium, Zinc	Acenaphthene, Anthracene, Benzo(a)anthracene, Benzo(a) pyrene, Fluoranthene, Fluorene, Naphthalene, Pyrene

[a] Constituents specified in the Order are shown in bold.

Of the constituents specified in the Order, selenium, sulphate, and nitrate failed to meet the surface water guideline at least once, while cadmium was within guidelines in all MUs. Selenium exceeded the guideline in MU-1, MU-2, MU-4, and MU-5. In MU-2, 100% of samples exceeded the guideline, while in MU-4 and MU-5 the percentage dropped to 26% and 21%, respectively. Six sulphate samples (out of 479 samples) exceeded for the dissolved fraction, all in MU-1. Sulphate concentrations are not typically reported as total concentrations. Nitrate failed to meet the guideline in MU-1 and MU-2, with fewer samples exceeding and a lower maximum concentration in MU-2 than in MU-1.

Parameters that affect water potability (i.e., hardness, pH, total dissolved solids, or TDS, and total organic carbon, or TOC) were reviewed, and were found not to meet guideline values. Hardness, pH, and TOC also failed to meet guidelines in reference areas. Constituents not specified in the Order that had exceeded a surface water guideline at least once are aluminum, arsenic, beryllium, bromide, cobalt, iron, magnesium, manganese, and vanadium. Multiple samples failed to meet the guideline for arsenic,[7] bromide, cobalt, iron, magnesium, and manganese and these constituents were carried forward in the evaluation. Three constituents (aluminum, beryllium, and vanadium) exceeded the guideline only once and also were carried forward. All the eight organic constituents fell within guideline values.

In summary, constituents carried forward from the current baseline evaluation for surface water due to failing to meet a guideline include twelve inorganic constituents (aluminum, arsenic, beryllium, bromide, cobalt, iron, magnesium, manganese, nitrate, selenium, sulphate, and vanadium). Eleven inorganic constituents and one organic constituent without guidelines were also carried forward for further evaluation.

[7] It should be noted that the arsenic guideline is lower than typical background arsenic concentrations in surface water in B.C.

Table 5-2. Constituents exceeding surface water guidelines (total and dissolved).[a]

MUs	Chemical	Percent exceeding[b]	Max concentrations[c] (mg/L)	Guideline (mg/L)
Total Concentrations				
MU-1, 2, 3, 4, 5, 6	Aluminum	8-30	0.712-4.03	0.2*
MU-1, 2, 3, 4, 5, 6	Arsenic	6-69	0.000640-0.00275	0.0003
MU-1	Beryllium	<1	0.00761	0.004
MU-1, 2, 4, 5, 6	Cobalt	1-13	0.00096-0.00557	0.00094
MU-1, 2, 3, 4, 5, 6	Iron	8-24	1.08-6.37	0.3
MU-1	Magnesium	1	173	100
MU-1, 2, 3, 4, 5, 6	Manganese	3-5	0.0515-0.197	0.05
MU-1, 2	**Nitrate (as N)**	16-27	14.7-27.0	10
MU-1, 2, 4, 5	**Selenium**	21-100	0.0127-0.105	0.010
MU-4, MU-5	Vanadium	1	0.0156-0.0176	0.0126
Dissolved Concentrations				
MU-4	Aluminum	<1	0.342	0.2
MU-4, 6	Arsenic	9-52	0.00044-0.00047	0.0003
MU-1, 2, 4, 5, 6	Bromide	1-42	0.063-1.60	0.05
MU-4	Cobalt	5	0.00503	0.00094
MU-4	Iron	<1	0.362	0.3
MU-1	Magnesium	2	165	100
MU-1, 2, 4, 5	**Selenium**	21-100	0.0127-0.111	0.010
MU-1	**Sulphate (as SO_4)**	1	775	500

[a] Constituents specified in the Order are shown in bold.
[b] Range of percent of samples exceeding from MUs in which guideline was exceeded.
[c] Range of maximum concentrations from MUs in which guideline was exceeded.
* Aluminum guideline based on dissolved concentration; all other guidelines based on total concentration.

5.4.2 Sediment Results

Sediment was tested for 33 inorganic constituents, of which 26 had soil guideline values. For the 26 constituents with guideline values, 22 constituents fell within the guidelines. Guidelines were not available for seven inorganic constituents. Sediment was also tested for 17 organic constituents, of which 15 had guidelines; none failed to meet their guidelines. Sediment screening results are summarized in Table 5-3.

Table 5-3. Summary of sediment screening results[a].

Constituents carried to effects assessment		
	Inorganic	**Organic**
Constituents Exceeding Guideline	Aluminum, Iron, Nickel, **Selenium**	None
Constituents Lacking Guideline	Bismuth, Calcium, Magnesium, Potassium, Sulphur, Titanium, Phosphorus	Acenaphthylene, Benzo(g,h,i)perylene
Constituents not carried to effects assessment		
	Inorganic	**Organic**
Constituents Not Exceeding Guideline	Antimony, Arsenic, Barium, Beryllium, Boron, **Cadmium**, Chromium, Cobalt, Copper, Lead, Lithium, Manganese, Mercury, Molybdenum, Silver, Sodium, Strontium, Thallium, Tin, Uranium, Vanadium, Zinc	2-Methyl naphthalene, Acenaphthene, Anthracene, Benz(a)anthracene, Benzo(a) pyrene, Benzo(b)fluoranthene, Benzo(k) fluoranthene, Chrysene, Dibenz(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-c,d) pyrene, Naphthalene, Phenanthrene, Pyrene

[a] Constituents specified in the Order are shown in bold.

Constituents exceeding sediment guidelines are summarized in Table 5-4. All sediment data are reported in mg/kg dry weight. Of the constituents specified in the Order, only selenium exceeded sediment guidelines: 70% of all samples in MU-1 and 21% of samples in MU-4. Nitrate and sulphate are not constituents of concern for sediment and were not analyzed.

Iron exceeded the sediment guideline in every MU. Nickel exceeded the guideline only in MU-1 and aluminum exceeded the guideline only in MU-6. All organic constituents fell within the sediment guidelines. Thus, sediment constituents carried further in the evaluation included selenium, iron, nickel and aluminum. Seven inorganic constituents and two organic constituents lacking guideline values were also carried forward.

Table 5-4. Constituents exceeding sediment guidelines.[a]

MUs	Chemical	Percent exceeding[b]	Max concentrations[c] (mg/kg dry weight)	Guideline (mg/kg)
MU-6	Aluminum	28	17,400	15,400
MU-1, 2, 3, 4, 5, 6	Iron	54-100	15,500-41,900	11,000
MU-1	Nickel	11	129	100
MU-1, 4	**Selenium**	21-70	5.30-81.6	3

[a] Constituents specified in the Order are shown in bold.
[b] Range of percent of samples exceeding from MUs in which guideline was exceeded.
[c] Range of maximum concentrations from MUs in which guideline was exceeded.

5.4.3 Fish Tissue Results

Fish tissue screening results are summarized in Table 5-5. Fish tissue was tested for 40 inorganic constituents, of which 23 have guideline values. Of these, 13 constituents fell within their guidelines. Organic constituents were not analyzed in fish tissue. All fish tissue data are reported in mg/kg wet-weight tissue.

Table 5-5. Summary of fish tissue screening results.[a]

Constituents carried to effects assessment	
Constituents Exceeding Guideline	Aluminum, Antimony, Arsenic, **Cadmium**, Cobalt, Iron, Lithium, **Selenium**, Vanadium, Zinc
Constituents Lacking Guideline	Bismuth, Calcium, Cesium, Gallium, Lead, Magnesium, Phosphorus, Potassium, Rhenium, Rubidium, Sodium, Tellurium, Thallium, Thorium, Titanium, Yttrium, Zirconium
Constituents not carried to effects assessment	
Constituents Not Exceeding Guideline	Barium, Beryllium, Boron, Chromium, Copper, Manganese, Mercury, Molybdenum, Nickel, Silver, Strontium, Tin, Uranium

[a] Constituents specified in the Order are shown in bold.

Constituents exceeding guidelines for fish are summarized in Table 5-6. Of the constituents specified in the Order, both selenium and cadmium had samples exceeding the guidelines (nitrate and sulphate are not constituents of concern for fish tissue and were not analyzed). in MU-1, MU-2 and MU-6, muscle tissue samples exceeded the selenium guideline, but whole body samples did not. In MU-4 both muscle and whole body fish samples exceeded the guideline. cadmium had a sample exceeding in MU-3 in one whole fish sample (out of 10 samples), and multiple samples exceeding in MU-4 (in three whole fish samples of 30 and five muscle samples of 80).

Eight other constituents exceeded guidelines:

- Arsenic – multiple samples exceeding in every MU[8]
- Cobalt – multiple samples exceeding in all MUs except MU-6
- Iron – one sample exceeding in MU-3 and two in MU-4
- Aluminum, antimony, lithium, vanadium and zinc) had only one sample exceeding a fish tissue guideline.

[8] It should be noted that average arsenic concentrations in reference area fish were higher than concentrations in fish from the Designated Area.

Table 5-6. Constituents exceeding fish tissue guidelines.[a]

MUs	Constituent	Percent exceeding[b]	Max concentrations[c] (mg/kg)	Guideline (mg/kg)
MU-3	Aluminum (Whole)	10	426	280
MU-4	Antimony (Muscle)	1	0.170	0.108
MU-1, 2, 3, 4, 5, 6	Arsenic (muscle)	30-73	0.0600-0.340	0.021
MU-3, 4, 5	Arsenic (whole)	44-90	0.0926-0.159	0.021
MU-4	**Cadmium (muscle)**	6	0.529	0.28
MU-3, 4	**Cadmium (whole)**	10	0.421-0.702	0.28
MU-1, 2, 4, 5	Cobalt (muscle)	6-30	0.114-2.13	0.082
MU-3, 4, 5	Cobalt (whole)	10-28	0.104-0.378	0.082
MU-4	Iron (muscle)	3	361	190
MU-3	Iron (whole)	10	316	190
MU-4	Lithium	1	1.70	0.54
MU-1, 2, 4, 6	**Selenium (muscle)**	6-47	5.75-15.1	3.6
MU-4	**Selenium (whole)**	30	14.9	3.6
MU-3	Vanadium (whole)	10	1.52	1.36
MU-4	Zinc	3	82.1	82

[a] Constituents specified in the Order are shown in bold.
[b] Range of percent of samples exceeding from MUs in which guideline was exceeded.
[c] Range of maximum concentrations from MUs in which guideline was exceeded.

5.4.4 Groundwater Results

Monitored constituents in groundwater and screening results are summarized in Table 5-7. A total of 91 locations were sampled. Most (79) were private groundwater wells, with additional samples from Elkford and Sparwood municipal wells, groundwater supplies with multiple users (e.g., mobile home parks), and surface water points of diversion (springs/creeks). Samples from eight locations were found to exceed or be within 20% of the selenium guideline and were re-sampled. An exception was a District of Sparwood well (Well #3) that was not re-sampled. One sample failed to meet the Aesthetic Objective (AO) guideline for sulphate, one the AO guideline for sodium, and one the AO guideline for chloride. No other guidelines were exceeded. Water samples were tested for 10 inorganic constituents, listed in Table 5-7, of which eight had guideline values. Two parameters lacking guideline values, calcium and potassium, were analyzed for evaluation of general water quality parameters not specific to human health.

Table 5-7. Summary of groundwater screening results.[a]

Constituents carried to effects assessment	
Constituents Exceeding Guideline	Chloride, **Selenium**, Sodium, **Sulphate**
Constituents Lacking Guideline	Calcium, Potassium
Constituents not carried to effects assessment	
Constituents Not Exceeding Guideline	**Cadmium**, Magnesium, **Nitrate (as N)**, Nitrite (as N)

[a] Constituents specified in the Order are shown in bold.

Constituents exceeding guidelines for groundwater are summarized in Table 5-8. As with surface water, guidelines are generally based on total concentrations; however, both total and dissolved selenium concentrations were included in the current baseline screening. Of the constituents specified in the Order, five selenium samples and one sulphate sample were above the groundwater guideline and were carried forward for further evaluation. Sodium and chloride were also carried forward due to samples exceeding guidelines, while calcium and potassium were carried forward due to lack of guideline values. Water hardness failed to meet guideline values.

Table 5-8. Constituents exceeding groundwater guidelines.[a]

MU	Sampling location	Constituent	Fraction (total, dissolved)	Max concentration (mg/L)	Guideline (mg/L)
MU-4	07-01	**Sulphate**	D	550	500
MU-4	02-18	**Selenium**	T, D	0.014	0.010
MU-4	02-20	**Selenium**	T, D	0.013	0.010
MU-4	02-17	**Selenium**	T, D	0.016	0.010
MU-4	02-03	Sodium	T	288	200
MU-5	04-22	Chloride	D	307	250
MU-5	04-09	**Selenium**	T, D	0.011	0.010
MU-5	03-04	**Selenium**	T, D	0.012	0.010

[a] Constituents specified in the Order are shown in bold.

5.5 Cumulative Impacts – Effects Assessment

The effects assessment characterizes constituents that did not screen out during the baseline evaluation. The focus of this assessment is identification of potentially complete exposure pathways for environmental media where constituents exceeded guidelines, followed by further risk-based screening and then risk calculations. Risk-based screening requires toxicity reference values (TRVs). Some constituents lacking guidelines may not have TRVs, and others may have guidelines that are not health-based. For these constituents, an initial assessment is made of the general level of toxicity of the constituent, and concentrations within the Designated Area are compared to concentrations in reference locations. Based on this analysis, an assessment was made on whether further quantitative analysis is needed or whether data gaps prevent full characterization.

Constituents exceeding guideline values are evaluated in the effects assessment according to the two-step approach summarized in Figure 5-2. Each MU had a unique list of exceeding constituents. However, to provide a more complete assessment, any constituent carried forward was further evaluated in all MUs. In the first step, an upper-bound estimate of mean concentrations for retained constituents in each MU was compared to pathway-specific benchmarks for primary exposure pathways. The pathway-specific benchmarks were conservatively calculated, assuming that only 20% of the safe dose was allowed for an individual pathway. In other words, if there was only one exposure pathway, an exposure up to five times the benchmark would still be protective of health. Alternatively, exposures via five pathways, each at or below the benchmark values would still be safe.

Data were examined to determine if the mean for samples collected from 2011-2013 were representative of ongoing exposures. The nature of toxicity associated with a constituent was also considered at this stage to determine if shorter-term exposures should be assessed. Among retained constituents, this issue is relevant only for nitrate. The outcome of this assessment is described Section 5.5.2.1.

Constituents that did not exceed primary pathway-specific benchmarks were not considered further. Constituents that exceeded a primary pathway-specific benchmark were retained to calculate pathway-specific risks (including secondary pathways) and to consider aggregate risks across all pathways. If no concern existed for aggregate risk, the constituent was not considered further. Multiple constituents with a potential for cumulative risks were evaluated further for consideration of physical and constituent factors influencing exposure and toxicity, and for interactive effects. Constituents were also evaluated with respect to reference area concentrations.

5.5.1 Characterization of Constituents Carried Forward

For a substantial number of constituents in surface water, sediment, fish, and groundwater, no TRVs were readily available to support the pathway-specific screening step. The following sections summarize the constituents for which TRVs were available, and provide qualitative assessment of constituents for which TRVs could not be identified. Data limitations or data gaps are also addressed.

5.5.1.1 Surface Water

Surface water was tested for both inorganic and organic constituents. Twelve constituents were carried forward from the baseline evaluation for surface water as a result of exceeding guidelines: aluminum, arsenic, beryllium, bromide, cobalt, iron, magnesium, manganese, nitrate, selenium, sulphate, and vanadium. Bromide, magnesium, and sulphate are discussed here qualitatively, but were not included in further screening and risk evaluation for the reasons described below. The other nine constituents had TRVs and were carried forward to the next step of the effects assessment.

Samples appearing to exceed the bromide surface water guideline are not reliable indicators because the data are all dissolved concentrations, whereas the guideline is based on annual mean total bromide concentrations in monthly raw water samples. Most concentrations were non-detectable; however, the detection limits were all equal to or above the guideline of 0.05 mg/L for total bromide. Consequently, the available data are not adequate to determine if bromide exceeds the guideline. The guideline is intended to determine the needed frequency of bromate monitoring in water supplies treated using ozonation, so its application in this context is not clear. Nevertheless, this data gap is noted in the conclusions, and no further analysis was conducted.

The guideline for magnesium is based on aesthetic factors, including water taste and odour. Few magnesium samples exceeded the guideline in MU-1 (7 of 473 samples) and the mean concentration was well within the guideline (36 mg/L vs. a guideline of 100 mg/L). Since magnesium is a required nutrient for human health, no TRVs are available and there is no anticipated health risk from reported concentrations. For that reason, magnesium was not evaluated further. Similarly, other general parameters used to assess general water potability (i.e., hardness, pH, TDS and TOC) were not considered in the effects assessment.

The guideline for sulphate is based on aesthetic factors and mild gastrointestinal distress, and no TRV is available due to the absence of significant adverse effects at any concentration evaluated. Few sulphate samples exceeded the guideline in MU-1 (6 of 479 samples) and the mean concentration was well within the guideline (157 mg/L vs. a guideline of 500 mg/L). There is no anticipated health risk from reported concentrations and sulphate was not evaluated further.

Inorganic constituents for which guideline values are unavailable include bismuth, calcium, phosphate, phosphorus, potassium, silica, silicate, silicon, sulphide, sulphur, and titanium. Of these, calcium, phosphorus (measured in the blood as phosphate ion), potassium, and sulphur are essential nutrients in larger amounts.[9] Phosphorus/phosphate and sulphur/sulphide are present as part of other chemicals, and were not evaluated for human health effects as free elements or ions. Bismuth has limited oral bioavailability in people, as evidenced by its use in laxatives. Silica/silicate/silicon and titanium are commonly used as whiteners in toothpaste.[10] Due to their low toxicity, these constituents were not evaluated further.

Nine organic constituents were also measured in surface water, eight of which have guideline values. None of these eight exceeded the guideline values. Phenanthrene is the only organic constituent for which a guideline value was unavailable. It has a similar toxicity profile to other polycyclic aromatic hydrocarbons (PAHs), for which surface water guidelines values are available. Due to this similarity and the lack of samples exceeding guidelines among the other PAHs, phenanthrene was not evaluated further.

5.5.1.2 Sediment

Sediment was tested for both inorganic and organic constituents. Aluminum, iron, nickel, and selenium exceeded guidelines and have TRVs. All four were carried forward to the next step of the effects assessment.

Inorganic constituents for which guideline values are unavailable include bismuth, calcium, magnesium, phosphorus, potassium, sulphur, and titanium. The absence of guidelines for these constituents in sediment reflects their low toxicity to people. Calcium, magnesium, and potassium are essential macrominerals, generally not considered to be human toxicants. Phosphorus and sulphur, also essential macrominerals, were not evaluated for human health effects as free elements. For the reasons given in Section 5.5.1.1, bismuth and titanium were not evaluated further.

Fifteen organic constituents fell within sediment guideline values. No guidelines are available for acenaphthylene and benzo(g,h,i)perylene. These constituents have similar toxicity profiles to the organic constituents for which sediment guideline values are available. Additionally, acenaphthylene was below the detection limit in every sample analyzed from the MUs and from reference data, while benzo(g,h,i)perylene was mostly below the detection limits. Due to this similarity and the lack of samples exceeding guidelines among the other organic constituents, the two organic constituents without sediment guideline values were not evaluated further.

[9] Magnesium, sodium, and chloride also are necessary macrominerals. Trace minerals needed in smaller amounts include iron, manganese, copper, iodine, zinc, cobalt, fluoride, and selenium.

[10] In contrast to the low oral toxicity of silica and titanium, inhalation of high concentrations of quartz silica or titanium oxide has been classified as carcinogenic to humans for silica (http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/quartz_silica.html) and possibly carcinogenic to humans for titanium (http://www.ccohs.ca/headlines/text186.html).

5.5.1.3 Fish Tissue

Fish tissue was tested for 40 inorganic constituents, 22 of which had guideline values. All 10 constituents with samples exceeding guidelines have TRVs and were retained for further evaluation. No organic constituents were analyzed in fish tissue.

Constituents for which no fish tissue guidelines are available include bismuth, calcium, cesium, gallium, lead, magnesium, phosphorus, potassium, rhenium, rubidium, sodium, tellurium, thallium, thorium, titanium, yttrium, and zirconium. A lead TRV (SNC-Lavalin 2012) was identified and used for further assessment in fish tissue.

As described above, bismuth, phosphorus, and titanium are considered to have low toxic potential for people. Calcium, magnesium, phosphorus, potassium, and sodium are also essential macrominerals and not typically included in health risk assessments. Cesium, gallium, rhenium, rubidium, tellurium, thorium, and yttrium are trace elements that are rarely evaluated in health risk assessments and for which no TRVs have been established. None of these constituents were carried forward in the effects assessment.

There are insufficient data to support derivation of TRVs for thallium and zirconium. Toxicity data for thallium is limited. Animal toxicity studies have reported hair loss (i.e., alopecia), generally reversible following cessation of exposure, but similar symptoms have not been reported in humans. US EPA 2009 concluded that weaknesses in the underlying database do not support quantitative toxicity assessment. Zirconium generally exhibits low toxicity and is often used in skin ointments and antiperspirants. US EPA 2012 determined that the available database is inadequate and does not support development of a zirconium TRV. Due to the low toxicity of these constituents and lack of reliable TRVs, thallium and zirconium were not evaluated further.

In summary, constituents carried forward from the baseline evaluation for fish tissue include the ten constituents exceeding guidelines (aluminum, arsenic, antimony, cadmium, cobalt, iron, lithium, selenium, vanadium, and zinc), and one additional constituent without a guideline value (lead).

5.5.1.4 Groundwater

Drinking water wells were tested for the four Order constituents and seven additional inorganic constituents. Constituent concentrations were usually represented by one sampling event and in some cases, two. Due to data limitations maximum concentrations of each constituent for each well are included in this assessment. Selenium, calcium, potassium, sulphate, chloride, and sodium were retained for further evaluation in the effects assessment. Of 91 locations sampled, selenium was slightly above the guideline in five well sources, and so was carried forward to the next step of the effects assessment.

One sulphate sample (550 mg/L) was above the guideline of 500 mg/L, which is based on aesthetic factors and potential for mild gastrointestinal distress. No sulphate TRV is available, due to the absence of significant adverse effects at any concentration evaluated. Consequently, there was no need for further health assessment of sulphate.

Chloride and sodium were above their guidelines in one well each. These essential macrominerals are related to local sources, and not mining influences; they were not evaluated further. Locations with concentrations exceeding guidelines for sulphate, chloride, and sodium were rare and are not considered a health concern, but they may affect potability.

Calcium and potassium lack guidelines and TRVs and are considered essential macrominerals; therefore, they were not evaluated further.

5.5.2 Pathway-Specific Benchmark Comparison

Identification of exposure pathways to include in the effects assessment was guided by the CSM (Figures 5-3 and 5-4). Exposure pathway completeness varies depending on people's access to and activities within each MU, which may be affected by factors such as season and water level. Exposure pathways are characterized as primary pathways, i.e., those with the greatest possible magnitude of exposure, or as secondary pathways, i.e., those with more limited potential for exposure. Pathway-specific benchmarks were initially calculated for primary pathways. Benchmarks were not calculated for secondary pathways because primary pathways were not found to present unacceptable risks.

The benchmarks are based on algorithms from Health Canada (2012) and B.C. MOE (2008, 2012) exposure assumptions, and specified acceptable risk levels, in addition to MU characteristics. For carcinogenic constituents, cancer risk is set at 1 in 100,000. For non-cancer health effects, "Hazard quotients" (see Section 5.5.3) are set to 0.2, so that cumulative exposures from multiple pathways and multiple exposure media do not exceed effects thresholds (MOE 2012). Exposure concentrations used to compare to the pathway-specific benchmarks were 95% upper confidence limits on the mean, generated using ProUCL 5.0 (US EPA 2013).

5.5.2.1 Surface Water

The primary complete exposure pathways for surface water include incidental ingestion and skin contact during swimming and other aquatic recreational activities. Drinking water was also included as a primary pathway; although, it is not a current complete pathway. Secondary pathways include consumption of game or livestock that may have consumed surface water, and consumption of plants that may have grown at the river's edge or been irrigated with river water.

Benchmark screening values were derived only for the two primary pathways: drinking water and swimming. The magnitude of potential exposure from use of surface water as a domestic water supply is far greater than the potential magnitude of exposure from all the other pathways combined. Consequently, if a constituent does not exceed the drinking water benchmark value within an MU, there is no need to characterize risks from secondary pathways.

Seven constituents (aluminum, beryllium, cobalt, iron, manganese, selenium and vanadium) fell within screening benchmarks for drinking water or contact while swimming. Annual average concentrations of nitrate also fell within the benchmarks. Additional analyses were conducted to assess changing nitrate concentrations in MU-1 over time, and seasonal fluctuations in MU-1 and MU-2.[11] Average nitrate concentrations in MU-1 were higher in 2013 than in 2011 and 2012. No similar trend was noted in MU-2. Nitrate concentrations were also markedly reduced during the spring freshet.

Quarterly average nitrate concentrations were calculated for MU-1 and MU-2 for 2011-2013, and also for MU-1 for 2013 only. These concentrations were compared with the maximum allowable concentration (MAC). Highest concentrations occurred during Q1 and Q4 (i.e., during low-flow periods). Nitrate concentrations for 2013 were above the pathway-specific benchmark for drinking water in MU-1 for Q1 and Q4 (January to March and October to December). When MU-1 concentrations were averaged over the three-year period, nitrate concentration was again above the drinking water benchmark during Q1. In MU-2, drinking water pathway benchmarks were not exceeded, and the swimming pathway benchmark was never exceeded in either MU. It was concluded that nitrate in MU-1 is above the surface water non-cancer benchmark for drinking water, and was carried forward to the next step of the effects assessment.

[11] Concentrations of some other constituents also appear to be increasing over time; however, that trend is moderate and does not result in the masking of exceeding benchmark concentrations when data from all three years, 2011-2013, are combined when calculating upper estimates of mean concentrations.

Arsenic exceeded the cancer screening benchmark for drinking water only. However, the cancer screening benchmark is three orders of magnitude lower than the mean background arsenic concentration of 0.0002 mg/L for Elk Valley surface water, and below the Health Canada MAC of 0.010 mg/L. Reported natural background arsenic levels throughout B.C. range from 0.001 to 0.002 mg/L (MOE 2007). The range of mean concentrations for MU-1 through -6 is 0.00016 to 0.0039 mg/L, which is generally consistent with B.C. background concentrations and lower than the Health Canada MAC. Nevertheless, arsenic was carried forward for further evaluation.

5.5.2.2 Sediment

The primary sediment exposure pathway includes exposure skin and incidental ingestion of sediment during recreational or harvesting activities. Swimming was selected as the scenario with the most intensive direct contact with sediment, and used as the basis for benchmark development. For sediment ingestion and skin contact while swimming, the frequency of exposure was the same as for surface water exposure. The skin surface area assumed included hands, lower arms, legs, and feet. A secondary sediment exposure pathway could be uptake into riparian plants that might be harvested and consumed. No benchmark for this pathway was derived, pending assessment of the primary sediment exposure pathway.

In all MUs, concentrations of aluminum, iron, nickel, and selenium in sediment fell within screening benchmarks for direct contact. Due to the limited areas of sediment with elevated constituent concentrations compared with background, and the lack of constituents exceeding the primary exposure pathway benchmark, secondary sediment exposure pathways were not examined further.

5.5.2.3 Fish

Constituent concentrations in fish are a function of concentrations in water, sediment, and prey. Due to the complexity of predicting fish tissue concentrations, measurement of constituent concentrations was the most direct measure of potential exposures via fish consumption. For First Nations members, fish consumption benchmarks were derived using the 95th percentile for consumers, 43 g/day, (Firelight 2013). Because the Firelight study examined rates of ingestion for adults only, the adult ingestion rate was adjusted using the relative ingestion rates for different life-stages, following Richardson (1997). For other fish consumers, a consumption rate of 40 g/day was identified. Given that this value is only slightly less than the First Nations value, a separate benchmark for other consumers was not calculated.

Benchmark screening was conducted for ten constituents that had exceeded guidelines (aluminum, antimony, arsenic, cadmium, cobalt, iron, lithium, selenium, vanadium, and zinc), and for one additional constituent without a guideline value for which a TRV was identified (lead). Seven of these constituents fell within the pathway-specific benchmarks (antimony, cadmium, iron, lead, lithium, vanadium, and zinc). Upper confidence limits of the means for aluminum, arsenic, cobalt, and selenium were above the pathway-specific benchmarks, as follows:

- Aluminum: for whole body in MU-3
- Arsenic: for cancer endpoint in MU-3
- Cobalt: for muscle tissue in MU-1 and MU-4, and whole body fish in MU-4 and MU-5
- Selenium: for muscle tissue in all MUs except MU-6, and for whole body fish in MUs-3, -4 and -5.

Potential health risks for the four constituents exceeding pathway-specific benchmarks are examined in Section 5.5.3.

5.5.2.4 Groundwater

Drinking water is the primary exposure pathway for groundwater. Secondary pathways may be consumption of plants irrigated with groundwater, and consumption of livestock that drink groundwater. Initially, benchmark values were derived only for use of groundwater as drinking water. Derivation of other benchmarks was only planned for constituents that exceed the drinking water benchmark, and then only if the other uses have been identified for groundwater in the affected MU. Selenium was the only constituent retained for pathway-specific evaluation. Selenium concentrations did not exceed the pathway-specific (i.e., drinking water) value of 0.047 mg/L.[12]

5.5.3 Pathway-Specific Risk Analyses

Pathway-specific benchmark screening identified two constituents (arsenic, nitrate) in surface water and four constituents (aluminum, arsenic, cobalt, and selenium) in fish tissue for which more detailed risk analyses were needed. Non-cancer hazards were calculated for nitrate in surface water and for all of these constituents in fish tissue. One constituent (arsenic) is also carcinogenic when ingested, so cancer risks were also calculated for that constituent in surface water and fish tissue.

5.5.3.1 Non-cancer Hazard Estimates

Non-cancer health risks are measured by comparing the exposure dose with a TRV, yielding a hazard quotient (HQ). HQs are calculated by dividing the expected average daily dose of a constituent by the TRV, which is the daily dose at which there is no risk of adverse effects. An HQ greater than one indicates that more of the constituent is being ingested than recommended, and that additional analyses are needed to determine if an increased risk of health effects from exposure to that constituent may occur.

Currently, people do not drink surface water in MU-1. Regardless, HQs were calculated for nitrate in surface water that might be consumed by infants age 0 to 5 months, from drinking formula made with surface water. Infants are at highest risk from nitrates because their intestinal flora convert nitrate to nitrite, which then binds with haemoglobin to form methaemoglobin. Methaemoglobinemia, or blue baby syndrome, results in impaired oxygen delivery to tissues, giving the skin a blue color.

Seasonal estimates of mean nitrate concentrations in MU-1 were used to calculate HQs for infants. HQs for infant ingestion of surface water in MU-1, by quarter, are below one, indicating that adverse effects from ingesting surface water are not expected (see Table 5-9).

Table 5-9. Hazard quotients for infant, surface water ingestion.

Nitrate (as N)	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
MU-1 (2013)	0.4	0.2	0.2	0.4

HQs for the constituents above the fish pathway benchmarks were calculated using the exposure parameters for a First Nations resident. The high-end ingestion rate is only slightly less for other fish consumers, and risks for other fish consumers are slightly lower than those predicted for First Nations fish consumers (data not shown). Table 5-10 provides the non-cancer HQs for the four constituents that exceeded the pathway benchmark. The HQs for all four constituents are less than one.

[12] The pathway-specific benchmark for selenium in drinking water is based on the upper tolerable intake level (UL) of 0.4 mg/day set by Health Canada. This UL is also the basis for Health Canada's proposed drinking water MAC of 50 µg/L. The health-based proposed MAC contrasts with the 1992 guideline currently relied on by B.C. MOE of 10 µg/L, which is based on allowing 10-25% of total selenium intake to be from drinking water.

Table 5-10. Hazard quotients for First Nations resident, fish ingestion.[a]

Constituent	MU-1	MU-2	MU-3	MU-4	MU-5	MU-6
Aluminum	0.01	0.006	0.001	0.03	0.004	0.003
Arsenic	0.007	0.02	0.01	0.01	0.005	0.01
Cobalt	0.2	0.1	0.008	0.3	0.1	0.02
Selenium	0.8	0.4	0.2	0.4	0.2	0.2

[a] Results shown for muscle tissue only

Dietary selenium intake accounts for approximately 98% of total intake. Average daily selenium intakes for residents of Halifax, Toronto, and Vancouver are provided by Health Canada;[13] no data specific to southeast B.C. or Alberta are available (Health Canada 2014). Based on TAC advice that Elk Valley residents' diets reflect an inland rather than a coastal diet, the diet composition and selenium intakes of inland Toronto residents were selected as representing Designated Area residents better than Vancouver or Halifax. Combining the Toronto resident selenium intake level (2.2 µg/kg-day) with intake from MU-1 fish (4.3 µg/kg-day), calculated using the upper confidence limit on the mean concentration, results in a total daily selenium intake (6.5 µg/kg-day) above Health Canada's tolerable upper intake limit level (UL) (5.7 µg/kg-day). Similar calculations for consumption of fish muscle tissue from MU-2 through MU-6 do not cause the UL to be exceeded. The UL also is not exceeded for MU-1 fish when samples collected from a heavily studied settling pond, Clode Pond, are excluded in the dataset[14]. MU-1 is currently closed to most fishing[15].

To assess if background selenium intakes might be higher among Elk Valley residents, other non-fish sources of dietary selenium intake were considered, such as consumption of wild game and native vegetation. Generally, meats and fish contain more selenium than plants. The relatively low concentration of selenium in fruits and vegetables results in a negligible contribution to overall dietary selenium intake. A higher contribution to dietary selenium is derived from protein sources, with the highest selenium levels observed in organ meats. Table 5-11 shows average selenium concentrations in foods analogous to traditional foods consumed by Elk Valley residents and First Nations members, based on an average of concentrations in foods in Toronto, Halifax and Vancouver (Health Canada 2014).

Table 5-11. Selenium concentration in various foods sampled in Toronto, Halifax, and Vancouver.

Food	Three-city mean selenium concentration (µg/g, as prepared)
Fish (freshwater & marine, shellfish, canned)	0.53
Meat (beef, pork, lamb, veal)	0.28
Organ meats (kidney, liver)	1.14
Poultry	0.33
Berries	0.005
Mushrooms	0.20
Nuts & seeds	0.29

[13] "All ages" average daily intake values are 2.2 µg/kg/day in Halifax and Toronto and 3.2 µg/kg/day in Vancouver (Health Canada 2014).
[14] Barriers preventing fish migration between Clode Pond, a settling pond, and the Fording River will be installed in the near future. This will result in lower overall fish tissue concentrations for MU-1 as fish reflecting exposures within Clode Pond become inaccessible outside the mine operations fenceline.
[15] Fishing is closed or limited to catch and release for most waters in MU-1 and MU-2 except by First Nations members.

Selenium concentrations were reported for a limited data set of Elk Valley game. Average selenium concentrations measured in deer, elk, and sheep organ meat (1.3 µg/g wet weight (N=17), liver and heart[16]) are greater than concentrations in game muscle tissue (0.51 µg/g wet weight). Average Elk Valley game organ and muscle tissue selenium concentrations are higher than those reported across three cities surveyed by Health Canada (see Table 5-11).

When applying reported tissue concentrations to average food intake rates for "all Canadians" and Ktunaxa who consume locally harvested game, total dietary selenium intake is slightly greater for the latter (2.3 µg/kg-day vs 2.1 µg/kg-day).[17] This suggests that selenium intake for Elk Valley resident hunters may be higher than for other Canadians who do not consume game.

5.5.3.2 Cancer Risk Estimates

Cancer risks are calculated by multiplying the lifetime average daily dose by the TRV. The calculated cancer risk is the incremental probability, or probability in addition to the background risk experienced by all individuals in the course of daily life, that an individual will develop cancer during his or her lifetime due to exposure to a constituent. The risk estimates were compared with the B.C. MOE acceptable risk level, which for carcinogens is 1 in 100,000.

Arsenic was the only cancer-causing constituent retained for further evaluation. Based on dissolved arsenic concentrations, cancer risk from drinking surface water ranges from 4 in 1,000,000 in MU-1 through MU-3, to 1 in 100,000 in MU-6 (Table 5-12). Based on total arsenic concentrations, cancer risk ranges from 6 in 1,000,000 in MU-1 and MU-2, to 2 in 100,000 in MU-5 (Table 5-12). The risk estimate for total arsenic concentrations in MU-5 is above the acceptable level established by B.C. MOE. Mean concentrations for dissolved surface water arsenic in MU-1 through MU-5 (0.00011 – 0.00019 mg/L) are similar to mean reference surface water concentrations (0.00018 mg/L). The mean concentration in MU-6 (0.00030 mg/L) is higher than the reference area mean.

Table 5-12. Cancer risks for arsenic in surface water, ingestion.

Arsenic	MU-1	MU-2	MU-3	MU-4	MU-5	MU-6
Dissolved	4E-06	4E-06	4E-06	7E-06	6E-06	1E-05
Total	6E-06	6E-06	7E-06	1E-05	2E-05	1E-05

Cancer risk from the ingestion of arsenic in fish ranges from 3 in 1,000,000 in MU-1 and MU-6, to 1 in 100,000 in MU-5 (Table 5-13). This falls within the acceptable risk level established by MOE. Upper estimates of mean arsenic concentrations in fish tissue for MU-1 through MU-6 are lower than mean reference tissue concentrations, indicating that eating fish harvested in the Elk Valley will not result in higher arsenic intake than eating reference area fish.

Table 5-13. Cancer risk from fish ingestion.

Arsenic	MU-1	MU-2	MU-3	MU-4	MU-5	MU-6
Muscle	3E-06	8E-06	5E-06	7E-06	6E-06	3E-06
Whole	--	--	1E-05	5E-06	6E-06	--

[16] Selenium concentrations in liver were much higher than heart concentrations.

[17] These estimates of total dietary selenium intake levels do not include contributions from local freshwater fish. Traditional food intake rates for muscle tissue, organ meat, berries, and mushrooms were obtained from the Firelight Study 2013.

Although the combined cancer risk for drinking surface water (total concentrations only) and eating fish (whole body only) in MU-5 would slightly exceed the B.C. MOE risk level, there is no evidence that surface water is being used as a drinking water. This reduces the likelihood of such combined exposures. It is also noteworthy that arsenic concentrations in fish are not higher in MUs with higher surface water concentrations. Further, the similarity of arsenic concentrations in the Elk Valley to reference area samples indicates that most arsenic in surface water and fish is likely due to natural sources rather than mining-related activities.

5.6 Protection of Groundwater

An understanding of regional groundwater conditions was developed from a recent drinking water evaluation and sampling program, the objectives of which were as follows:

- Identify drinking water supplies in the Elk Valley that may be affected by mine-influenced water and potentially contain elevated concentrations of Order constituents (cadmium, nitrate, selenium, and sulphate).
- Evaluate whether concentrations of Order constituents are above applicable drinking water quality guidelines (WQGs), by completing a drinking water supply sampling campaign.

A total of 91 locations (85 of which were groundwater sources) were collected to assess groundwater quality, including private wells, Elkford and Sparwood municipal wells, other supplies with multiple users, and samples from surface water points of diversion (springs/creeks). Samples from eight locations were found to exceed or be within 20% of the selenium guideline, and were re-sampled. One sample failed to meet the AO guideline for sulphate, one the AO guideline for sodium, and one the AO guideline for chloride. The sodium and chloride results exceeding the guidelines were judged to result from local, non-mine sources (e.g. water softener).

As described in Section 5.1.2, two localized transport pathways for selenium in groundwater were identified: source release to upland groundwater, and surface water recharge from the Elk River to groundwater in the floodplain. Shallow groundwater (i.e., <15 m below grade) in the Elk River floodplain has a higher degree of hydraulic connectivity to the Elk River than deep groundwater, resulting in a greater potential for shallow groundwater to be influenced by constituents in the Elk River. In particular, shallow groundwater in floodplain areas hydraulically downgradient of a meander may receive a higher component of surface water recharge. Surface water recharge to groundwater also appears to be higher where river gradients are higher.

Parts of the Elk River are likely a source of groundwater recharge, which supports conclusions that groundwater quality in the floodplain may be influenced by the Elk River. Based on these findings, it is anticipated that by directly addressing surface water quality though implementation of the Plan, groundwater within the populated areas of the Elk Valley (floodplains) will be protected.[18]

5.7 Uncertainties and Data Gaps

Data gaps and uncertainties related to analytical detection limits, selection of analytes, availability of game tissue, and dietary selenium intake were identified throughout the analysis are summarized here:

- A data gap was identified for bromide in surface water, where only dissolved concentrations were measured, and the detection limits were equal to or above the guideline value for total bromide. This data gap is not judged to be a high priority from a health risk perspective as there is not currently evidence that bromide is associated with mining activity, and it is not a constituent likely to accumulate in fish.
- For some constituents (bromide, chloride, sulphate), the water quality baseline guidelines are applicable to total constituent concentrations in water while the dataset contained only dissolved concentrations. This data gap is likely insignificant because health risks associated with these constituents are low.

[18] Individual mining operations are developing groundwater monitoring networks and monitoring programs to improve understanding of groundwater at an operational (local) level. Results of these investigations will be used to help improve Teck's understanding of local groundwater in relation to potential mitigation scenarios.

- Over the 2011-2013 time-period, constituents analyzed in surface water were not consistent across all MUs, resulting in slightly varying constituent lists for each MU. For example, sulphur was measured in surface water only in MU-6. The significance of this possible data gap is low, constituents of greatest potential health concern (e.g., nitrate and selenium) were monitored across all MUs.
- Sample size was limited for fish tissue data in the 2011-2013 time period, resulting in lower sample sizes compared to datasets for other environmental media for which samples had been collected throughout the three-year period. Smaller sample sizes typically result in greater variability within datasets, which is reflected in higher estimates of the UCLM. Continued monitoring through the Regional Aquatic Effects Monitoring Program will reduce uncertainty in characterizing fish tissue concentrations for future health assessments.

Game muscle and organ meats are expected to be harvested locally and could be a factor affecting background selenium intake. Based on the existing data set, there is uncertainty in the estimate of background selenium intake for Elk Valley residents. Lack of selenium concentrations in other traditional foods, such as berries and mushrooms, is not considered an uncertainty because the contribution of these foods to total dietary selenium intake is negligible compared with the selenium contribution from game meats and fish.

5.8 Conclusions Regarding Current Conditions

Baseline screening of current water quality identified numerous constituents that met guidelines for surface water, sediment, fish, and groundwater. Constituents that sometimes exceeded guidelines, as well as those with no guideline values, were carried forward to the multi-step effects assessment.

Constituents for which no TRVs are available were evaluated qualitatively to determine if the absence of a TRV was a data gap that needed to be filled to assess potential health risk. In most cases, constituents without TRVs were judged unlikely to present a health risk at the concentrations observed. Many of these constituents were nutritional macro- or microminerals not typically included in health risk assessments. Others were considered similar in toxicity to constituents for which TRVs are available and for which guidelines were not exceeded (e.g., some of the PAHs).

A minor data gap was identified for bromide in surface water, where only dissolved concentrations were measured and the detection limits were equal to or above the guideline value for total bromide; however, the bromide guideline is used to monitor water supplies after treatment, and not typically used to assess raw water quality.

Pathway-specific screening against benchmark values was conducted for each exposure medium. Benchmark values were derived for the primary exposure pathways. Based on the outcome of screening for the primary pathways, the need to develop benchmark values for secondary exposure pathways was assessed. For surface water, only nitrate in the drinking water exceeded the pathway-specific benchmark.[19] Other pathways pose a risk orders of magnitude lower than drinking water, so benchmarks for the secondary pathways were not developed. For sediment and groundwater, the primary pathway-specific benchmarks were not exceeded, and thus no benchmarks were derived for secondary pathways.

As summarized in Table 5-14, constituents for which non-cancer risks were calculated included nitrate in surface water consumed as drinking water, and aluminum, arsenic, cobalt, and selenium in fish. None of these constituents were found to pose non-cancer risks. Because no constituents were evaluated in multiple exposure pathways or exposure media, there was no need to calculate aggregate risks for any constituents. Cancer risks were estimated for arsenic in surface water and fish. The resulting estimates did not exceed MOE's acceptable risk level of 1 in 100,000 for dissolved arsenic concentrations, and dissolved arsenic concentrations in MU-1 through MU-5 surface water were not higher than reference areas. Similarly, fish concentrations were not higher than reference areas, and risks were in the acceptable range.

[19] Arsenic exceeded a cancer risk benchmark, but the benchmark was far below natural background concentrations.

Table 5-14. Constituents included in pathway screening and risk estimates.

Exposure medium	Pathway-specific screening	Risk estimates	Conclusions[a]
Surface Water	Aluminum, **Arsenic**, Beryllium, Cobalt, Iron, Manganese, Selenium, Vanadium, **Nitrate (as N)**	Nitrate (as N)	Nitrate exceeded pathway-specific benchmark, but risk estimates showed no risk of adverse effects. Dissolved arsenic concentrations were similar to those in reference areas and cancer risks did not exceed acceptable levels.
Sediment	Aluminum, Iron, Nickel, Selenium	—	No constituents exceeded pathway-specific benchmarks; no risk calculations were necessary.
Fish	**Aluminum**, Antimony, **Arsenic**, Cadmium, **Cobalt**, Iron, Lithium, **Selenium**, Vanadium, Zinc	Aluminum, Arsenic, Cobalt, Selenium	Aluminum, arsenic, cobalt and selenium exceeded pathway-specific benchmark, but were not found to pose unacceptable health risks.
Groundwater	Selenium	—	No locations had selenium concentrations exceeding pathway-specific benchmark; no risk calculations were necessary.

[a] Pathway-specific benchmarks are those calculated specifically for this evaluation, as described in Section 5.5.2.

An additional analysis was conducted for selenium to determine if intakes from fish would still be acceptable when Canadian dietary intakes of selenium are considered. Intake of selenium via consumption of fish from MU-1, plus background dietary intake, was predicted to exceed Health Canada's UL only if samples from Clode Pond (a settling pond) were included. Elk Valley residents who regularly consume local game may have higher dietary selenium intakes than Canadians who do not consume game. Selenium concentrations were highest in the livers of game animals.

Considered together, work conducted to assess protection of human health and protection of groundwater did not identify unacceptable health risks associated with current water quality in the Designated Area. Thus, no specific actions related to water quality are needed for protection of human health. Furthermore, considering the high degree of hydraulic connectivity to the Elk River in localized areas, active mitigation associated with reducing surface water concentrations will serve to protect groundwater.[20]

5.9 Future Conditions

Water quality targets for each of the Order constituents at each Order station are established based primarily on protection of aquatic biota (see Chapter 8, Table 8-16). Most long-term water quality targets to protect aquatic biota are lower than those needed to protect human health.

Long-term targets for selenium in MUs 1-5 exceed the current B.C. MoE WQG for drinking water. The guideline value is not based on adverse health effects, but on a fraction of typical dietary selenium intakes. In the Upper Fording River (where there are no existing or proposed drinking water consumers), the long-term target for selenium also exceeds the pathway-specific benchmark and the proposed Health Canada MAC. This suggests that, although no current unacceptable health risks are identified, this stretch of the river should not be used for drinking if concentrations are above the guideline.

[20] Individual mining operations are developing groundwater monitoring networks and monitoring programs to improve understanding of groundwater at an operational (local) level. Results of these investigations will be used to help improve Teck's understanding of local groundwater in relation to potential mitigation scenarios.

The short-term selenium water quality targets and Fording River nitrate concentrations prior to 2019 are also above pathway-specific benchmarks, and indicate that surface water in the Upper and Lower Fording River should not be used for drinking if selenium concentrations are at or above the short-term targets or if nitrate concentrations are above the long-term target.

A full discussion of water quality targets and mitigation actions is presented in Chapter 8.

Chapter 6

Development and Selection of Management Options

Chapter Overview

This chapter describes the ongoing research and development (R&D) programs though which Teck identifies, assesses and improves methods to protect water quality. It also explains the assessment process used to select water-quality management options, and Teck's commitment to continuing assessment of other options as new data and technologies become available. The detailed implementation plan and sequence of management options are discussed in Chapter 8, and the implementation plan for calcite management is described in Chapter 7.

Concordance with Ministerial Order and Terms of Reference

Chapter 6 satisfies Section B.10 and B.15 of Schedule C of Ministerial Order M113 and Section 3.9(a) of the Elk Valley Water Quality Plan Terms of Reference.

Highlights

- **Extensive resources dedicated to identifying and investigating management options.** Teck has been examining and taking action on water-quality management since 2010, including commissioning an independent advisory panel on selenium management, which outlined several proposed actions and principles for prevention, control and removal of selenium from water. Based on recommendations from the independent advisory panel, Teck launched an R&D program focused on watershed and selenium management in 2011.
- **Active water treatment and clean-water diversion are the most effective options to stabilize selenium and other concentrations in the short term:**
  - Active water treatment has been proven to reduce constituents of interest and is necessary to meet water quality targets in the short term. This is the best available management option. It can reduce in-stream concentrations of constituents of interest with varying effectiveness, depending on the technology used.
  - Clean-water diversions reduce volumes of water affected by waste rock, reducing the amount of water that needs to be treated. This can be particularly effective when it involves the diversion of large, upstream, undisturbed watersheds, such as Upper Line Creek and Upper Kilmarnock Creek. Diversions may be particularly useful in the future when site-specific projects are considered.
- **Teck's R&D programs will continue to seek improvements to active water treatment and diversion methods, while also investigating alternatives that could reduce the need for active water treatment over the long-term.** Teck has identified potentially attractive ways to reduce future treatment requirements, including waste-rock covers and saturated fills. Teck is committed to the R&D needed to ensure that these and other technologies are realistic candidates for future plans.

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6.1 Research and Development

6.1.1 Program Objectives

Teck's R&D programs investigate options for managing selenium and other constituents of interest, including those specified in the Order. The overall objectives of these programs are as follows:

- Identify and develop new technologies and techniques, and/or enhance existing technologies, to manage water quality.
- Communicate results of this program through Teck's internal technology transfer process.

Teck's R&D efforts relevant fall into two categories: source control, and active water treatment. Source-control R&D investigates both constituent sources and control methods. It includes studies of alternative technologies such as covers and in-pit passive treatment, as well as nitrate and calcite control. It also contributes to the basic water quantity and quality predictions, to help develop the initial implementation plan options. The active water treatment program focuses on investigation of technologies, including periodic surveys of new methods.

6.1.2 Program Structure

Teck's R&D programs are a coordinated effort with clear objectives, deliverables and reporting structures.

Source-control R&D is under the direction of the General Manager, Environment, Coal, and is overseen by the R&D Management Team, which comprises members of Teck's senior management. Source-control R&D is led by a dedicated manager, who is directly supported by a field lead and R&D site coordinators at each mining operation. The site coordinators are essential, as much of the R&D work is field-based and requires site-specific environmental, health and safety planning for the many third-party researchers involved.

Teck's active water treatment technology program is implemented by a team of research scientists and engineers from Teck's Applied Research and Technology (ART) group. This is coordinated and aligned with source-control R&D, and rolls up into the overall R&D program as shown in Figure 6-1.

Both source-control R&D and the active water treatment program are supported by Teck's Mine Engineering and Water Quality Projects groups. These groups are responsible for identifying opportunities to incorporate R&D learnings into engineering practice, and into the development and implementation of water-quality management options.

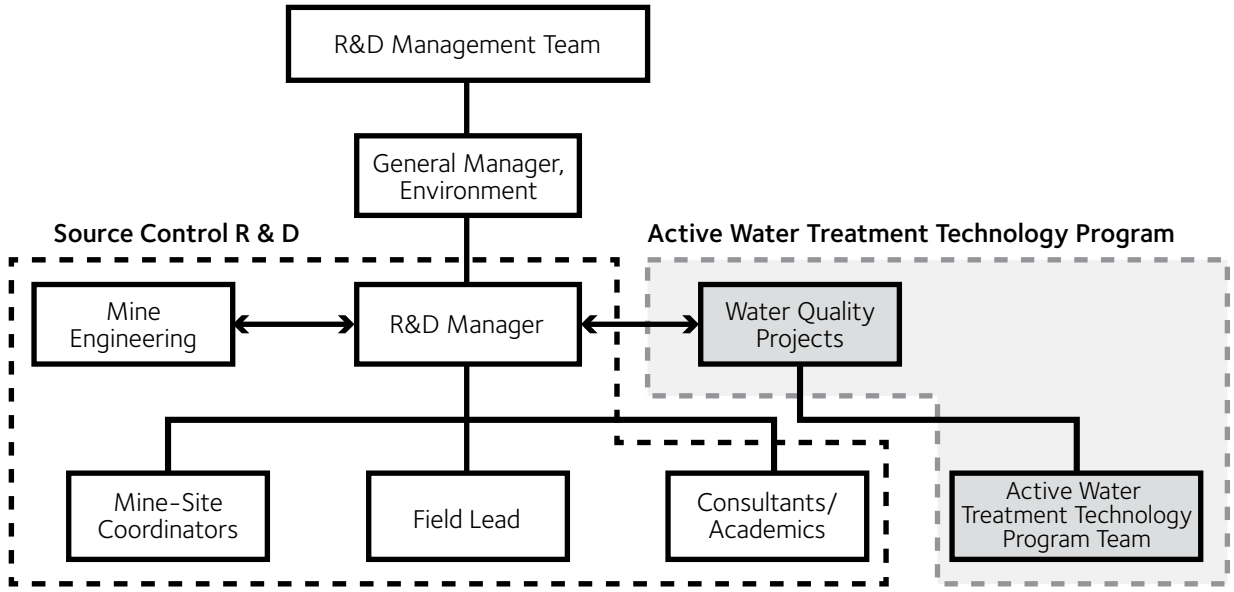


Figure 6-1. R&D organization structure.

The R&D programs include rigorous independent research conducted in partnership with several research leaders from Canada and the US. The current team includes the University of Saskatchewan, McMaster University, and Montana State University, and specialists from SRK Consulting, BGC Engineering, O'Kane Consultants, Integral Ecology and WorleyParsons.

6.1.3 Learnings to Date

Figure 6-2 illustrates the nine areas of source-control R&D in the context of an idealized mine-affected, reconstructed watershed. Highlights to date from the source-control R&D program include:

- the development of decision-support tools for assessing the timing and sizing of water treatment facilities and other management options
- compilation and syntheses of watershed-scale data to help build the regional water quality model
- improved understanding of the physical, geochemical and microbiological processes that lead to constituent release from waste rock, including options to control some of those processes
- field testing and analysis of the effects of soil covers and other surface treatments on water percolation, and the release of constituents from waste rock
- multiple lines of evidence indicating that it might be feasible to treat mine-affected water passively in pits backfilled with waste rock (saturated fills).

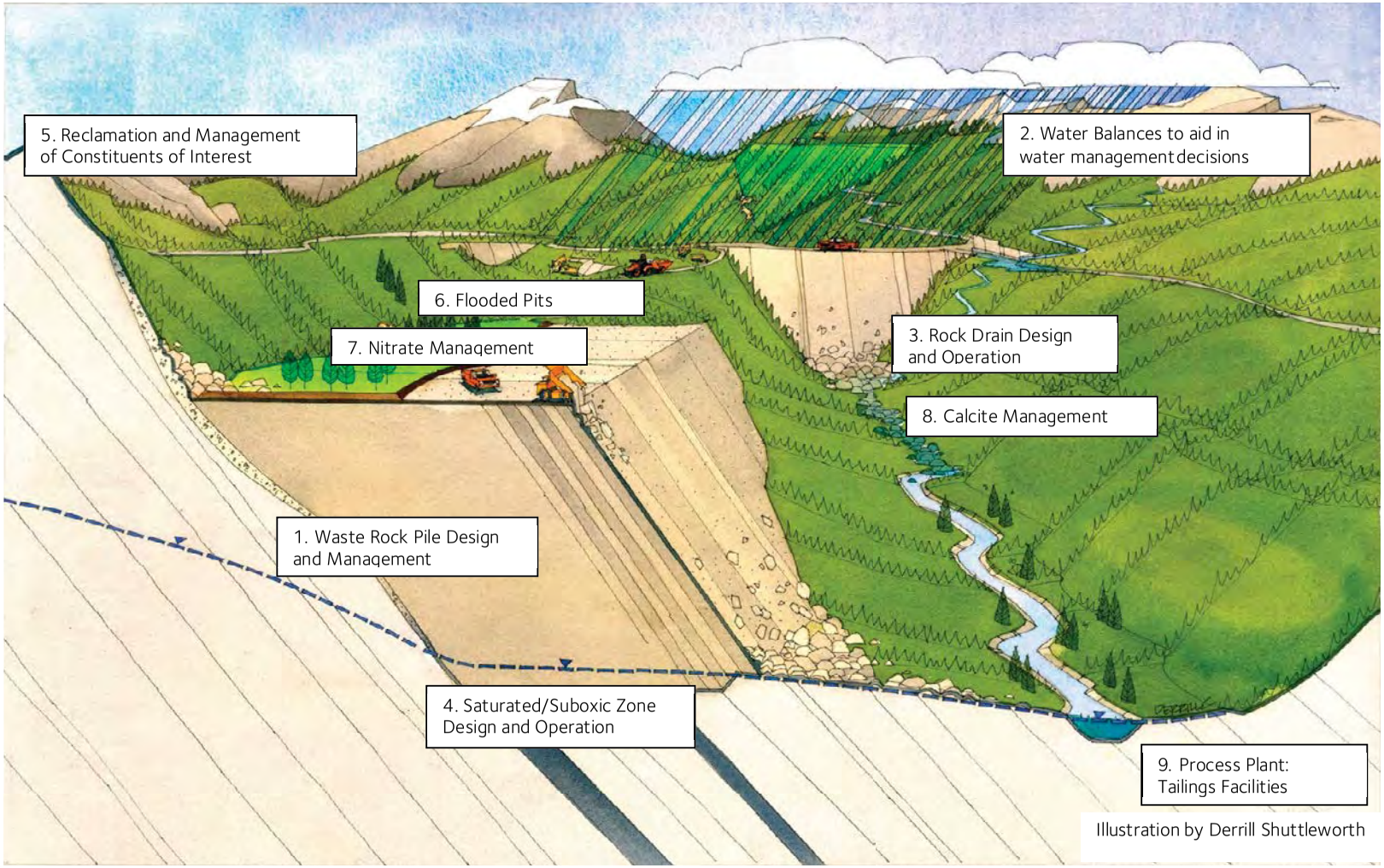


Figure 6-2. Nine research areas of source control research and development.

Several source-control practices were identified that could improve water quality and, with further development, be implemented at full scale. The highest priority identified to date is the use of saturated fills to treat mine-affected water, and the testing of a proprietary method to reduce nitrate losses from blasting. These and other continuing R&D initiatives are discussed in Section 6.3.

Highlights of the active water treatment program include the 2011 testing of four active biological treatment technologies, which rely on microorganisms that convert selenium to a particulate form that can be removed through settling. Of the four technologies tested, only two achieved effluent selenium concentrations of less than 20 µg/L. The four technologies were then evaluated at a conceptual level, considering pilot results as well as other parameters including, but not limited to, performance, operability, technology readiness, economics and full-scale footprint. Fluidized Bed Reactor treatment (a type of biological treatment) was selected for full-scale implementation at Line Creek Operations.

Further active water treatment technology investigations were conducted in 2012 and 2013. Following a comprehensive literature and vendor review, the outcome of these investigations was to improve the understanding of each technology, the current status of development, and possible applications in the Elk Valley. Technologies were compared in terms of water quality, cost, constructability, operability, technology status, supportability and sustainability (in energy consumption, facility footprint, emissions, etc). The following technologies selected as the most promising:

- biological treatment
- reverse osmosis
- electrodialysis reversal coupled with reverse osmosis.

These technologies were pilot-tested in 2013 to explore performance under conditions in the Elk Valley, and to address process risks and uncertainties. Biological treatment was confirmed as the leading technology for the removal of nitrate and selenium.

6.2 Assessment of Options

6.2.1 Approach

The selection of water-quality management actions, on a regional basis and over the extended timeframe required by the Order, is a complex task. The scale of the affected area, the multiple mine sites and many receiving streams, and the number of possible action combinations all need to be considered.

Teck used an iterative process to assess options coming out of the R&D programs, and to select the methods that are best-suited to the initial implementation plan. This process began in late 2013 with the development of computer models to examine the effect of various management options for water quality in the Fording and Elk Rivers. Initial analyses looked at combinations of active water treatment, clean-water diversion, and geosynthetic covers. Annex D.2 describes the combinations of water-quality management options that were modelled. By examining patterns in the model predictions, Teck's project team identified ways to improve each combination of options.

In February 2014, a larger group of Teck staff and consultants was assembled to participate in two workshops, to review initial water-quality predictions and the ideas assembled by the project team, and to select a preferred combination of management options. In both workshops, participants were first asked to brainstorm objectives for water quality planning and methods for water management. Participants then assessed scenarios developed by the project team to see how well they met the identified objectives, and whether any of the identified methods could lead to improvements. The workshops included discussion of confidential technical and financial information, so it was not possible to involve external stakeholders, but participants were asked

to consider all of Teck's responsibilities to its stakeholders, as well as their personal perspectives as members of local communities.

In the first workshop, participants examined the initial water-quality management options and concluded that two additional scenarios should be developed. The first was an improved combination of active water treatment and clean-water diversion. The second was a "minimum treatment scenario" that incorporated methods still being investigated in the source-control R&D program, with the objective of reducing reliance on active water treatment over the long term.

Teck's project team further developed the two new scenarios for review by participants in the second workshop. The revised active water treatment and clean-water diversion scenario was very similar to that considered in the initial modeling, but with changes to the sequence and scheduling of treatment facility implementation. The second new scenario assumed that two R&D methods, passive water treatment in saturated fills and waste rock covers, would prove to be technically feasible. After initial implementation of active water treatment and clean-water diversion systems, the scenario included a gradual conversion to passive treatment when and where saturated fills became available, and covering of waste-rock dumps located further from the saturated fills. The long-term condition in this scenario still required active water treatment along the upper Fording River, but relied on passive treatment and covers elsewhere.

In the second workshop, additional improvements to both of the revised scenarios were identified, but implications for the Plan were clear. Specifically, participants agreed that active water treatment, supplemented by clean-water diversion, should be the primary water-quality management method for Plan implementation . However, they also agreed that methods with the potential to reduce long-term reliance on active water treatment could be very attractive to Teck and external stakeholders, and therefore should be considered for future plans.

The reasons for those conclusions can be summarized as follows:

- Active water treatment and clean-water diversion are the only methods that are sufficiently proven to meet the Order requirement to begin stabilizing contaminant concentrations.
- Depending on R&D progress, alternative technologies could supplement or replace active water treatment in later stages of Plan implementation, and reduce the long-term need for active water treatment.
- The primary benefits of the alternative methods is that they reduce long-term commitments for Teck, and post-closure concerns for external stakeholders. Some alternative methods could also provide additional "non-water" benefits such as improved reclamation, biodiversity and land use.

6.2.2 Selected and Future Options

Teck recommends two options for initial implementation: active water treatment and clean-water diversion. Teck also identified two options that are currently in R&D but that are believed to be good candidates for later stages of the Plan.

6.2.2.1 Selected Option: Clean-water Diversion

Diversion involves the construction of earthen dikes or other physical barriers and/or pipes or other conduits to route clean water around mining activities. Diversions offer the advantage of mimicking natural, gravity-driven flows from higher to lower elevations. With dikes, no energy is required and maintenance, personnel and operating costs are low. A reduction in the volume of clean water that comes in contact with mine waste could reduce selenium and other constituents of interest downstream of the operation. Diversions also reduce the volume of water passing through mining waste rock, thereby reducing the volume potentially requiring treatment. Figure 6-3 provides a schematic of a typical gravity-driven clean-water diversion.

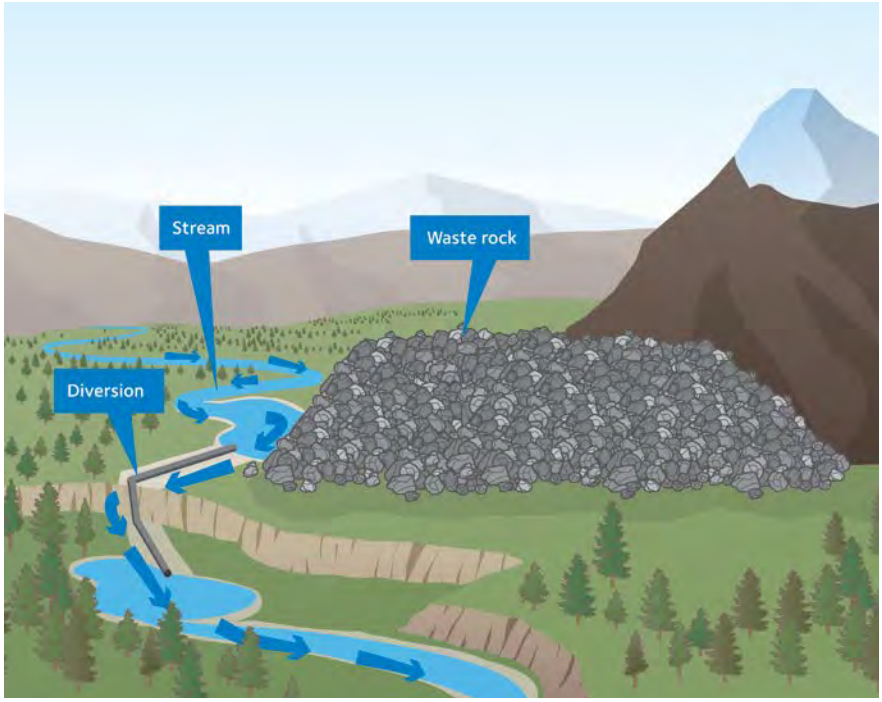


Figure 6-3. Typical gravity-driven clean-water diversion.

Diversions are not maintenance-free, and they require monitoring. If a diversion is not properly located or designed, some water may bypass it, undermining its effectiveness. A diversion's efficiency is influenced by local factors, and it must be designed in a site-specific manner.

Pipes and pump-driven flows can compensate for some of a diversion's shortcomings, and offer more flexibility and the ability to accommodate challenging topography, but these increase operating costs and maintenance requirements.

As part of recent overall water-quality management efforts, Teck built and operated two gravity-flow clean-water diversions: one at Fording River Operations on Kilmarnock Creek and one at Greenhills Operations on Swift Creek. Lessons learned from these projects suggest that piped clean-water diversions may be the preferred option, although this will be considered on a case-by-case basis during the design of each diversion project.

Diversions will be commissioned at the same time as associated downstream active water treatment facilities. Diversions were assumed to be large enough to convey freshet (May) flows in an average year. During design of a specific diversion, the infrastructure would be protected from the 1:200-year flood as per provincial policy. Potential clean-water diversions are detailed in Annex D.2. Selection of individual diversions for the initial implementation plan is explained in Chapter 8.

6.2.2.2 Selected Option: Active Water Treatment

Active water treatment involves processing water that has passed through waste rock spoils to reduce constituents of interest, and returning the treated water to receiving streams to maintain natural flow volumes. Figure 6-4 depicts the application of active water treatment.

Based on results from the active water treatment program, two technologies are being considered for implementation at this time.

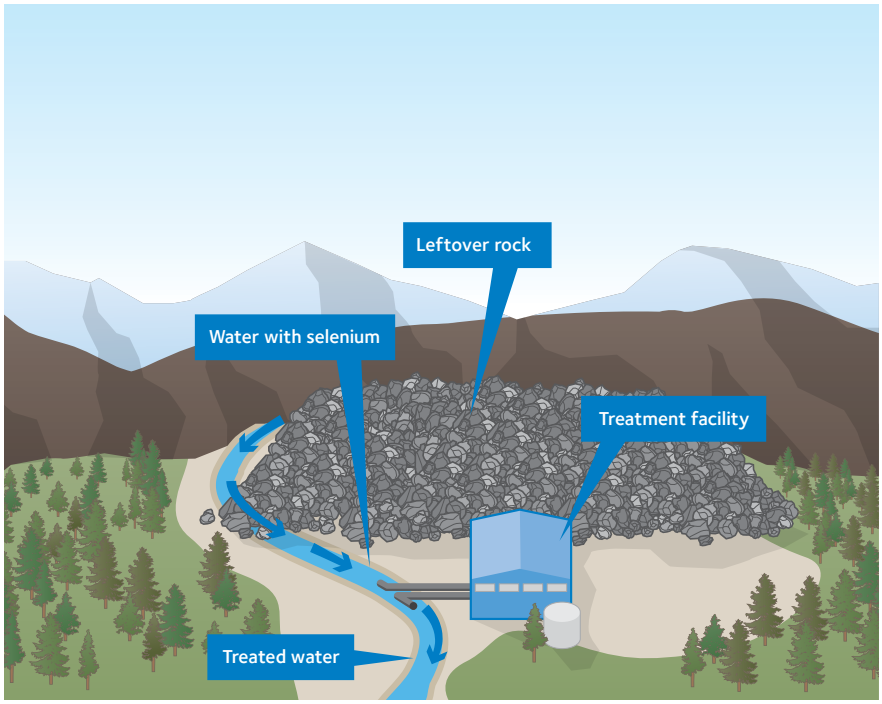


Figure 6-4. Active water treatment of mine-affected water.

Biological treatment relies on microorganisms and is effective at removing nitrate and selenium, and is the industry-preferred active water treatment technology for selenium. The influence of technology selection from a regional planning purpose is limited: concentrations coming out of treatment facilities are assumed to be consistent at 20 µg/L for selenium and 0.3 mg/L for nitrate – the design targets for biological treatment. Current biological treatment technologies do not remove sulphate.

At this time, biological treatment requires the addition of phosphorus for the removal of nitrate and selenium. As outlined in Chapter 4, phosphorous does not currently exceed WQGs in the Designated Area. In recognition that the Designated Area is phosphorous-limited, an evaluation was performed of potential changes in trophic status within the Fording and Elk rivers and in Lake Koocanusa; refer to Annex I.1 and Annex I.2.

In **membrane treatment**, water passes through a thin layer of material that captures all compounds larger than a specified particle size. Membrane treatment has the potential to reduce all constituents of interest, but there are challenges associated with:

- treating water to the point where it is too clean (i.e., constituents need to be added before releasing it back to the receiving streams, to mimic natural water quality)
- management of solids generated from the process
- remaining performance uncertainty, compared to biological treatment.

These challenges, coupled with membrane treatment's greater implementation and operating costs, make biological treatment the preferred treatment technology.

Based on the best available information, it is anticipated that at the point of discharge (end-of-pipe), biological treatment may result in a residual total phosphorus concentration of 0.3 mg/L without additional phosphorous treatment. The Plan's model was used to assess if this residual phosphorus could affect trophic status within the Fording and Elk rivers. As detailed within Annex I.2, the initial implementation plan may change the trophic status of the Fording River from oligotrophic to mesotrophic; while the Elk River would remain oligotrophic. As outlined in Annex I.1, the initial implementation plan is not expected to change the oligotrophic status of Lake Koocanusa.

Once a site is selected, it is estimated that four years are required to build an active water treatment facility. This process is divided into three project stages:

- planning and scoping (8 months)
- engineering and permitting (16 months)
- construction and start-up (24 months).

Water is captured and conveyed to treatment facilities at locations called intakes. Intake locations influence the quantity and quality of the water going to the treatment facility. Many factors contribute to the choice of intake location, including access, safety (avalanche and waste rock pile stability), the desire to collect water with the highest concentrations, and hydrogeological conditions that determine how much mine-influenced water is at surface or in shallow groundwater. In each drainage area, these factors govern how much mine-influenced water is likely to be collected. Based on preliminary information gathered for regional planning purposes, assumptions were made for each catchment and incorporated into the model. During detailed design, site conditions will be investigated to support design decisions, and planning assumptions updated as required.

Construction of Teck's Line Creek active water treatment facility (Figure 6-5) began in the summer of 2012, and the facility is scheduled to begin treating water in the summer of 2014. The facility will treat an average of 7,500 m^3 of water daily — enough to fill three Olympic-sized swimming pools. The treatment facility is anticipated to remove approximately 650 kg of selenium and 40,000 kg of nitrate per year. Planning is underway for a second treatment facility at Fording River Operations.



Figure 6-5. West Line Creek Active Water Treatment Facility, April 2014.

Active water treatment produces residuals that require management. Residuals contain removed constituents as well as other solids generated through the treatment process. Residuals from biological treatment consist primarily of bacterial biomass and selenium, and can be placed in a landfill. Residuals from membrane treatment are sometimes hazardous.

Teck has considered and evaluated methods to manage residuals, including but not limited to:

- beneficial re-use through application on land (e.g., as a soil supplement or fertilizer)
- extraction and recovery of selenium

Unfortunately, selenium concentration in residuals is well above the limit for land application, and cannot be extracted and recovered from the large volumes of water and biomass involved. As a result Teck's current approach is to dewater residuals to a solids content of ~20%, at which point they have the consistency of wet soil, and then to store them in lined containment cells. When full, these storage cells will be capped and covered for long-term storage.

6.2.2.3 Potential Future Option: Saturated Fill Treatment

Saturated fill is waste rock that has been deposited into a pit and then flooded. Areas of saturated fill are common in Elk Valley coal mines, and future sites are included in Teck's mine plans. Early source-control R&D identified the possibility that saturated fills could be used to treat selenium through the microbial reduction of selenate to less mobile forms. Research has confirmed that the microbes needed to treat selenium are present, and there is strong evidence that selenium concentrations in saturated fills are much lower than would be expected in their absence.

In 2013, Teck initiated controlled studies of the saturated fill in the closed Henretta pit at Fording River Operations, to evaluate controls on selenium and nitrate attenuation (Figure 6-6). It was hoped that saturated fills not only treat water that flows through them naturally, but could also treat water from other areas of the site. This semi-passive system could be an attractive alternative to active water treatment plants. As discussed in Section 6.3.2, saturated fill treatment is a high priority for continuing R&D.



Figure 6-6. Testing of Henretta saturated fill, 2013.

6.2.2.4 Potential Future Option: Covers

Teck is evaluating a wide range of waste rock covers or surface treatments with potential roles in water-quality management. The scale at which covers would be needed is an economic challenge, and it is not yet clear whether any of these options will prove feasible, but they indicate the scope of Teck's investigations. Five examples are shown in Figure 6-7:

1. **Bare Waste Covers** are included for comparison only. Freshly placed Elk Valley waste rock has a high permeability and a low fines content, so it will not retain water long enough to support vegetation and provides little protection against water or air infiltration. Over time and depending on rock type, weathering increases the fines content and decreases permeability.
2. **Current Reclamation Covers** for most waste dumps in the Elk Valley include re-sloping dump faces to no steeper than 2H:1V, and directly planting or seeding. Depending on rock type, surface traffic and weathering history, some waste can develop sufficient fines to become a soil-like material.

3. **Simple Covers** make use of salvaged organic and mineral matter, placed as a single-layer cover.
4. **Complex Covers** most commonly include a layer of heavily compacted soil overlain by a layer of uncompacted soil. The lower layer acts as a water barrier, allowing plants rooted in the upper layer to remove it by evapotranspiration. In the work to date, a slightly different complex cover is envisioned, with the lower layer created by intensely compacting the waste surface, followed by placement of an upper layer comprising a mix of salvaged organic matter and mineral soil.
5. **Geomembrane Covers** employ a synthetic liner as a near-impermeable barrier. Most large applications have been limited to tens of hectares, rather than the hundreds needed to cover large dumps in the Elk Valley. Water that cannot infiltrate geomembranes must go somewhere, so a drainage layer is usually included above the geomembrane.

Simple, complex and geomembrane covers may offer the additional benefits of facilitating reclamation and controlling air ingress. Restricting air ingress could improve water quality by limiting oxidation, but this has not been demonstrated.

Soil or fine-grained waste rock covers can also reduce net percolation and rates and water treatment costs. Their effects on water seepage water quality, particularly in suboxic zones, however, have not yet been determined in sufficient detail.

A limitation of all covers is that their full benefits are not realized immediately. Simulations of drain-down times at dumps covered with geomembranes indicate that water would continue to seep out for decades, although at continually diminishing rates. Another limitation of covers is that waste rock dumps deform over time and, until dump settlement has slowed, the risk of damaging a cover system is elevated. Constructability is a further limitation, particularly for more elaborate covers.

As part of any cover project, it would be necessary to identify material sources, establish re-sloping requirements and the associated impacts on undisturbed ground, determine surface-water quality management requirements, and finalize many other site-specific details.

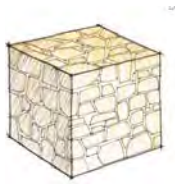
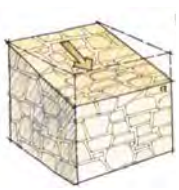
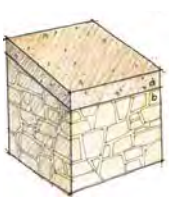
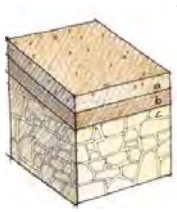
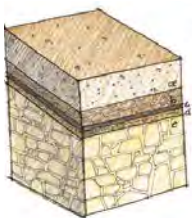
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<tr><td>Waste slopes re-shaped to 3H:1V</td><td>Waste re-sloped to 3H:1V & proof-rolled</td></tr>
<tr><td>Net Percolation (% of Mean Annual Precipitation)</td><td>> 50%</td><td>> 40%</td><td>~ 30%</td><td>~ 20%</td><td>< 5%</td></tr>
<tr><td>Design & Construction Complexity</td><td></td><td colspan="3">→ Increasing complexity, cost and additional disturbance →</td><td>Significant technical challenges</td></tr>
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Figure 6-7. Summary of cover types.

6.3 Continuing R&D to Advance Future Options

New technologies and water-quality management methods, either now in the R&D phase or expected to emerge in coming years, have the potential to reduce the long-term reliance on active water treatment. Although these new technologies and methods are not yet advanced enough to be included in the initial implementation, they need to be considered for later iterations of the Plan.

6.3.1 Approach to Technology Development

Teck's overall approach to advancing technologies from initial research to full deployment consists of the follow steps:

1. Identify basic knowledge and technology.
2. Identify sites for full-scale implementation.
3. Bound the risks.
4. Prioritize implementation technologies and sites.
5. Implement at full scale.
6. Monitor and improve first implementation.
7. Consider broader technology applications within mine plans.

Many of the above steps include sub-tasks. For example, bounding the risks for active water treatment technologies usually requires a pilot-scale test. Teck does not include such sub-tasks in the general steps, because they are not always needed.

The emphasis is on bringing technologies to a first full-scale implementation (Step 5). The results can be monitored and used to assess the value of further implementations, at a level suitable for comparison to the water-quality management options that were selected for initial implementation.

The emphasis on the first full-scale implementation also reflects two realities of many mine-environmental technologies. First, the full effects and costs of a mine environmental technology are often incompletely understood, and sometimes hotly debated, before full implementation. Second, site-specific conditions often mean that a technology must be modified in a site-specific manner. Both of these factors challenge the typical R&D paradigm in which technologies are proven at a small scale and then broadly rolled out without further changes. Teck's approach does not expect R&D to prove technology benefits, but only to provide the basic understanding (Step 1) and to constrain the risks (Step 3) to a level at which full-scale implementation can proceed with confidence.

6.3.2 Specific Technology Development Activities

Teck's long-term commitment to R&D is discussed further in Chapter 10. The main themes over the next two years are as follows:

- Source-control R&D currently addresses the semi-passive treatment of water in backfilled pits (saturated fills). The geochemical conditions that develop in these saturated fills favour microbial communities that can remove selenium and nitrate. Evidence that this process occurs in Teck's pits has already been found, and testing will focus on whether it is a reliable treatment method. Plans for the next two years include laboratory investigation of the underlying microbial and chemical processes, including rate-limiting factors and the risk of unfavourable reactions. An investigation of a saturated fill that is believed to be a good candidate for full-scale implementation will be initiated with a view to pilot scale trails in 2015.

- Covers are another focus of source-control R&D. Two lines of investigation are moving ahead in the next two years. One is an engineering review to determine if there are ways to construct geomembrane covers more cost-effectively and with less impact on the surrounding areas. The other is continued monitoring of cover and reclamation trials begun in 2012; data from these sites are providing a strong basis for assessing the possible effectiveness of soil covers for reducing water ingress and supporting reclamation.
- Design of capture and diversion systems associated with new active water treatment facilities will apply findings from the hydrology and groundwater components of the R&D program. Site-specific investigations will transform this body of work from research into practical application.
- The active water treatment program will continue to track known technologies, with additional bench testing where warranted. A separate initiative is underway to determine whether completely new methods have longer-term potential. The program will also continue to investigate options for managing residuals. To date, R&D on residuals has focused on improving knowledge, by analyzing residuals generated from pilot-scale and analogous full-scale treatment facilities. This will be extended to studying residuals generated from Teck's Line Creek active water treatment facility when it begins treating water in the summer of 2014. Information gathered through R&D on residuals will inform and facilitate the permitting and design of future active water treatment facilities and the long term residuals management strategy.
- In 2012, Teck begin development of a nitrate management plan to reduce nitrate losses from blasting. The limits of improved blasting practices were defined, and the focus shifted to alternative explosives technologies to reduce nitrate losses at source. After reviewing potential options, High Viscosity Emulsion (HVE) products were selected for further evaluation. In 2013, lab evidence was collected that HVE reduces nitrate leachate. Field trials have been conducted, and preliminary results are positive and consistent with lab results. Teck intends to adopt HVE as a leading method of reducing nitrate entering the environment.
- Calcite R&D is discussed further in Chapter 7.

The above summarizes the current plan, but is subject to change based on a number of factors and conditions, including further monitoring, results from the initial implementation plan, changing conditions in the valley, economic and other factors.

Chapter 7
Calcite Management

Chapter Overview

This chapter describes Teck's study of the formation of calcite in mine-affected streams and other streams not affected by mining. It outlines options to manage the formation of calcite in the Elk Valley watershed; medium- and long-term targets established for the rate of calcite formation; and proposed actions to achieve the targets.

Concordance with Ministerial Order and Terms of Reference

Chapter 7 satisfies the calcite-related components of Section A.1 and A.2, Section A.3(b), SectionB.5, B.7(a), B.13 and part of B16 of Schedule C of Ministerial Order M113 and Section 2.0(c)(ii), Section 3.3(a), Section 3.7, part of Section 3.8(a), Section 3.8(d), Section 3.9(b), Section 3.10(b), part of Section 3.11(a)v and (c), part of Section 3.13 and part of Section 3.16 of the Elk Valley Water Quality Plan Terms of Reference.

Chapter Highlights

- **Targets established**:
  - Limited data exist to establish a final target Calcite Index, based on a scale from 0.0 (no calcite observed) to 3.0 (stream bed fully concreted). However, 2013 results identified reference streams with a Calcite Index ≤0.50, which was established as the long-term target in mine-exposed streams that provide habitat or other value to fish.
  - A Calcite Concretion Score of ≥0.50 (out of a possible 2) was used to identify priority streams to be managed in the medium term. Achieving medium-term targets will take up to 10 years, and 15 years will be required to meet the long-term targets. For these streams, the goal will be to reduce the Calcite Index to below the long-term target.
  - Calcite targets, in terms of both levels of calcite and the timing of remedial actions, will be adaptively managed as implementation of the Plan proceeds. The long-term Calcite Index target will be reviewed as more data become available, and should be viewed as an interim target.
- **Protection of aquatic habitat in affected streams.** Calcite will be managed to achieve acceptable long-term targets. Long-term targets will be developed, taking into account the purpose of the Plan as stated in Section 1.2 of Chapter 1.
- **Priorities identified based on levels of calcite and potential impact on fish.** Of 352 km of streams surveyed in 2013, 89% had calcite formation levels (as measured on the Calcite Index) similar to that observed in streams not affected by mining. Four streams – Greenhills Creek, Corbin Creek, Dry Creek and Erickson Creek – were identified as priority streams because calcite formation is in the upper range as measured by a Calcite Concretion Score, and because they support fish habitat.
- **Evaluation of technologies to determine the best for implementation at a priority stream within three years.** Teck is studying several calcite treatment methods and technologies that can run unattended for extended periods, require few or no reagents, generate little or no waste, can accommodate variable amounts of water, and require minimal infrastructure.
- **Adaptive management.** As more data are collected, the calcite management plan will be adapted and adjusted.

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7.1 Introduction

The molecular source of calcite, calcium carbonate, is common in natural streams and poses a water-quality concern only when its rate of accumulation harms stream-bed habitats. This chapter describes the environmental issues and technological options involved in managing calcite formation.

Calcite formation has been observed in the Elk Valley watershed downstream of mining activities and, to a lesser extent, in reference streams unaffected by mining. In limited reaches of certain streams, calcite precipitation completely covers portions of the stream bed, making the gravels largely immovable.

In 2008, a survey of calcite occurrence in the Elk Valley was initiated (Berdusco 2009), and Teck recently refined the monitoring program to quantify, monitor and assess potential effects of calcite deposition within the watershed. By reviewing results of the survey, targets can be established and streams prioritized for calcite management. An evaluation of potential technologies to manage calcite precipitation in the receiving environment is also underway.

As the extent of calcite formation in the Elk Valley and its potential effects on the aquatic environment become clear, targets and methods to meet the overall objective will be refined. The overall objective is to manage calcite to achievable long-term targets. Interim long-term targets have been developed that take into account the purpose of the Plan as stated in Section 1.2 of Chapter 1.

7.2 Calcite Formation

The chemistry of calcite formation involves two steps, both of which present management opportunities. Step 1 occurs as water drains from waste rock spoils, where it absorbs elevated levels of calcium and carbonate along with carbon dioxide. CO_2 is released as the water seeps from the spoils. This increases the pH of the water, creating a chemical condition favourable for Step 2, the precipitation of calcium carbonate. This condition involves the critical saturation index of calcite. Within a spoil, the saturation index is lower than the critical value, meaning calcium carbonate can remain dissolved. But downstream, the index can exceed the critical value, which leads to precipitation of calcite. Precipitation continues until calcium and carbonate fall below critical levels.

The rate of calcite precipitation varies with each stream's chemistry, nutrients, temperature, topography, velocity, and turbulence (Hammer et al. 2005). Some of these factors change daily, while others are seasonal. Algae, moss and other organisms in the stream bed also affect the chemistry of precipitation. Managing calcite build-up is further complicated by the fact that the chemical conditions that lead to calcite formation can reduce other constituents of concern (SRK 2011).

Calcite precipitation does not occur instantaneously, but depends on several factors:

- rates of CO_2 off-gassing
- availability of a site for the calcite crystal to begin growing
- inhibition of precipitation (e.g., magnesium ions or phosphorous compounds)
- slow transformations between bicarbonate (HCO_3-) to carbonic acid (H_2CO_3).

Groundwater within the Elk Valley is supersaturated with Ca-Mg-Fe carbonates (Harrison et al. 2000) and as such, precipitation of calcite at groundwater discharges/seeps into streams/tributaries is common.

The scaling formed in kitchen kettles or hot-water heaters involves a similar chemistry. It is not toxic, and can occur naturally; but excessive calcite build-up can change the characteristics of stream beds by cementing rocks together and affecting habitat for fish and invertebrates.

7.3 Monitoring and Assessment

The 2008 calcite survey focused on the geochemistry of calcite deposition and the presence or absence of calcite. It did not provide sufficient information to quantify the rate of calcite deposition/dissolution downstream of mining activities, or to guide the design of biological monitoring programs. In 2013, however, a program was developed to quantify, monitor, and assess potential effects of calcite deposition in the Elk Valley. Objectives of the program were to:

- standardize the methodology for data collection and reporting of calcite deposition
- document the extent and degree of calcite deposition
- determine trends (i.e., rates) of calcite deposition
- assist in determining if, when, and where calcite mitigation is required.

To achieve these objectives, all mine-exposed streams in the receiving environment (i.e., downstream of areas disturbed by mining) were surveyed. Where settling ponds control suspended solids, the receiving environment is considered as downstream of such constructed works.[1]

The program also monitors reference streams to provide data on the extent, degree, and rate of natural calcite deposition. Reference streams are considered persistent over the long term, and are far from mines. Their selection considered the natural variation in abiotic factors (i.e., elevation, stream order, geology, and channel morphology), and used three steps:

- Characterize exposure reaches by stream order, bedrock geology, spatial distribution, and channel morphology.
- Review reference sites from past calcite monitoring and other programs such as the RAEMP or current baseline assessments, and select appropriate locations using reach characteristics.
- Review additional areas as required to represent the spectrum of stream characteristics observed in exposure areas.

The program is described fully in Annex J.1.

7.3.1 Methods

The monitoring program quantifies and describes the extent and the degree of calcite deposition. These measurements are used to calculate a Calcite Index. Observations on types and characteristics of calcite deposits are also collected (e.g., calcified algae, calcified moss/tufa, barrage tufa, calcite scale, and/or insect tufa).

The Calcite Index is used to quantify and monitor calcite deposition within the Elk Valley watershed. These data, in association with information on the types and the characteristics of calcite deposits, can be used to refine environmental monitoring study designs (e.g., inform site selection).

7.3.2 Extent of Calcite Deposition

The extent of calcite deposition describes the spatial coverage expressed on two scales. The first is the sampling-site scale (areal extent); and the second is the reach scale (linear extent). Detailed measurements at the sampling-site scale are extrapolated to quantify calcite deposition over the reach.

Sampling-site scale (areal extent): A modified Wolman pebble count procedure is used to estimate calcite extent at a sampling site. The standard Wolman 1954 pebble count procedure requires an observer to move systematically over the area of interest, stopping periodically and randomly selecting a particle for observation. This procedure is repeated until 100 particles with diameters >2 mm (e.g., gravels) are measured. Smaller particles are recorded as fines. An estimate of areal calcite coverage is derived from these data.

[1] The calcite monitoring program does not, nor is it intended to, address mine works as authorized under EMA authorizations.

To ensure that measurements made on the sampling-site scale are representative of the reach scale, pebble counts are conducted within up to four habitat types per site. Habitat types are generally the Type 2 habitats outlined in Johnston and Slaney 1996, and include riffles, cascades, pools and glides. Pebble counts are completed to cover the relative proportions of habitat types observed.

Reach scale (linear extent): The linear extent of calcite deposition is estimated by aggregating sample site results. Depending on the length of the reach, up to three sites are surveyed on each reach, and the results are averaged to provide an overall value for the Calcite Index by reach.

7.3.3 Degree of Calcite Deposition

This term is used to describe calcite deposition at a given location (i.e., the level of stream-bed concretion). Estimates are derived from the level of effort required to remove a particle by hand from the stream bed, as detailed in Table 7-1.

Table 7-1. Derivation of calcite deposition scores.

Resistance	Degree of deposition	Score
Negligible	Not concreted	0
Noticeable, but removable	Partially concreted	1
Immovable	Fully concreted	2

7.3.4 Calcite Index

The Calcite Index expresses the extent and the degree of calcite deposition as a single measure, providing an objective metric that can be applied throughout the Elk Valley watershed. For each reach, a Calcite Index is calculated by summing the extent and degree of calcite precipitation:

Where:

$$CI = CI_p + CI_c$$

$$CI = Calcite\ Index$$

$$CI_p = Calcite\ Presence\ Score\ = \frac{Number\ of\ pebbles\ with\ calcite}{Number\ of\ pebbles\ counted}$$

$$CI_c = Calcite\ Concretion\ Score = \frac{Sum\ of\ pebble\ concretion\ scores}{Number\ of\ pebbles\ counted}$$

The Calcite Presence Score ranges from a value of 0.00 (no calcite observed) to a possible maximum of 1.0 (every pebble has calcite). The Calcite Concretion Score ranges from 0.0 (no pebbles are concreted) to 2.0 (every pebble is fully concreted). The Calcite Index is therefore expressed on a scale from 0.0 (no calcite observed) to 3.0 (stream bed fully concreted), as shown in Figure 7-1. The annual rate of calcite deposition/ dissolution and its variability both spatially and temporally can be quantified and monitored using the Calcite Index. Specifically, the annual rate of calcite formation will be calculated and reported using:

where:

$$\frac{d(CI_{MI})}{dt} = \frac{CI_{MI}(t+1) - CI_{MI}(t)}{(t+1) - t}$$

$$CI_{MI} = Calcite\ Index\ of\ a\ stream\ (reach\ specific)$$

$$t = time\ (years)$$

For example, if a reach has a Calcite Index of 0.56 in 2013 and 0.32 in 2014, the rate of calcite formation for that reach would be reported as -0.24/year, with the negative value representing an overall reduction in calcite formation.

The pebble count provides a standard approach to data collection and the reporting of calcite deposition. These data are used to calculate a Calcite Index for the extent and degree of calcite deposition in the Elk Valley watershed, and permit the determination of rates (trends) of calcite deposition. The Calcite Index can be used to inform environmental study designs and EMA-authorized monitoring programs (e.g., RAEMP), and interpret monitoring results. The Calcite Index will also be used to assist in determining if, when, and where calcite mitigation is required.

7.3.5 2013 Monitoring Results

The first year of monitoring using the methods detailed above was completed in 2013, and included all mine-exposed streams in the receiving environment and selected reference stream reaches. Results, showing Calcite Index by reach, are presented in Annex J.3.

7.3.5.1 Low Calcite Index (0.00 – 0.99)

Reaches with low mean Calcite Index scores represented 94% of the 352 km of streams surveyed. Sampling sites within this range had variable levels of calcite and lacked concretion (Figure 7-1). All reference stream reaches fell within this range, with Alexander Creek recording the highest reference Calcite Index of 0.48.



Figure 7-1. Typical conditions at a reference stream during 2013 sampling (Grace Creek Reach 1, with Calcite Index = 0.30).

7.3.5.2 Mid-Range Calcite Index (1.00 – 1.99)

Reaches with mid-range Calcite Index scores represented about 3% of the length of the streams surveyed. These sites had a minimum of 65% of pebbles with calcite present, and concretion scores averaging 0.75 out of a possible 2. Stream-bed particles were distinguishable but conglomeration was apparent (Figure 7-2).



Figure 7-2. Conditions at a mine-influenced stream during 2013 sampling (Greenhills Creek Reach 3, with Calcite Index = 1.30).

7.3.5.3 Upper Calcite Index (2.00 – 3.00)

Reaches with upper-range Calcite Indexes occurred in nine streams, represented by 14 reaches and about 3% of the streams surveyed. Reaches had a minimum of 83% of pebbles with calcite present, and had extensive concretion. Most stream-bed particles could not be removed by hand. In many areas, they were completely covered and were no longer visible due to the thickness of the calcite deposit (Figure 7-3). In some cases, channel morphology was affected; some terracing (barrage tufa) was noted.





Figure 7-3. Conditions at a mine-influenced stream during 2013 sampling (Cataract Creek Reach 1 with Calcite Index = 3.00).

7.3.6 Summary of Monitoring Results

Results from the 2013 monitoring program are illustrated in Figure 7-4.

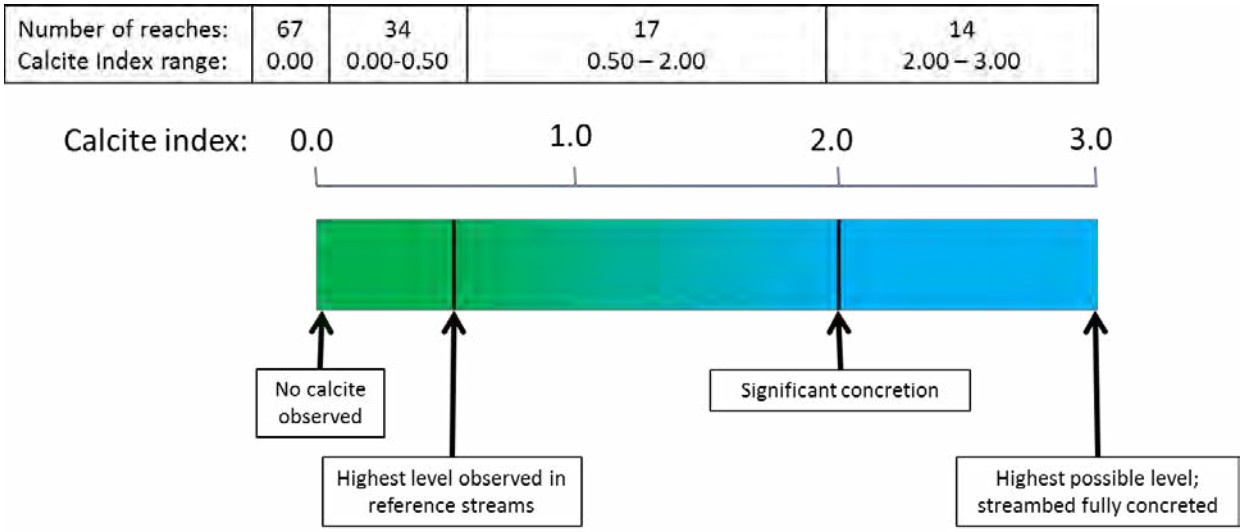


Figure 7-4. Calcite Index scores in the Designated Area during the 2013 monitoring program.

Calcite Index ranges or "bins" were created to describe the distribution of stream length over a range of Calcite Index scores. Of the over 352 km of stream surveyed (287.5 km exposed and 64.7 km reference), 89% of the exposed streams had a Calcite Index similar to that observed in reference streams (≤0.50; see Table 7-2).

Table 7-2. Calcite Indices and associated stream lengths surveyed in 2013.

Calcite Index range	Reference				Exposed			
	Fording and Elk		Tributaries		Fording and Elk		Tributaries	
	km	%	km	%	km	%	km	%
0.00-0.50	21.8	100	42.9	100	143.0	97	111.5	80
0.51-1.00	0	0	0	0	4.7	3	9.4	7
1.01-1.50	0	0	0	0	0	0	5.1	4
1.51-2.00	0	0	0	0	0	0	6.3	4
2.01-2.50	0	0	0	0	0	0	2.8	2
2.51-3.00	0	0	0	0	0	0	4.7	3
Total	21.8	100	42.9	100	147.7	100	139.8	100

A summary of results for the 2013 calcite monitoring program are provided in Annex J.3, with an overview of the streams and associated reaches surveyed illustrated in Figure 7-5.

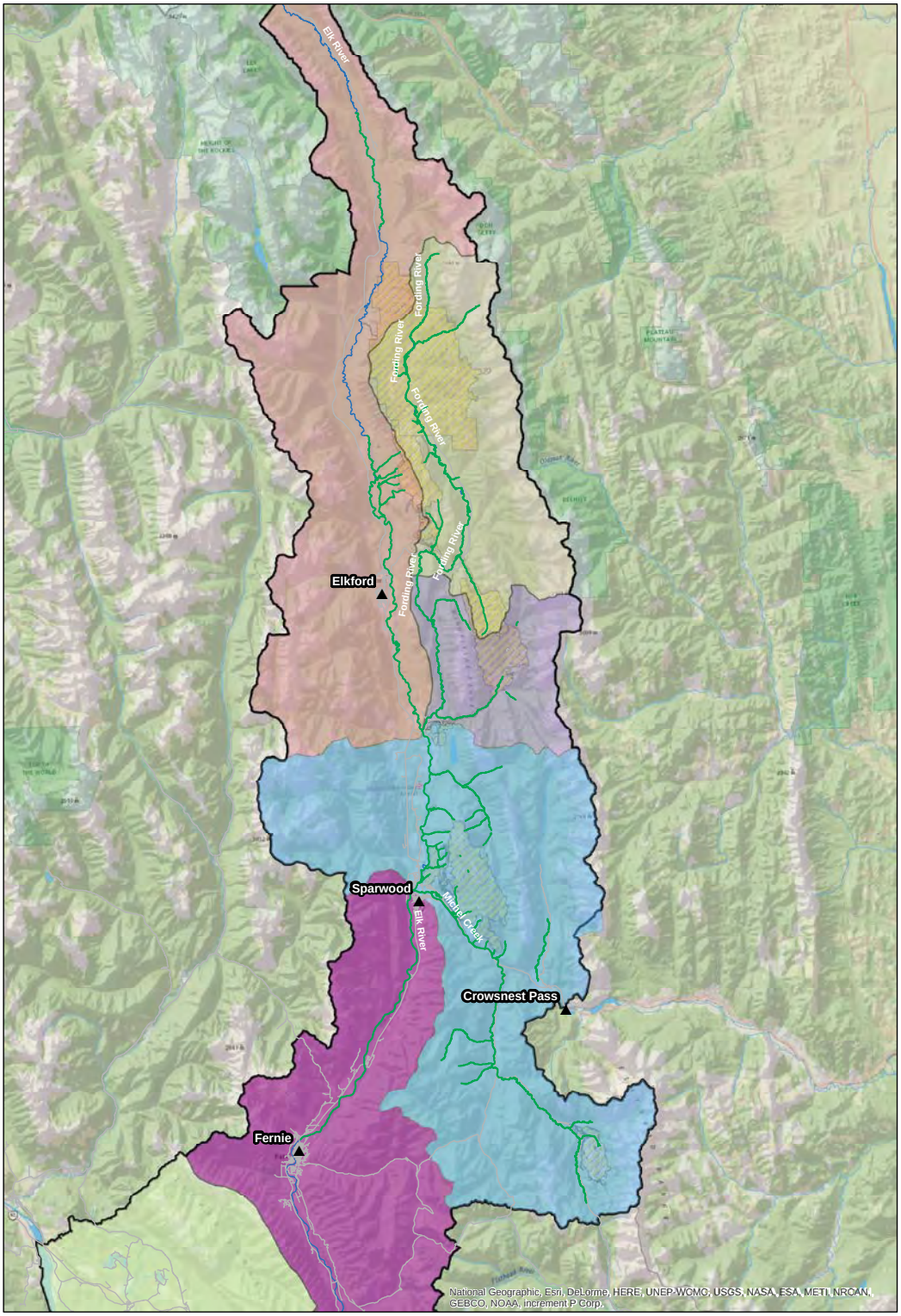


Figure 7-5. Calcite survey locations (2013). Note: The different shading represents Management Unit limits.

An example of the level of detail recorded in each of the surveyed streams and reaches (mine-exposed and references) is provided in Figure 7-6. A complete set of maps depicting the results at all streams is provided in Annex J.3.

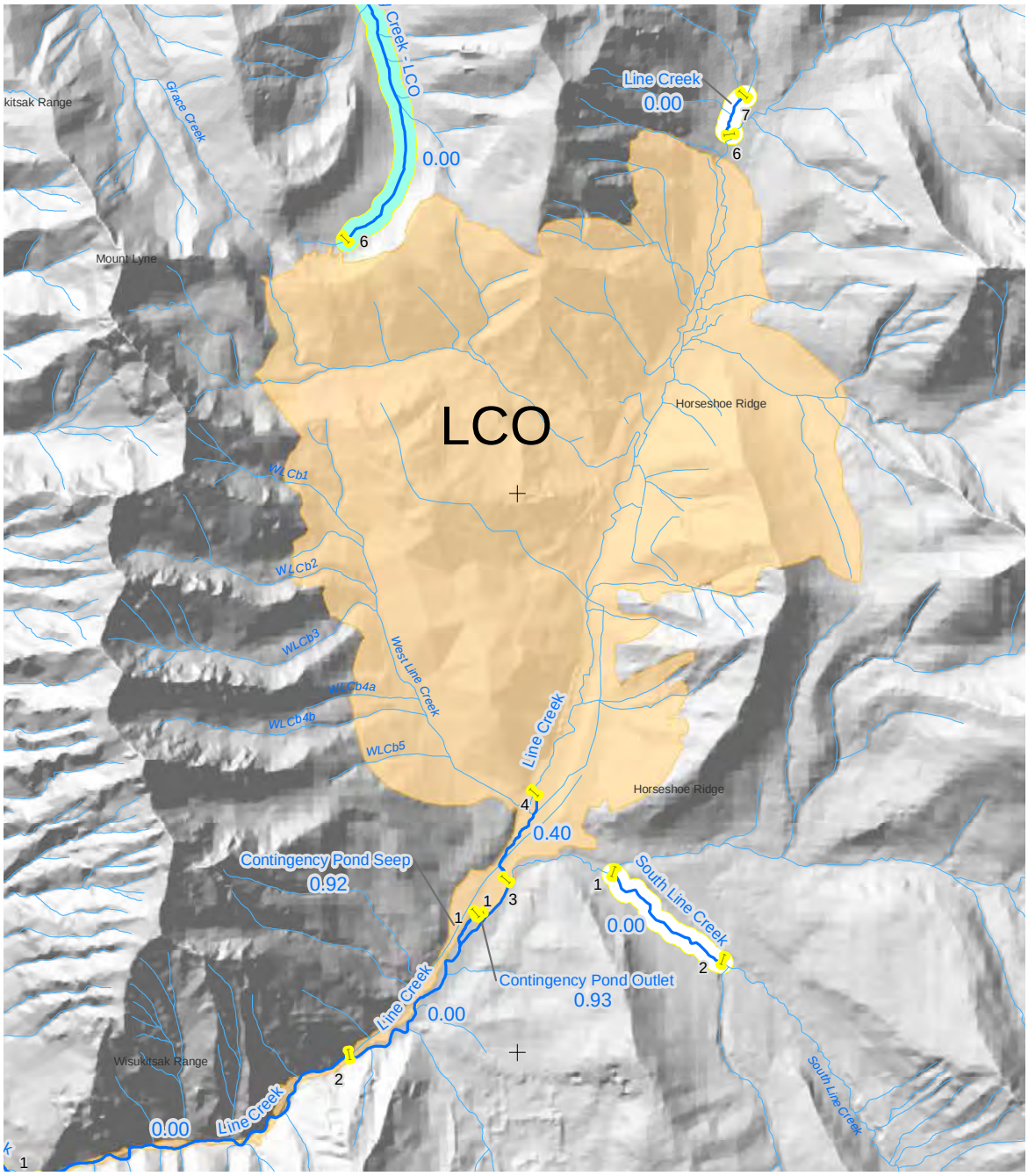


Figure 7-6. Calcite Index results from streams surveyed near Line Creek Operations in 2013.
Note: Mine-exposed reaches (in blue), reference reaches (white outline), and reaches which are expected to be mine-exposed in the future (green outline).

7.3.7 Calcite as a Physical Stressor

As illustrated by Figure 7-7, calcite precipitation can affect the aquatic habitat including stream substrate, stream bank vegetation, riparian areas, and channel morphology (Hlushak 2012). Alterations to these habitat components may directly affect benthic invertebrates and periphyton, which in turn may affect other receptors (SRK 2011).

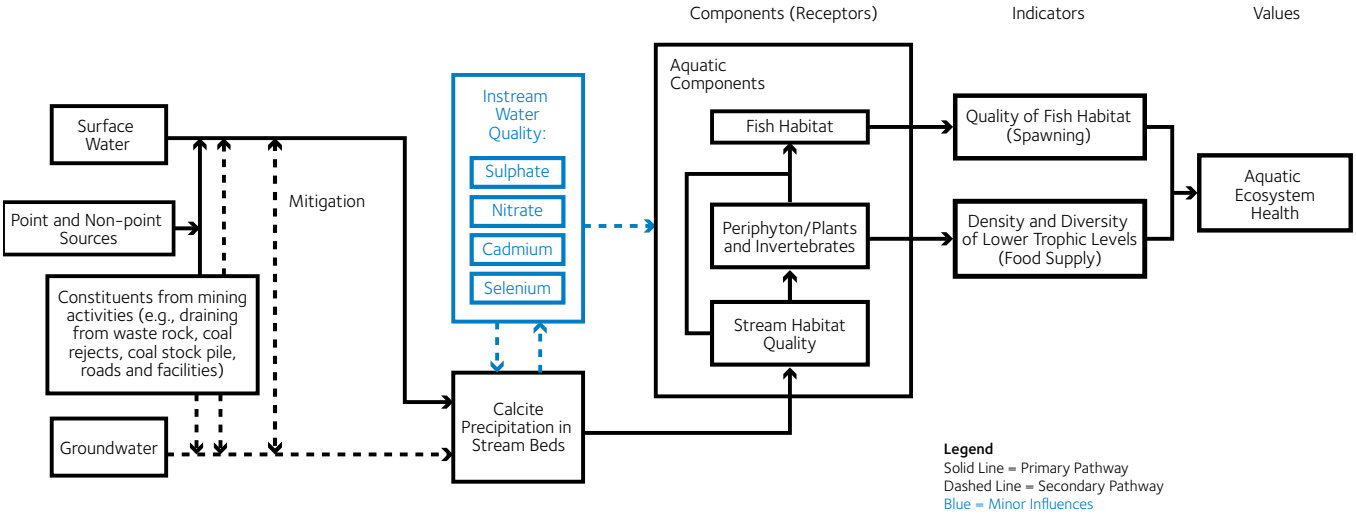


Figure 7-7. Calcite precipitation influence diagram.

Variations in invertebrate community composition and abundance have been related to elevation, latitude, water temperature, water velocity, water depth, light intensity and substrate characteristics, among other variables (Jacobsen et al. 1997; Quinn et al. 1994). Given that each invertebrate species has specific substrate requirements, it is reasonable to expect that substrate manipulation (e.g., calcite precipitation) may directly affect the aquatic invertebrate community and indirectly affect aquatic-dependent receptors (e.g., benthivores).

In addition, SRK 2011 demonstrated that calcite can reduce the availability of constituents of interest by incorporating (i.e., co-precipitating) trace elements from the water column. These elements include, but are not necessarily limited to, cadmium, magnesium, manganese, nickel, selenium and zinc.

7.4 Narrative Objective and Targets

The narrative objective[2] for calcite management is to understand and manage mine-related calcite formation such that stream-bed substrates in the Elk and Fording rivers and their tributaries can support abundant and diverse communities of aquatic plants, benthic invertebrates, and fish comparable to those in reference areas.

As 2013 was the first year of calcite monitoring, there are limited data to establish a final target Calcite Index at this time. However, 2013 results identified reference streams with a Calcite Index ≤0.50 (i.e., Alexander Creek Reach 2). Consistent with the calcite precipitation influence diagram developed in association with the TAC, and per advice received from by the TAC (Meeting No. 6), calcite concretion (rather than presence) may contribute to the physical stress in the environment. In consideration of the TAC's advice and for the purposes of the initial implementation plan, a Calcite Index of 0.50 was established as the long-term target value. A Calcite

[2] Section 3.7 of the Terms of Reference stipulates that "the Plan will, for the purpose of establishing medium and long-term targets, articulate narrative objectives to guide calcite management."

Concretion Score of ≥0.50 was used to identify priority streams to be managed in the medium term. Although management measures will begin immediately, achieving medium-term targets will take up to 10 years, and 15 years will be required to meet the long-term targets. This timing reflects ongoing evaluations associated with development of calcite control and remediation technologies discussed in Section 7.6. Furthermore, calcite targets (levels and timing) will be adaptively managed as outlined in Section 7.7. Medium- and long-term targets are summarized below.

Long-Term Target: Calcite Index ≤0.50 in mine-exposed streams in the receiving environment which provide habitat to fish or directly provide other valued aquatic ecosystem components for fish. The long-term Calcite Index target will be reviewed as more data become available, and should be viewed as an interim target.

Medium-Term Target: For streams identified by a Calcite Concretion Score ≥0.50, reduce the Calcite Index to below the long-term target of 0.50. Priority streams selected for treatment are mine-exposed streams in the receiving environment that provide habitat to fish or directly provide other valued aquatic ecosystem components for fish.

A decision framework was developed to guide the selection of mine-affected streams in the medium term (Figure 7-8). In this framework, "Receiving Environment" refers to portions of streams downstream of constructed works, such as settling ponds, culverts and similar structures. The framework provides an overlap with the mine planning process, in that streams subjected to future mine-related activity, and for which comprehensive management plans have or will be developed, are not prioritized for calcite management in the medium term, while streams that remain intact are prioritized.

A stream known to be non-fish-bearing and that does not provide direct surface water to fish-bearing streams will not, at this time, be considered in the establishment of calcite targets. For example, because Kilmarnock Creek is not a fish-bearing stream and does not provide direct overland flow to a fish-bearing stream (i.e., the Fording River), it is not identified for calcite management even though calcite has been recorded in its reaches.

The decision framework was used to select streams for management action in the medium-term by assessing mine-impacted streams with a Calcite Concretion Score ≥0.50. The process was used to assess 22 reaches, and results of the process are presented in Table 7-3.

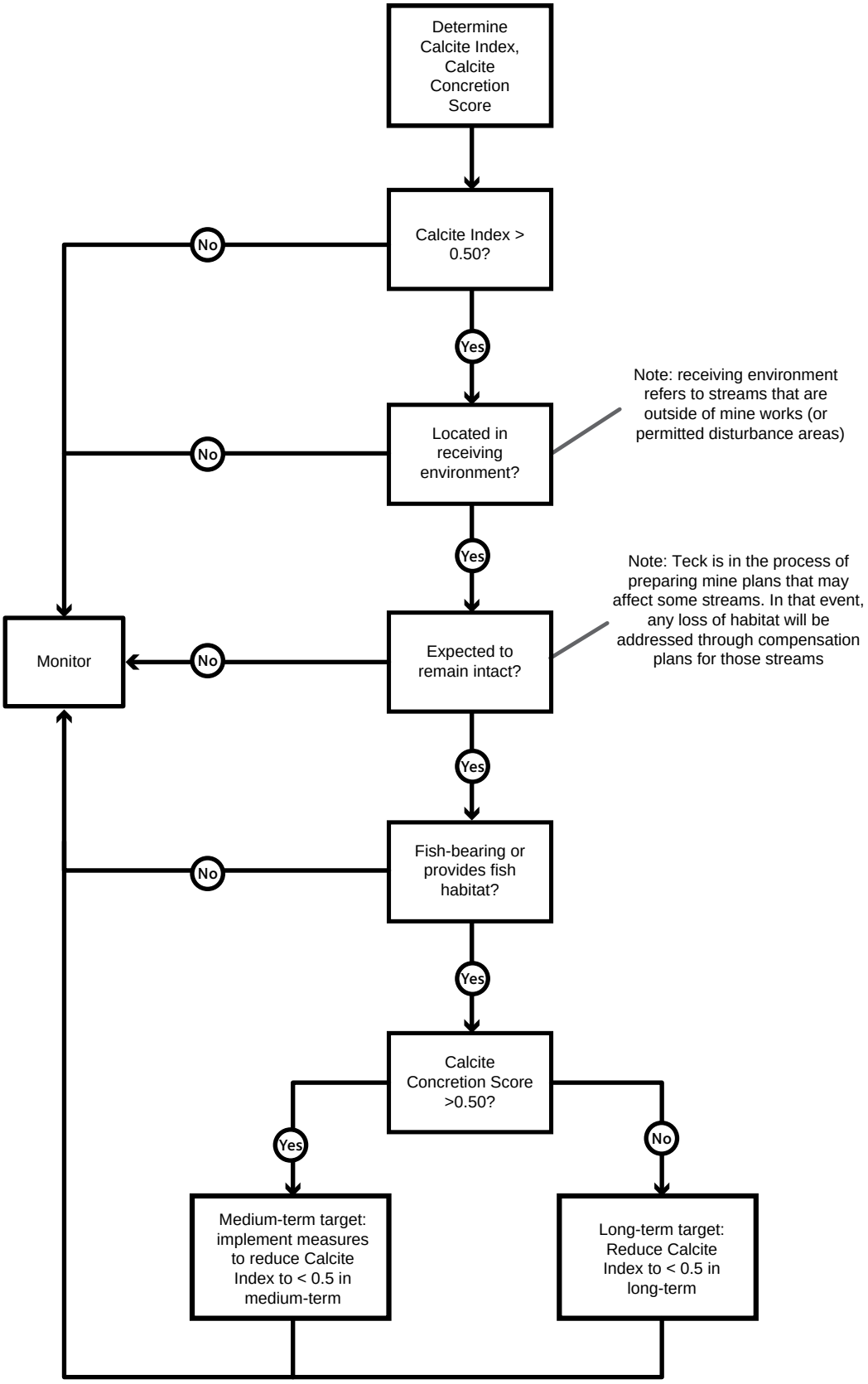


Figure 7-8. Decision framework to identify streams for medium- or long-term calcite targets.

Table 7-3. Streams to be managed in the medium term based on the Decision Framework and 2013 calcite monitoring results.

Stream	Reach	Concretion score	Receiving environment?	Remain intact?	Fish-bearing?	Action?
Kilmarnock Creek	1	1.33	No	na	na	monitor
Porter Creek	3	1.80	No	na	na	monitor
Smith Pond Outlet	1	1.72	No	na	na	monitor
Wolfram Creek	3	1.93	No	na	na	monitor
South Wolfram Creek	1	1.00	No	na	na	monitor
Swift Creek	1	1.71	Yes	Yes	Yes: See Note[5]	See Note[1]
Cataract Creek	1	2.00	Yes	Yes	Yes: See Note[5]	See Note[1]
	2	0.89	No	na	na	monitor
	3	2.00	No	na	na	monitor
Corbin Creek	1	0.99	Yes	Yes	Yes	Yes
	2	1.74	Yes	Yes	Yes	Yes
Dry Creek (Elkview)*	1	1.38	Yes	Yes	Yes	Yes: See Note[3]
	2	1.38	No	na	na	monitor
	3	1.35	No	na	na	
	4	0.68	No	na	na	
Erikson Creek	1	1.36	Yes	Yes	Yes	Yes: See Note[4]
	2	0.89	Yes	Yes	Yes	Yes: See Note[4]
	3	1.40	Yes	Yes	Yes	Yes: See Note[4]
Bodie Creek	3	0.52	No	na	na	monitor
Eagle Pond Outlet	1	0.90	Yes	Yes	No	monitor
Greenhills Creek	3	0.47	Yes	Yes	Yes	Yes: see Note[2]
	4	0.84	Yes	Yes	Yes	

Note[1]: As part of the proposed Swift Project, Cataract and Swift Creek flows will be diverted to an active water treatment facility; the resulting loss of stream flow will be addressed through the Environmental Assessment for the Swift Project.
Note[2]: Although Reach 3 of Greenhills Creek does not meet the 0.50 prioritization criteria, it has been included because it is adjacent to reach 4 with a concretion score of 0.84.
Note[3]: Loss of habitat in Reach 3 as a result of future mine plans will be addressed through a compensation plan that will be part of the Baldy Ridge Extension Project, which is currently under development.
Note[4]: Flow may be taken to a water treatment plant; calcite management will be coordinated accordingly.
Note[5]: Although both Swift and Cataract are not known to be fish-bearing, Reach 1 of these streams have been included as "fish habitat" for the purpose of this selection, as they are directly connected through surface flow to the Fording River.
Note*: There are two streams named "Dry Creek" one is at Elkview Operations; the other is at Line Creek Operations.
Creeks identified as "Yes" for Action have been selected as priority streams for calcite management in the medium-term.
Note na = not applicable as determined using the decision framework for calcite.

7.4.1 Priority streams

Four streams – Greenhills Creek, Corbin Creek, Dry Creek, and Erickson Creek – were identified as the priority streams for calcite management. These streams are shown on Figure 7-9. Management actions are designed to attain the medium-term targets stabilizing and reducing further calcite formation, and achieving a Calcite Index below the long-term target of 0.50 (or as refined in consideration of reference conditions). The long-term calcite target will be refined as additional monitoring data in reference and mine-exposed streams become available.

7.5 Implementation

To meet medium-term targets, the following steps have already been initiated or will be followed:

Step 1: Treatment Technology Evaluation and Selection. A review of treatment technology options for calcite mitigation is ongoing. As suitable technologies are identified, and considering site-specific constraints, viable treatment technology options will be tested, selected, and incorporated into design and construction plans based on their effectiveness, environmental safety, and social and economic considerations. Treatment technologies under consideration are summarized in Section 7.6.

Step 2: Design and Construction. Construction will begin after an assessment of the technology has been completed and permits obtained.

Step 3: Operation. The treatment system will be operated as necessary (e.g., seasonally) to maintain the Calcite Index at or below the target.

Step 4: Stream Rehabilitation. Depending on the treatment technology, it may be necessary to rehabilitate the stream substrate. Before starting any in-stream work, an assessment will be made of the change in rate of calcite formation. If the stream shows signs of restoration without further intervention, physical rehabilitation may not be required. Should rehabilitation be necessary, methods will be evaluated and selected.
Step 5: Monitoring. Streams prioritized for calcite management in the medium term will continue to be monitored for calcite formation before and after treatment.

Step 6: Adaptive Management. Teck will monitor, conduct research, re-evaluate control methods, and refine targets (scores and timelines) if necessary.

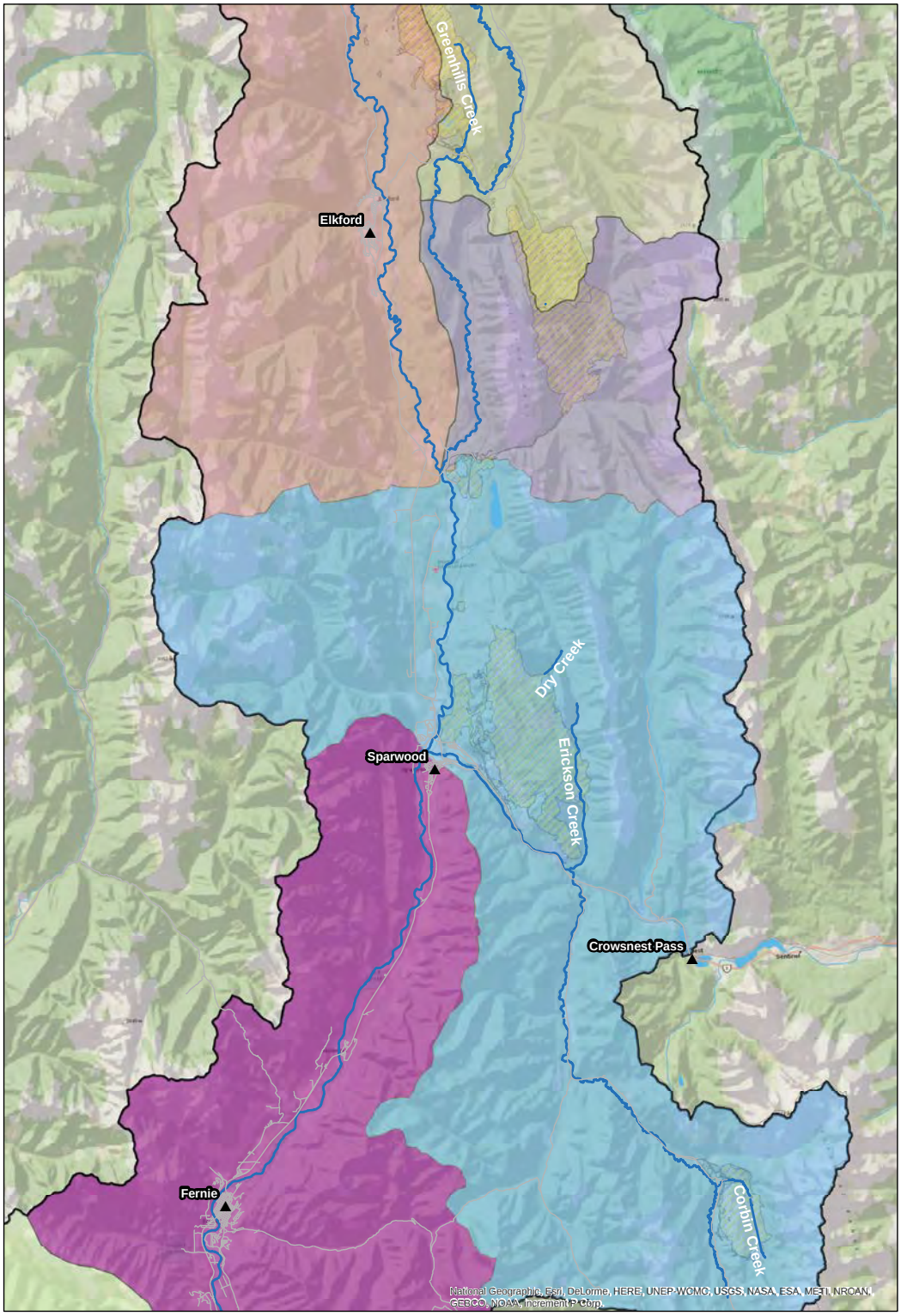


Figure 7-9. Medium-term target streams: Greenhills, Corbin, Erickson and (EVO) Dry creeks.

7.6 Treatment Technology Options

Work to date has identified several calcite treatment methods and technologies, as described in the sections that follow:

1. alkalinity reduction
2. constructed cascades
3. antiscalants
4. pond treatment
5. trickling filters
6. ultrafine limestone or precipitated calcium carbonate (PCC).

These technologies have been chosen for evaluation because they can be designed to run unattended for extended periods (weeks or months), require few or no reagents, generate little or no waste, can accommodate large and variable flows, and require minimal infrastructure. In contrast, alternative proven treatment techniques such as lime addition (to raise the pH to convert excess dissolved CO_2 to carbonate and precipitate calcium carbonate) are energy-intensive, and generate considerable waste.

Some treatment options have the potential to affect other water quality parameters (i.e., constituents of interest). For example, calcite precipitation can sequester trace amounts of cadmium as a carbonate. Alkalinity reduction may release residuals (e.g. chloride or nutrients, depending on the additive).

The systems described in this section can be implemented in streams where treatment of other constituents of interest (e.g., selenium) is not being considered. At locations where an active water treatment plant is to be constructed, options to reduce calcite will be considered as part of the overall design process.

More details of the treatment options are provided in Annex J.2.

7.6.1 Alkalinity Reduction

Alkalinity reduction is widely practiced in other applications (e.g., pre-treatment for reverse osmosis, cooling-system management and drinking-water supply), and has potential for certain streams due to its simplicity and effectiveness. Alkalinity reduction is achieved through the safe addition of an acid that shifts the carbonate equilibrium toward a state that prevents precipitation of calcium carbonate, and accelerates the stripping of carbon dioxide to the atmosphere.

A potential shortcoming involves residual anions. For example, addition of hydrochloric acid leaves residual chloride. Estimates of acid doses are site-specific and in practice, the target dosage would be determined by site-specific testing and analysis. This option will be implemented only once it has been shown to have no impact on aquatic health.

Alkalinity reduction has been successfully tested on a pilot scale at Corbin Creek at the Coal Mountain Operation. That test established the dosage levels required to prevent further calcite precipitation, and demonstrated the method's overall environmental acceptability.

7.6.2 Constructed Cascades

Constructed cascades mimic natural processes. The cascade arrangement provides the aeration and surface area necessary to relieve calcite supersaturation. Constructed cascades are suitable for remote sites with the right terrain and topography. They may be considered alone and/or in combination with other treatment alternatives (e.g., alkalinity reduction or antiscalant addition). Constructed cascades will leave a residual solid of calcite, which may need to be disposed of periodically in a manner that does not result in the calcite being re-dissolved.

7.6.3 Antiscalant Addition

Antiscalants are chemical compounds that interfere with the precipitation process through a number of mechanisms such as chelation, threshold inhibition, crystal modification, and dispersion. These mechanisms can use commercially available antiscalant formulations.

7.6.4 Pond Treatment

Pond treatment can be considered where rock drains feed a relatively large, deep settling pond and electrical power is available. Pond treatment consists of the following:

- aerators that strip carbon dioxide, enclosed in a baffled treatment area
- dry limestone powder or PCC addition, to provide surface area for precipitation in the same space as the aeration
- a low-head pumping system to provide a controlled retention time in the treatment area.

A typical design consists of a circular baffled area within a sedimentation pond that may accommodate six or seven floating aerators. Water is pumped from the aerated zone at a controlled rate. The settled solids will require periodic disposal in a manner that does not result in the calcite becoming re-dissolved.

7.6.5 Trickling Filter

A trickling filter is a solid-liquid-gas contact system that is widely used for sewage treatment. It consists of a ring of aeration media and a rotating water distribution arm powered by falling water. Water cascades through the media, and in doing so draws air into the bed. After the water has equilibrated with the atmosphere, calcite precipitates onto the solid media and on suspended solids.

Trickling filters can provide both CO_2 stripping and a large solid surface area in a compact space, without the need for electrical power. However, the fundamental principles are just starting to be widely understood and it is not known if this technology has been applied to calcite mitigation. Its use in controlling calcite scaling is still in the early stages of development. Finally, the process generates solid waste that requires further management.

7.6.6 Ultrafine Powdered Limestone Addition (PCC)

Ultrafine powdered limestone addition may be considered in combination with a gas transfer system such as a pond aerator, a cascade, or a trickling filter. Ultrafine limestone is normally produced using calcite precipitation processes, and is hence called PCC. PCC particles are typically on the nano-scale (10-9 to 10-8 m diameter) in size, and have surface areas of 10 m2/g or more. PCC is a common, commercially available additive used in the paper industry.

PCC acts as a seed to stimulate calcite precipitation in solution rather than on the stream bed. This technology would be suited to systems with cascades or floating aerators for gas transfer, and a settling pond some distance downstream of the addition point to remove suspended particles. However, since the dose of PCC is expected to be small, the resulting increase in total suspended solids will also likely be low, and a downstream settling pond may not be required. PCC addition has not been tested in this application, so the required dosage would need to be determined experimentally. Solids that do settle in a pond will require periodic disposal.

7.7 Adaptive Management (Future Work)

Calcite management plans outlined in this chapter are based on current knowledge of the levels of calcite deposition, as measured by the Calcite Index. As more data are collected, Teck will adapt and adjust the program to achieve the desired overall objective of managing mine-related calcite formation such that stream-bed substrates within the Designated Area support abundant and diverse communities of aquatic plants, benthic invertebrates, and fish, comparable to those in reference areas.

The adaptive management framework for calcite is depicted in Figure 7-10. Ongoing monitoring, research and learning will provide the foundation for evaluating whether adjustments to the approach of calcite management are warranted.

The monitoring, research, and learning components of adaptive management have specific objectives and desired outcomes relating to calcite. These objectives and desired outcomes are illustrated in Figure 7-11, and described in detail in the sections that follow.

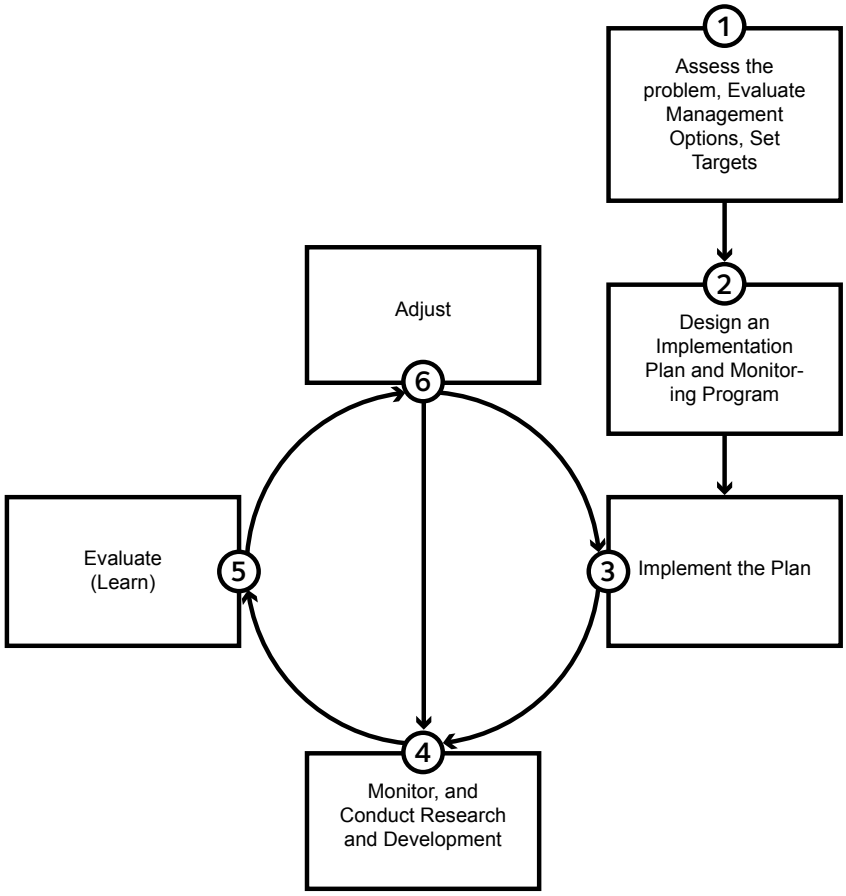


Figure 7-10. Calcite adaptive management framework.

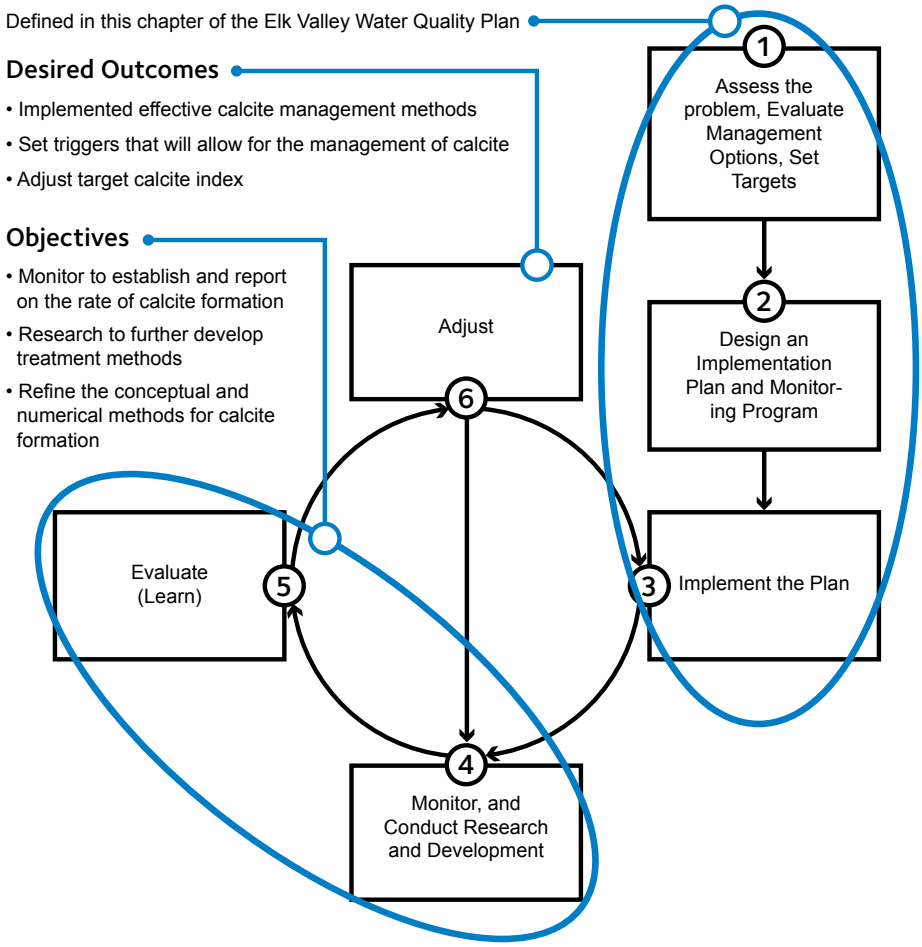


Figure 7-11. Objectives and desired outcomes of the adaptive management framework for calcite.

7.7.1 Monitor, Research, Evaluate

2013 was the first of three years for the refined calcite monitoring program. The program will provide a baseline of current conditions and a method of quantifying the rate of calcite formation within the Elk Valley watershed. Following the third year, it is envisioned that ongoing monitoring will continue, with its frequency adjusted based on observed rates of calcite formation (where rates are stable, the frequency may be reduced). During 2014 and 2015, results will be reported for each sampling unit (stream reach) in terms of change in Calcite Index per year. The rate will continue to be calculated and reported after the program's completion, again with adjustments to the reporting frequency.

7.7.2 Research to Further Develop Treatment Methods

Pilot-scale testing has been undertaken of alkalinity reduction through acid addition. These tests established alkalinity reduction as a viable treatment technology, and have provided guidance on the level of treatment required. Additional evaluation is needed to optimize acid type and addition levels. Specifically, blends of acids (reducing the concentration of any single anion) will be evaluated to optimize treatment levels.

The 2013 pilot test revealed that calcite formation reduces the concentration of dissolved cadmium. Where cadmium concentrations may be of concern, precipitation of calcite upstream of the receiving environment would be a preferred management method if feasible. Additional tests are needed to evaluate these technologies and to establish design guidelines.

Antiscalants are widely used to prevent the formation of calcite and other scales. Their use in streams is not well-documented, but they are known to be used at some coal mines in West Virginia (McIntyre 2013), and have proven to be more cost-effective than acid addition, without environmental impact. Antiscalants are also effective at removing scale deposits, and may be used as a remediation technique. Consequently, tests will be initiated to evaluate the use of antiscalants as an alternative to alkalinity control through acid addition, and as a remediation method.

7.7.3 Refine the Conceptual Model and Numerical Methods for Calcite Formation

Refining the conceptual model and numerical methods will help implement management solutions before significant calcite formation occurs in stream habitats. Teck developed the potential saturation index (SIpot) concept to indicate the potential for calcite to precipitate in streams where it has not yet been observed downstream of mining activity, or to provide an indication of the level of treatment required to manage precipitation. Teck will undertake additional investigations at selected streams to evaluate the merits of SIpot as a predictive numerical tool. The design of this investigation has not been completed, but it is expected to include continuous flow monitoring, frequent chemistry analysis and local calcite precipitation monitoring. The SIpot method is expected to be used in analyses triggered by observed increases in Calcite Index.

7.7.4 Adjust the Plan

7.7.4.1 Implement Effective Calcite Management Methods

Although alkalinity reduction through acid addition is a proven method to prevent calcite formation in streams, other methods may prove to be more effective or have less residual impact. The actual method chosen for calcite management will likely be site-specific, and as knowledge and understanding grows, may change over time.

7.7.4.2 Establish Triggers

Consistent with the TAC's advice, the medium-term target of the initial implementation plan is to prioritize streams based on a Calcite Concretion Score of ≥0.50. To reduce the likelihood of potential effects occurring, Teck will establish triggers for further management action based on observed Calcite Index levels. Two types of triggers will be established: an analysis trigger and an implementation trigger.

As detailed in Section 7.4, medium-term targets have been identified and selected based on a Calcite Concretion Score of 0.50. This score was selected based on the TAC's advice and associated hypothesis that it may represent a level at which physical stress to stream-bed organisms are possible. As such, it represents an implementation trigger. At the time of writing, this hypothesis remains an uncertainty and as such, will be adaptively managed.

To reduce the likelihood of a Calcite Concretion Score of >0.50, Teck will also establish an analysis trigger[3] at a Calcite Index value of 1.00. The analysis trigger will be applied to streams not currently affected by mining, and to streams with a Calcite Index <1.00. The value of 1.00 represents a point at which, in consideration of the TAC's advice, any further increase in the Calcite Index must be a result of an increase in the concretion score, and not the simple presence of calcite without concretion.

When the analysis trigger is reached, Teck will initiate an evaluation of the stream conditions. Following a careful review of the data, if it is determined that Calcite Index levels are in fact trending upward due to increased concretion scores, a root-cause analysis will be conducted to determine if the results are due to coal mining or to other outside factors. Identification of the root cause will guide the adaptive management decision-making process, help identify and evaluate solutions, and help to predict, using a balance of probabilities approach, if and when a Calcite Concretion Score >0.50 is likely to be reached. If it is determined that it is likely, Teck will implement management actions with the objective of keeping it <0.50 or at the value consistent with the overall objective.

[3] As with the implementation trigger, the analysis trigger will be adaptively managed as additional information is collected.

The analysis methodology will evolve over time, as Teck's knowledge base increases. An example of the analysis and implementation trigger methodology is presented in Figure 7-12. In this example, an analysis is triggered at time t, when the observed calcite index value has moved from <1 to a >1. By analyzing the available data and using a balance of probabilities approach, Teck will assess whether the Calcite Index is likely to stabilize as depicted by Analysis A, or increase beyond a Calcite Concretion Score of 0.50 as depicted by Analysis B. If the analysis suggests that Analysis B is probable, Teck will evaluate available options and develop an implementation plan with the objective of preventing this.

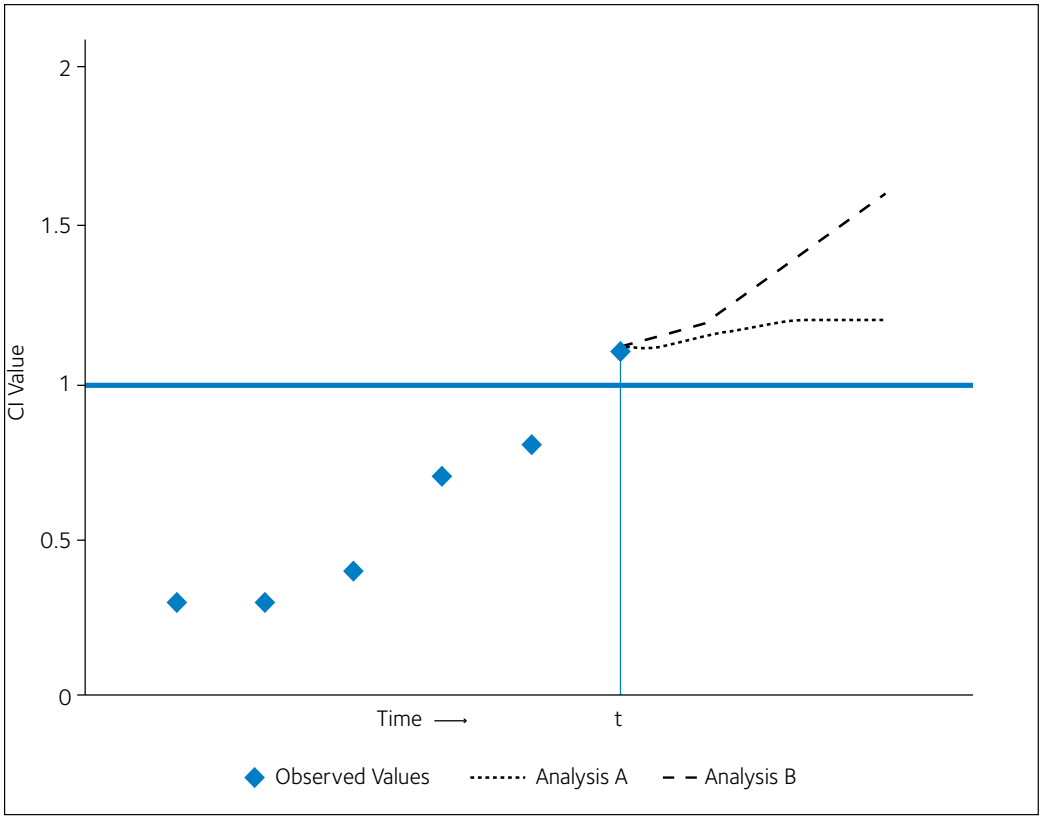


Figure 7-12. Example of the analysis and implementation triggers.

7.7.4.3 Refine the Long-term Target

The interim target Calcite Index of 0.5 is based on limited data. Through continued calcite and aquatic effects monitoring as administered under EMA authorization, Teck will attempt to determine the Calcite Index that reflect stream-bed substrates that can support communities of aquatic plants, benthic invertebrates, and fish that are comparable to those in appropriately selected reference areas.

7.8 Reporting

There will be two reporting cycles regarding calcite: 1) an annual calcite update; and 2) a three-year Plan report that corresponds to the reporting cycle for aquatic effects monitoring (see Chapters 10 and 11). The reports will include evaluation against relevant management triggers and any associated root cause analyses and adaptive management outcomes.

The annual calcite report will provide an update of monitoring and management activities for the previous year and and will report on progress towards meeting calcite targets and timelines. The first annual report will be prepared in 2015 for monitoring and management activities completed to the end of 2014. The anticipated scope of the annual calcite update includes:

- an update of calcite mitigation measures for the previous year
- calcite monitoring results, including an analysis of the rate of change of calcite formation
- results of any supporting studies completed.

A three-year Plan report will be completed on a cycle that corresponds to the aquatic effects monitoring. The first reporting cycle will be 2017. The anticipated scope of the three-year adaptive management report is fully described in Chapter 11.

The Plan reports will be structured to meet permit reporting requirements related to calcite management that fall within the scope of the Plan.

7.9 Summary of Work to Date

Teck has begun taking the steps required to achieve medium-term and long-term objectives and targets for calcite management. Table 7-4 presents a summary of these steps and their status.

Table 7-4: Immediate, medium- and long-term objectives.

Time scale	Objective	Implementation step	Purpose	Status
Immediate (within three years)	Begin to stabilize the rate of calcite formation	Refine and implement calcite monitoring program	Establish the rate of calcite formation; define areas that require treatment	Started: first year of three-year calcite monitoring program complete
		Pilot testing of treatment technologies	Determine which treatment methods are effective and environmentally, socially and financially acceptable	Started: candidate treatment technologies identified; alkalinity reduction tested at pilot scale (Section 7.6.1)
		Implement treatment at one of the priority streams	Begin work in a priority stream to reduce the Calcite Index below the long-term target value	Planning stage: Teck will implement a treatment option on the first of the priority streams within three years
Medium Term (10 years)	Reduce the rate of calcite formation	Define target streams using decision framework	Prioritize streams	Complete: priority streams identified (Section 7.4.1)
		Implement calcite management technologies	Reduce Calcite Index in selected streams to long-term target	Planning stage: treatment technology selection to be determined through ongoing technology evaluations (Section 7.6)
Long Term (15 years)	Control the rate of calcite formation to acceptable levels	Establish narrative objective	Define acceptable levels	Complete: Narrative objective defined (Section 7.4)
		Establish long-term target	Meet acceptable levels	Interim target established (Section 7.4); method and timing for refining target defined (Section 7.7.4)
		Meet long-term target	Meet narrative objective	Started: Calcite monitoring has identified potential streams; additional technology advancements and research are ongoing - findings of which will inform decision-making; Adaptive Management Framework for Calcite (Section 7.7)

Note: Medium- and long-term targets established as part of the initial implementation plan will be guided by additional monitoring data and R&D. As a result, targets may be adjusted in value and/or time to be consistent with the narrative objective.

Chapter 8

Water-Quality Targets and Implementation Plan

Chapter Overview

This chapter presents the short-, medium- and long-term water-quality targets and timeframes for selenium, sulphate, nitrate and cadmium at Order stations in the Elk Valley, and the process used to develop those targets. It also describes an initial implementation plan to achieve water-quality targets and the key activities included in the plan.

Concordance with Ministerial Order and Terms of Reference

Chapter 8 satisfies Section A and sections B.1, B.3, B.4, B.8, B.9, B.10, B.12, B.14 and B.15 of Schedule C of Ministerial Order M113 and Section 2 and section 3.8(a, b, and c), 3.3, 3.5, 3.6, and 3.11(a) of Schedule C of the Elk Valley Water Quality Plan Terms of Reference.

Highlights

- **Teck is proposing water-quality targets that protect aquatic and human health:**
  - B.C. water-quality guidelines (WQGs) for aquatic life have been set as the long-term water-quality targets for selenium, nitrate and sulphate in Lake Koocanusa.
  - B.C. WQGs for the protection of aquatic life have also been set as the long-term water-quality targets for nitrate in the Elk River, and sulphate in the Elk and Fording rivers at the Order stations in the Designated Area.
  - The long-term cadmium water-quality target has a margin of safety that is comparable to the Canadian Cadmium WQG for the protection of aquatic life.
  - Where long-term concentrations could not meet WQGs or targets that provide a comparable margin of safety, site-specific targets were derived that are protective of aquatic life and achievable. Site-specific targets were established for selenium in the Elk and Fording rivers and for nitrate in the Fording River.
  - Site-specific targets are based on aquatic life benchmarks, established through study of sensitive species, and are developed to protect aquatic life and human health.
- **Teck developed the Elk Valley Water Quality Planning Model as a regional planning and assessment tool to determine effectiveness of water-quality mitigation measures.** The Model estimates concentrations of selenium, nitrate and sulphate and was calibrated using monitoring data. During implementation, Teck will continue to refine the model based on local-scale models, site-specific investigations of mine-affected water, and new information from monitoring data and Teck's R&D program.
- **More than 700 possible scenarios were evaluated** to develop an initial implementation plan to meet the long-term water-quality targets for selenium, nitrate, sulphate and cadmium.
- **Three active water treatment facilities, combined with diversions, will reliably and efficiently reduce selenium and nitrate in the short term:**
  - The West Line Creek active water treatment facility (AWTF), built at a capital cost of $105 million, will open in summer 2014, with a capacity of 7,500 m3 of water per day.
  - A second AWTF and associated diversions will be developed at Fording River Operation by 2018 and is anticipated to have a capacity of 20,000 m3 of water per day.
  - A third facility and diversions will be built at Elkview Operation by 2020 and is anticipated to have a capacity of 30,000 m3 of water per day.
  - Further mitigation outlined in the initial implementation plan will be implemented as required to meet the targets set out in the Plan.

Table S-1. Summary of long-term water-quality targets.

Management Unit	Description	Order stations	Selenium (µg/L)[1]	Nitrate (mg/L)[2]	Sulphate (mg/L)[3]	Cadmium (µg/L)[4]
1	Upper Fording River (upstream Josephine Falls)	FR4	57	11	429	0.39
2	Lower Fording River	FR5	40	11	429	0.39
3	Elk River upstream Fording River	ER1	19	3	429	0.24
4	Elk River from Fording River to Michel Creek	ER2	19	3	429	0.24
5	Elk River downstream Michel Creek	ER3, ER4	19	3	429	0.24
6	Lake Koocanusa	LK2	2	3	308	0.19

Note: Hardness dependent targets based on equations below for nitrate (MU-1 & 2 only), sulphate and cadmium are shown for the following illustrative average hardness levels as mg/L as $CaCO_3$: Fording River (FR5) 360; Elk River 200; and Lake Koocanusa 150. Actual target is to be based on synoptic measured hardness and nitrate, sulphate and cadmium concentrations.

Note[1]: The long-term selenium target for MU-6 is specified in Ministerial Order M113. Targets in MU-1 to MU-5 are site-specific

Note[2]: Nitrate targets in MU-3 to MU-6 are equal to the B.C. WQG for the protection of aquatic life. Targets in MU-1 and MU-2 are site-specific

Note[3]: Sulphate targets are equal to the B.C. WQG for the protection of aquatic life. The target in MUs 1-2 is a site-specific hardness based equation; target values shown are for a representative hardness level of 350 mg/L as $CaCO_3$.

Note[4]: Cadmium targets are equivalent to the Canadian WQG for the protection of aquatic life (CCME 2014), but expressed as a dissolved concentration. The cadmium target is a hardness-based equation: target values shown are for representative hardness levels of 360mg/L as $CaCO_3$ in the Fording River, 200 mg/L as $CaCO_3$ in the Elk River and 150 mg/L as $CaCO_3$ in Lake Koocanusa.

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8.1 Introduction

This chapter describes the derivation of short-, medium- and long-term water-quality targets for selenium, sulphate, nitrate and cadmium (Order constituents) at each Order station in the Elk Valley. It describes the process behind the development of an initial implementation plan that employs the management options described in Chapter 6, along with the timeframes for meeting water-quality targets. Calcite management, including targets and timeframes, is discussed in Chapter 7.

Development of the Plan involved the concurrent evaluation of current water-quality conditions, development of site-specific water-quality benchmarks, and implementation planning. Results indicated that WQGs or benchmarks that provide a comparable margin of safety to WQGs can be met for some Order constituents in portions of the Designated Area, and that site-specific long-term targets are required only for selenium and nitrate in parts of the Designated Area. As a result, water-quality targets were developed following the process shown in Figure 8-1:

1. Water-quality benchmarks were developed for selenium, nitrate, cadmium and sulphate that protect aquatic life present in the Elk Valley (Section 8.2).

2. A first iteration of the initial water quality implementation plan was developed to meet level 1 selenium benchmark concentrations in the upper Fording River and the Elk River, and a selenium target concentration of 2 µg/L in Lake Koocanusa. Concentrations for nitrate, which is treated in the initial implementation plan, and sulphate, which is not treated, were also modelled. The initial implementation plan is presented in Section 8.5.

3. The current water-quality conditions and predicted concentrations based on the results of the first iteration of the initial implementation plan were compared with the water quality benchmark concentrations and the B.C. WQGs (Section 8.3.1). If current and expected future conditions could achieve WQGs or benchmarks that provide a comparable margin of safety as guidelines, then these values were set as the long term targets. As a result of this evaluation, B.C. WQGs or benchmarks that provide a comparable margin of safety as guidelines were selected as long-term water-quality targets at Order stations in the following parts of the Designated Area:[1]
   - selenium, nitrate, sulphate and cadmium in Lake Koocanusa (MU-6)
   - nitrate, sulphate and cadmium in the Elk River (MU-3 to MU-5)
   - sulphate and cadmium in the Fording River (MU-1 and MU-2).

4. If expected future conditions could not achieve WQGs or benchmark values that have a comparable margin of safety (i.e. selenium in the Elk and Fording rivers and nitrate in the Fording River), then an integrated assessment was completed in parallel with adjustments to the initial implementation plan to derive long-term targets that are achievable and protective of aquatic ecosystem health (i.e., aquatic life) in the MU. The integrated assessment evaluates aquatic ecosystem protection within each MU by integrating the effect of constituent concentrations in mainstem rivers, mine-influenced tributaries and tributaries that are not influenced by mining. The integrated assessment provides a methodology for assessing the regional (i.e., MU scale) influence of local-scale water-quality conditions. Integrated assessments were also completed to assess integrated effects for all constituents in MUs that contain mine-influenced tributaries (i.e., MUs 1-4). The methods and results for the integrated assessment are presented in Section 8.3.2 and 8.3.3, respectively.

   The end result of steps 3 and 4 was long-term targets for all water quality constituents in all MUs and an initial implementation plan to achieve them. A summary of long-term water quality targets is presented

[1] As described in Section 8.2.5, the cadmium benchmark for the most sensitive aquatic species is provides a margin of safety that is comparable to the recently released Canadian WQG for the Protection of Aquatic Life (CCME 2014). Similarly, the sulphate benchmark is an extension of the B.C. water WQG of 429 mg/L to apply in areas where hardness levels are greater than 250 mg/L as CaCO3.

in Section 8.3.4. A multiple-stressor analysis was completed to assess the potential for mixture effects amongst the Order constituents and interaction of multiple stressors. This was used to confirm the conclusions of the constituent-specific analyses, including the selection of long-term target concentrations (Section 8.4).

5. Short-term targets for stabilization were set for Order stations and constituents in MUs where concentrations currently or are expected to exceed long term targets. Timeframes for meeting short-term targets are defined by the initial implementation plan. Short-term targets and timeframes are presented in Section 8.6.1.

6. Medium-term targets and timeframes were set at the same locations as short term targets to demonstrate progressive improvement in water quality is occurring over time. Medium-term targets and timeframes are presented in Section 8.6.2.

Short-, medium- and long-term water quality targets are defined as maximum monthly average concentrations. The monthly average concentration is defined as the average of the samples collected in a month, or a single sample if it is the only one collected. The maximum monthly average concentration is the highest monthly average concentration in a year.

This process follows the Order requirements for developing targets (Schedule C, Section 10), and results in long-term targets that meet the environmental management objectives of the Plan, as defined in Schedule C, Section A of the Order. Where constituent levels currently or are expected to exceed long-term targets in the short-term, the Plan achieves the overall objective of stabilizing and reversing increasing trends of constituents, to reach acceptable levels in the long-term.

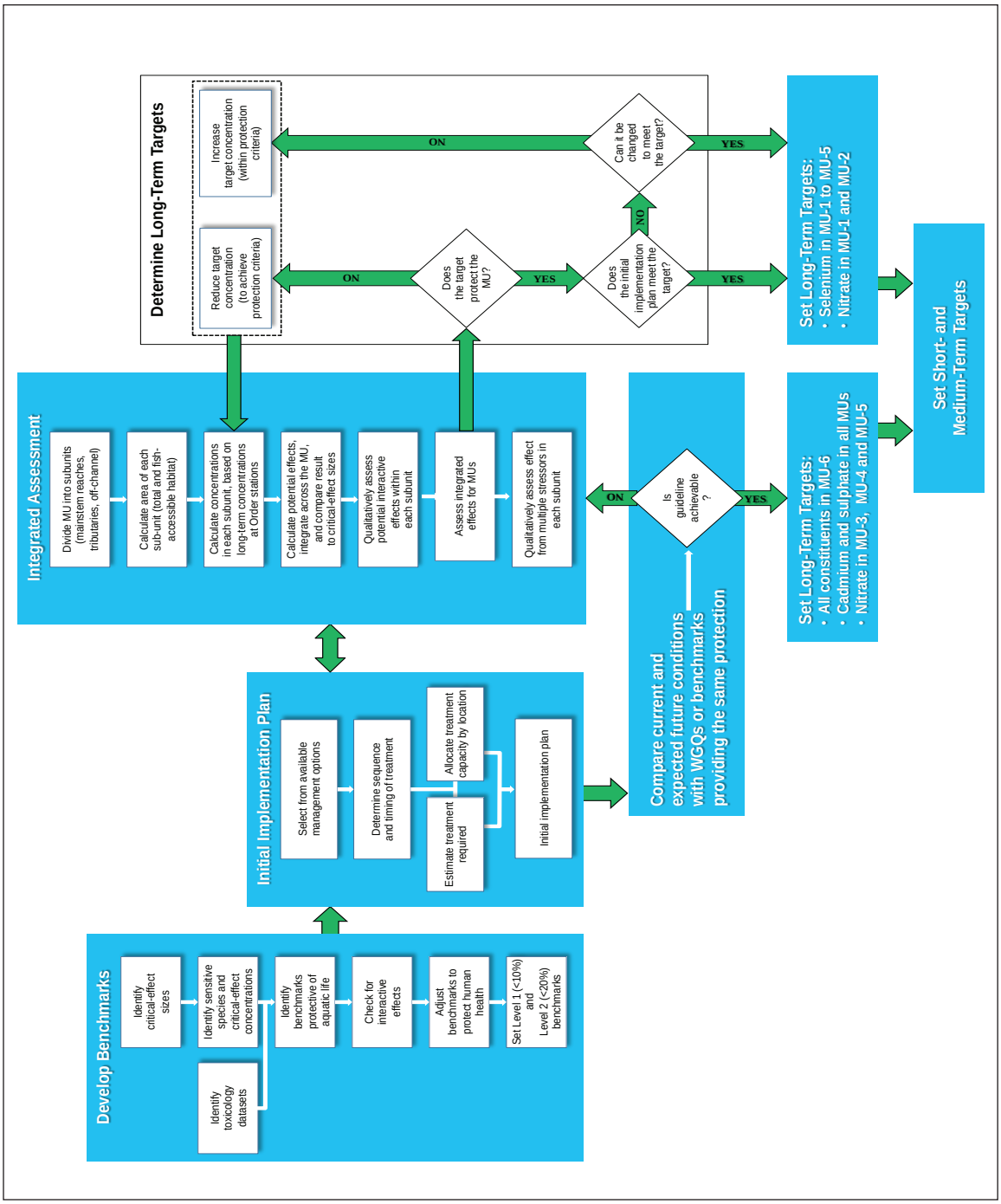


Figure 8-1. Overview of process for developing water-quality targets.

8.2 Water Quality Benchmarks

Water-quality benchmarks were derived for Order constituents (selenium, nitrate, cadmium and sulphate) for the protection of aquatic life in the Elk Valley. Water-quality benchmarks were derived from toxicity test results relevant to the Elk Valley, with a focus on endpoints such as growth or reproduction for the most sensitive species.

The approach to developing benchmarks considered protection of both aquatic and human health, and consisted of the following tasks:

1. Identify "critical-effect sizes" commonly accepted in toxicological literature that describe a level of effect, derived from laboratory testing to individuals, that is not likely to result in changes to populations or communities of sensitive aquatic species in the environment. Critical-effect sizes are typically expressed as a percentage effect for a life-history endpoint, such as a 10% effect on growth or reproduction.
2. Develop site-relevant toxicity datasets for each constituent through a literature review. For nitrate and sulphate, incorporate toxicity test results from the Elk and Fording rivers.
3. Identify sensitive aquatic species and determine concentrations that result in critical-effect sizes of ~10% (Level 1) and 20% (Level 2) to sensitive life-history endpoints.
4. Identify water-quality benchmarks for the protection of aquatic life by combining the information from tasks 2 and 3, accounting for uncertainty where possible and identifying follow-up studies or monitoring to address residual uncertainties (addressed in Chapters 10 and 11).

Tasks 1 to 4 are discussed in more detail below. No adjustments to benchmark were required for protection of human health (see Chapter 5).

8.2.1 Critical-Effect Size

Toxicological responses of aquatic organisms to increasing constituent concentrations can usually be defined by a continuous dose-response curve derived through laboratory testing, in which the effect on reproduction, growth or other life-history endpoint increases as concentrations increase (Figure 8-2). A critical-effect size is the level of effect to organisms in laboratory tests below which changes to populations or communities of sensitive species are not expected to occur and which cannot be distinguished from the results of normal background variability.

The US EPA defines 20% as the critical-effect size for most cases. It represents an effect to organisms in laboratory testing that, while statistically distinct from reference or control organisms, is not expected to cause meaningful and measurable changes in a natural population (US EPA 1999, 2013). Suter et al. 1995 also uses a critical-effect size of 20%, but acknowledges that the minimum detectable effect varies by species, habitat and sampling method. For mobile species, they concluded that a difference <20% "can seldom be reliably detected" and represents a de minimis effects level. A USGS study by Mebane 2010 similarly identifies a 20% critical-effect size for benthic invertebrates in any environment, and for fish

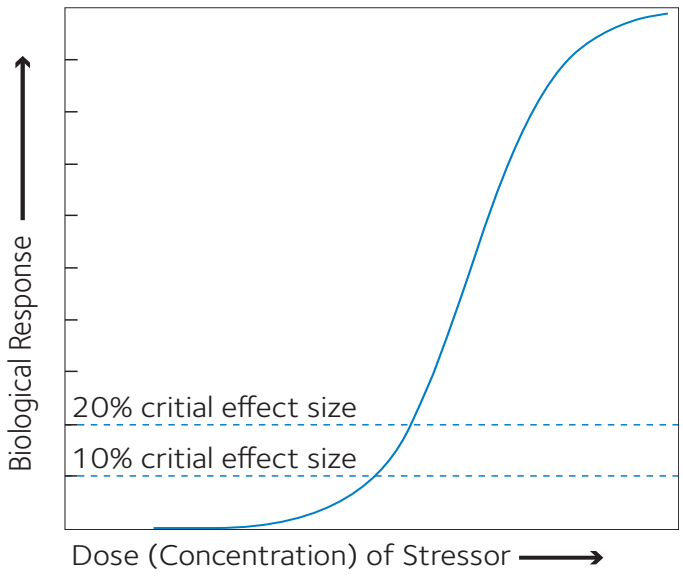


Figure 8-2. Typical dose-response curve.

when exposed to a single stressor, although it suggests a smaller effect size of 10% for fish when multiple stressors are present.

Two levels of water-quality benchmarks are defined for selenium, nitrate and sulphate in the Designated Area: Level 1 benchmarks for a 10% effect size, and Level 2 benchmarks for a 20% effect size. Cadmium concentrations in the Elk and Fording rivers are below the Level 1 benchmark; therefore, no Level 2 benchmark was developed.

8.2.2 Selenium

Selenium is a micronutrient that organisms require for optimal health (Wood et al. 2012). Selenium can bioaccumulate (Stewart et al. 2010), and at elevated tissue concentrations can produce detrimental effects in sensitive aquatic species (Chapman et al. 2010). Selenium toxicity varies widely among aquatic species (Chapman et al. 2010; US EPA 2004: B.C. MOE 2014b; DeForest et al. 2012), although reproductive impairment is typically the most sensitive pathway through which it affects them.

The rate of selenium bioaccumulation varies with environmental conditions. It tends to be higher in still-water (lentic) areas exhibiting lower oxygen content than in flowing, well-oxygenated (lotic) systems (Brix et al. 2005, Hillwalker et al. 2006, Orr et al. 2012) such as the Elk Valley. However, environmental conditions in lentic and lotic systems are variable, resulting in substantial overlap in rates of selenium bioaccumulation between the two types of environments (Simmons and Wallschläger 2005).

In 2014, the MOE updated the provincial selenium WQG for the protection of aquatic life (B.C. MOE 2014b). This guideline applies to all aquatic environments, including more sensitive lake environments. The selenium guideline is 2 micrograms per litre (µg/L), with an alert concentration of 1 µg/L.

8.2.2.1 Selenium Toxicity

A literature review indicated selenium concentrations in tissues at which effects could occur in sensitive aquatic species in the Elk Valley, including fish, benthic invertebrates and birds. A total of 41 species are represented in the assembled dataset: 17 fish, 14 bird and 10 invertebrate species.

Life-history endpoints evaluated included reproductive effects related to selenium in eggs, and potential changes in growth rates as a result of dietary intake. Studies were ranked and classified, with an emphasis on field studies and experiments completed under conditions comparable to those of the Elk Valley.

The review focused on sensitive aquatic species in the Elk Valley and similar species found elsewhere. For example, tissue benchmarks for fish in the upper Fording River (above Josephine Falls) were based on westslope cutthroat trout (WCT), as this is the only species present in that part of the watershed. On the recommendation of the TAC, brown trout was used to derive the Elk and lower Fording River fish tissue benchmark because, while not present in the system, it is the most sensitive tested species similar to fish found there.

Level 1 and 2 benchmark tissue concentrations for sensitive aquatic organisms (fish, birds and invertebrates) are summarized in Table 8-1. The benchmarks are specific points along a dose-response curve that defines the relationship between tissue concentration and the percentage effect of the response. Dose-response curves were generated for WCT reproduction, brown trout reproduction, juvenile fish growth, bird reproduction and juvenile bird growth. A dose-response curve is not available for benthic invertebrates. The derivation of the tissue benchmarks in Table 8-1 and the underlying dose-response curves (where available) are presented in Annex E.

Amphibians are also sensitive to selenium; however, reliable dose-response associations could not be established due to a lack of data. The limited available data suggest that amphibians are less sensitive to selenium and bioaccumulate selenium to a lesser extent than fish, birds or invertebrates. Therefore, benchmarks that protect fish, birds and invertebrates should be protective of amphibians as well, although data limitations represent a source of uncertainty.

Table 8-1. Benchmark selenium concentrations in tissues that result in potential effects.

Receptor/endpoint(s)	Tissue type	Benchmark tissue concentrations for selenium (mg/kg dw)		Dose-response curve available? (yes/no)
		Level 1 (~10% effect size)	Level 2 (~20% effect size)	
WCT/reproduction	Egg	25	27	Yes
Other fish (brown trout)/reproduction	Egg	18	22	Yes
Juvenile fish/growth (based on invertebrate tissue concentrations)	Diet	11	18[1]	Yes
Birds/reproduction	Egg	12	16	Yes
Juvenile birds/growth	Diet	15	22	Yes
Invertebrates/growth and reproduction	Whole body	13	20	No

Note[1]: Not applicable to WCT for the reasons outlined in Section 8.2.3. Note: mg/kg dw = milligrams per kilogram dry weight.

8.2.2.2 Selenium Bioaccumulation in the Elk Valley

Studies of selenium bioaccumulation in the Elk Valley have produced site-specific models (statistical equations) for periphyton, benthic invertebrates, fish, water birds and amphibians (e.g., Orr et al. 2012, Golder 2010). Some of these studies include two-step and three-step models that calculate bioaccumulation at each level in the food chain (e.g., Orr et al. 2012; Minnow 2014). Others have one-step models that calculate bioaccumulation directly from water into fish and birds (e.g., Golder 2010; deBruyn et al. 2012). In consultation with the TAC, Teck has reviewed and revised, as appropriate, the models for use in deriving water-quality benchmarks for the protection of aquatic life.

The Elk Valley is primarily a lotic system containing a small proportion (~10% of total aquatic habitat area) of off-channel habitats with some degree of lentic characteristics, such as still or slow-moving water and plants typically found in ponds or marshes. One uncertainty identified in previous model applications was selenium bioaccumulation in off-channel habitats, and how this could influence overall selenium bioaccumulation in the Elk Valley. To address this uncertainty, Teck undertook a stratified, random-sampling of off-channel habitats with lentic characteristics. Data from 60 off-channel habitats were used to develop models of selenium bioaccumulation by periphyton and benthic invertebrates in those areas. Analysis of the off-channel bioaccumulation data, in combination with existing data, identified the following:

- Selenium bioaccumulation relationships in Elk Valley lotic and off-channel areas are comparable, and can be captured in a single model. Bioaccumulation in off-channel areas, including those with lentic characteristics, is typical of lotic environments. Similar behaviour was noted by Simmons and Wallschläger 2005 in studies of other lentic areas outside of the Designated Area.

- There are two truly lentic receiving environments with higher selenium bioaccumulation in the Elk Valley[2]: a portion of the Fording River Oxbow (in the upper Fording River); and Goddard Marsh (a wetland that receives mine drainage from Elkview Operations). The model developed by Orr et al. 2012 represents selenium bioaccumulation for these two environments.
- That the off-channel sampling program did not identify any other sites with enhanced selenium bioaccumulation indicates that the two lentic environments are uncommon, and do not influence overall selenium bioaccumulation in the Elk Valley.

One-, two- and three-step models can characterize the variability in predicted tissue concentrations and examine uncertainties. The resulting suite of models predicts the statistical distribution of tissue concentrations that would result from exposure to a given selenium concentration. As a conservative approach, the two-step models resulting in the highest predicted selenium tissue concentrations were used to develop selenium benchmarks. This approach addresses variability in the observed data and accounts for uncertainty in how that variability can be described statistically. The two-step models are summarized in Table 8-2, and all bioaccumulation models are presented in Appendix C of Annex E.

Table 8-2. Elk Valley two-step selenium bioaccumulation models.

Model component	Model equations
Water to Invertebrates	$log_{10}[Se]_{inv} = 0.696 + 0.184 \times log_{10}[Se]_{aq}$
Invertebrates to Fish Eggs	$log_{10}[Se]_{fish\ egg} = 1.02 + 0.026 \times log_{10}[Se]_{inv}$ for $[Se]_{inv} < 6.8$ mg/kg dw $log_{10}[Se]_{fish\ egg} = 0.126 + 1.10 \times log_{10}[Se]_{inv}$ for $[Se]_{inv} \geq 6.8$ mg/kg dw
Invertebrates to Bird Eggs	$log_{10}[Se]_{bird\ egg} = 0.414 + 0.523 \times log_{10}[Se]_{inv}$

Note: [Se]aq = aqueous total selenium concentration (µg/L); [Se]peri = periphyton selenium concentration (mg/kg dw); [Se]inv = invertebrate selenium concentration (mg/kg dw); [Se]fish egg = fish egg clutch or ovary selenium concentration (mg/kg dw); [Se]bird egg = bird egg selenium concentration (mg/kg dw)

8.2.2.3 Selenium Benchmarks for Protection of Aquatic Life

The bioaccumulation models are used to calculate aqueous selenium concentrations corresponding to tissue benchmarks (Table 8-2). The resulting concentrations represent water-quality benchmarks. In practice, the methodology for fish and bird reproduction endpoints is more complex, because the models calculate a statistical distribution of tissue concentrations. A solution was developed to account for variability in tissue concentrations and in the dose-response relationship, to calculate an effect size for a population exposed to a given aqueous selenium concentration. The concentration that results in the specified critical-effect size is the corresponding water-quality benchmark.

The methods for calculating water-quality benchmark concentrations for invertebrates, juvenile fish and birds were more straightforward. Bioaccumulation models were used to calculate the water concentration at which invertebrate-tissue concentrations would equal the Level 1 and 2 benchmarks for potential effects on benthic invertebrates themselves, or on juvenile fish and birds as a result of consumption. This calculation was completed using the 95% upper confidence limit (UCL) of mean invertebrate-tissue concentrations. As a result, the water-quality benchmark concentrations are values at which there is 95% confidence that mean invertebrate-tissue concentrations will be lower than the Level 1 or 2 benchmarks.

The combined use of bioaccumulation models and dose-response curves to calculate water-quality benchmarks is complex, but can be summarized as follows. The toxicological response of fish and birds occurs as a

[2] Clode Settling Pond (a settling pond at Fording River Operations) also exhibits enhanced selenium bioaccumulation, but is an industrial facility and not part of the receiving environment.

continuous response that can be characterized as a dose-response curve (Figure 8-2 above). For a given water concentration, the models predict a distribution of tissue concentrations that follows a bell (log-normal) curve. The dose-response curve can be used to calculate the percentage effect for each egg concentration in the distribution. By combining all effect sizes for each point on the distribution, an overall effect can be calculated for a population exposed to a given water concentration.

Calculated Level 1 and Level 2 benchmark concentrations are shown in Table 8-3. The table divides benchmarks for fish into two areas: the upper Fording River, where WCT is the only fish species present; and the remainder of the system, where more sensitive species may be present. The lowest applicable benchmarks are those carried forward into the long-term target-setting process (i.e., those that describe effects on the most sensitive species).

Table 8-3. Selenium benchmarks for aquatic receptors in the Elk Valley (all units µg/L of total extractable selenium).

Receptor and endpoint	Level 1 10% effect size	Level 2 20% effect size
Upper Fording River		
Fish reproduction (for WCT)	70	187
Juvenile fish growth (for WCT)	>46	>466
Elk River and lower Fording River		
Other species (brown trout)	19	74
Juvenile fish growth (other species)	46	466
Applicable to Elk and Fording rivers		
Bird reproduction	394	n/c
Juvenile bird growth	203	n/c
Invertebrate growth and reproduction	104	n/c

Note: n/c = not calculated, because resulting value will be higher than most sensitive end point (not calculated); '>' denotes unbounded NOECs (no observed effect concentrations)

The Level 1 selenium water-quality benchmark applicable to the upper Fording River is 70 µg/L, which is based on reproductive effects on WCT. Benchmarks for bird reproduction, juvenile bird growth, and invertebrates are higher. The benchmark for juvenile fish growth is not applicable to the upper Fording River, because studies with juvenile WCT have reported no effects at the Level 1 benchmark.

The Level 1 selenium benchmark applicable to the lower Fording and Elk rivers is 19 µg/L. This is based on reproductive effects on brown trout, which are representative of more sensitive fish that may be present. All other benchmarks were higher.

A 10 or 20% reduction in reproductive output is not equivalent to a 10 or 20% reduction in a population abundance. Density-dependent compensation for early life-stage mortality[3] is a widely accepted concept in fish population biology (Hilborn and Walters 2001), and modelling studies indicate that effects on cutthroat trout populations occur only when reproductive effects exceed 40 to 60% (Van Kirk and Hill 2007). Consequently, no changes to fish populations, or to populations of other receptors in the Designated Area, are expected to occur at the chosen (i.e., lowest) Level 1 and Level 2 selenium water-quality benchmarks outlined in Table 8-3.

[3] Density dependent compensation is a process by which survival at a later life stage improves when the density of organisms is reduced by mortality at an earlier life stage. In trout, this can occur when juveniles live in areas with limited overwintering habitat. At high juvenile densities, the rate of overwinter survival is relatively low. If juvenile densities are reduced (e.g., by embryo-alevin mortality), the rate of overwinter survival improves, offsetting mortality at the earlier life stage.

8.2.2.4 Accounting for Uncertainty

Sources of uncertainty in the selenium toxicity and bioaccumulation assessment are described in Annex E. These include the sensitivity of aquatic receptors to selenium, and the rate at which selenium bioaccumulates in the Designated Area. These uncertainties were explicitly recognized and addressed, to the extent possible, when deriving the benchmarks outlined above.

For example, the toxicity of selenium to 41 aquatic or aquatic-feeding species was reviewed, and the most sensitive species were brought forward and used to define the tissue benchmarks outlined in Table 8-1. Similarly, multiple bioaccumulation models were developed and reviewed with the TAC. Sensitivity analyses were completed to examine how changes to input assumptions or model formulations would alter the model predictions. These analyses included consideration of:

- one, two and three-step models
- linear and piece-wise model formulations with different breakpoints
- variations in fish size
- the inclusion or exclusion of data from non-representative areas (such as those collected from mine workings)
- the inclusion or exclusion of data of uncertain quality (such as those without measured moisture content, which is an important consideration when calculating selenium content in dried tissues).

In all cases, results that were determined by the TAC to be reasonable, yet conservative, were carried forward and used to develop the selenium benchmarks.

Sensitivity analysis was also completed on the reproductive dose-response relationships used to define the benchmarks. The purpose of this exercise was to determine how the critical-effect size associated with a given water concentration may change in relationship to the dose-response curve. Using the results of this analysis, sensitivity of the Level 1 benchmarks was assessed. These results were also used to set long-term selenium targets that have upper-bound effect sizes of <20%.

Based on the above, the selenium benchmarks are considered to be best estimates of concentrations that will result in effect sizes of ≤10%. They were derived using conservative assumptions and have a low degree of residual uncertainty, which will be managed through follow-up activities during implementation, as discussed in Chapter 11.

8.2.3 Nitrate

Nitrate affects aquatic organisms by direct contact. At elevated concentrations, it can interfere with osmoregulation (the ability to maintain appropriate cellular ion levels) (CCME 2012). The B.C. WQG for the protection of aquatic life for nitrate is 3 milligrams of nitrogen per litre (mg/L of NO_3-N).

Nitrate benchmarks for the Fording River were developed by:

- compiling site-relevant toxicity datasets and identifying sensitive life-history endpoints (such as growth and reproduction) from the literature and results of site-specific testing
- adjusting the available information to account for the effect of water hardness
- using the compiled datasets to identify the most sensitive life-history endpoints and species for each group of aquatic species, and to determine hardness-adjusted concentrations that result in effect sizes of ~10% (Level 1) and 20% (Level 2)
- combining the resulting information to identify benchmarks for the protection of aquatic life, accounting for uncertainty.

Toxicity datasets were developed for invertebrates, fish and amphibians. Datasets were not developed for aquatic plants and algae or wildlife, because they tend to be less sensitive to nitrate (Annex F). As a result, benchmarks that protect fish, benthic invertebrates and amphibians will also protect other species.

Once compiled, the toxicity datasets were adjusted to hardness conditions reflective of the Fording River. These adjustments were made because work by Nautilus 2011a,b, Baker et al. 2012 and Rescan 2012 indicate that nitrate toxicity decreases as water hardness increases. The hardness relationship used to complete the adjustments is described in Annex F.

Review of the hardness-adjusted toxicity data outlined in Annex F identified the water flea, *Ceriodaphnia dubia (C. dubia)*, to be the most sensitive aquatic species. This finding was confirmed through the development of a species sensitivity distribution using hardness-adjusted toxicity results from literature and site-specific tests (see Annex F). Consequently, Level 1 and 2 benchmarks for nitrate were defined based on the sensitivity of *C. dubia*.

In addition, results from site-specific testing showed a greater sensitivity of *C. dubia* to nitrate than suggested by test results in the literature. As a result, site-specific test results were used to define species sensitivity to nitrate. The resulting values are summarized in Table 8-4.

Table 8-4. Sensitivity of aquatic receptors to nitrate in the Fording River.

Receptor group	Representative species and test type	Effect level (mg/L of NO_3-N)	
		Level 1 (~10% Effect)	Level 2 (~20% Effect)
Fish	Rainbow trout (*Oncorhynchus mykiss*) 39-day embryo-alevin development completed using augmented site water	16	21
Benthic invertebrates	Water flea (*Ceriodaphnia dubia*) 8-day reproduction completed using augmented site water	11	15
	Amphipod (*Hyalella azteca*) 14-day biomass completed using augmented site water	19	23
Amphibians	Northern leopard frog (*Rana pipiens*) 52-d growth in length (Level 1) Pacific tree frog (*Pseudacris regilla*) 10-day growth from literature (Level 2)	33	405

Note: Amphibian values are literature values because there are no site-specific test results. Values shown for a representative hardness of 360 mg/L as $CaCO_3$; derived as outlined in Benchmark Derivation Report for Nitrate and Sulphate (Annex F).

The hardness-dependent Level 1 and Level 2 benchmarks for the Fording River are 11 and 15 mg/L of NO_3-N, respectively, at 360 mg/L as $CaCO_3$. As previously noted, they are based on site-specific toxicity tests of *C. dubia*, which is the most sensitive receptor. With seasonal changes in hardness, the Level 1 benchmark for nitrate currently would range from 8 mg/L of NO_3-N in July (when hardness is at a minimum), to 16 mg/L of NO_3-N when hardness peaks in winter.

To assess potential effects on the wider benthic invertebrate community, a second set of Level 1 and 2 benchmarks were defined, using site-specific testing for *Hyallela azteca (H. azteca)*. In both site-specific testing and in literature-based species-sensitivity distributions, *H. azteca* growth is a sensitive life-history endpoint, but not as sensitive as *C. dubia*. The benchmark derived from site-specific nitrate toxicity tests for *H. azteca* was used to assess potential effects on benthic invertebrate communities, whereas the *C. dubia* benchmarks were used to assess effects on the most sensitive aquatic species.

At elevated levels, nitrate combined with phosphorus can increase primary productivity (i.e., plant and algae growth), to the potential detriment of dissolved oxygen levels and other water-quality parameters (CCME 2012). The potential for increased primary production was not evaluated when setting benchmarks for nitrate, because the Designated Area is a phosphorus-limited system (see Chapter 4). Consequently, the potential for eutrophication will be driven primarily by phosphorus rather than nitrate. The potential for mine-related effects of phosphorus on primary productivity is mainly related to the proposed use of biological AWTFs for selenium and nitrate, which are assessed in Chapter 6.

8.2.4 Sulphate

Sulphur is an essential element for all forms of life (B.C. MOE 2014b), but direct contact with elevated concentrations of sulphate can interfere with osmoregulation and cellular membrane function (Davies and Hall 2007, Grosell et al. 2007, Cormier et al. 2013).

The B.C. WQG for sulphate varies with hardness, up to a maximum of 250 mg/L as CaCO3 (Table 8-5). For higher hardness, site-specific testing is recommended (B.C. MOE 2013).

Table 8-5. WQG for sulphate.

Water hardness (mg/L as CaCO3)	Sulphate concentration (mg/L)
0 to 30 (very soft)	128
31 to 75 (soft to moderately soft)	218
76 to 180 (moderately soft to hard)	309
181 to 250 (very hard)	429
>250 (very hard)	Need to determine based on site water

Source: B.C. MOE 2013.

Consistent with the direction provided in the B.C. MOE sulphate guideline, site-specific testing was completed. A literature review was also undertaken to identify the sensitivity of aquatic species to sulphate. As with nitrate, site-relevant toxicity datasets were developed for fish, benthic invertebrates and amphibians, which are typically more sensitive to sulphate than terrestrial species or aquatic vegetation (Appendix D of Annex F). Sulphate benchmarks and targets developed to protect fish, benthic invertebrates and amphibians will therefore protect other organisms.

Rainbow trout was identified as the most sensitive aquatic species. This finding is consistent with that of B.C. MOE 2013, which used rainbow-trout test results to set the WQG. More specifically, the WQG considered tests by the Pacific Environmental Science Centre (PESC) that followed standard methods, and by Simon Fraser University's Chris Kennedy, who used greater sample numbers. Kennedy's results had smaller confidence intervals (Table 8-6) and were used to set the WQG.

Table 8-6. Rainbow trout sensitivity to sulphate in waters with hardness ≥ 250 mg/L as $CaCO_3$.

Study group	Test	Thresholds[1]		
		Level 1 (~10% Effect)	Level 2 (~20% Effect)	Level 3 (~50% Effect)
Pacific Environmental Science Center[2]	21-day embryo-alevin survival	191 (71 – 517)	502 (239 –1055)	1,392 (668–2,898)
Chris Kennedy[2]	21-day embryo-alevin survival	654 (615 – 695)	857 (819 – 896)	1,379 (1,329–1,433)
Work completed in support of the Elk Valley Water Quality Plan[3]	28-day embryo-alevin development	381 (86 – 610)	530 (176 – 772)	998 (861 – 1,087)

Note[1]: 95% confidence intervals are shown in parentheses.
Note[2]: Reported in B.C. MOE 2013.
Note[3]: Reported in Annex F.

Tests using high-hardness waters from the Elk Valley (up to 1,400 mg/L as $CaCO_3$) resulted in effect concentrations comparable to the PESC findings but lower than the Kennedy results (Table 8-6). The site-specific results indicate that rainbow trout sensitivity to sulphate does not increase at hardness >250 mg/L as $CaCO_3$ within the Elk and Fording rivers. Consequently, the sulphate benchmark for hardness conditions >250 mg/L as $CaCO_3$ is set to 429 mg/L, which is equal to the B.C. WQG for hardness conditions of 180 to 250 mg/L as $CaCO_3$.

Toxicity testing using water from the Fording and Elk Rivers indicated that extension of the sulphate WQG of 429 mg/L is applicable to hardness values up to at least 800 mg/L as $CaCO_3$. This conclusion is based on the following toxicity testing results:

- Sulphate spiking tests conducted as part of the Phase 1 mixture toxicity tests exhibited no evidence of osmotic stress at hardness levels up to at least 800 mg/L as $CaCO_3$. For example, the sulphate IC20 concentrations and associated hardness levels for the two most sensitive species (rainbow trout embryo-alevin development and *C. dubia* reproduction) were 530 mg/L sulphate at a hardness of 830 mg/L as $CaCO_3$, and 595 mg/L sulphate at a hardness of 910 mg/L as $CaCO_3$, respectively (Golder and Nautilus 2013).
- Testing in Fall 2013 confirmed no evidence of toxicity in all treatments with elevated sulphate and hardness. Sulphate was not found to be toxic to any test species up to the maximum concentration tested, even in combination with hardness values greater than 1,000 mg/L as $CaCO_3$ (Annex F).

Additional site-specific toxicity testing will be completed during plan implementation to assess sensitivity of aquatic organisms and validate the sulphate benchmark at hardness levels >250mg/L as $CaCO_3$(see Chapter 11).

8.2.5 Cadmium

Effects of cadmium on aquatic organisms are generally assessed through direct contact, as cadmium can interfere with the uptake of calcium from water (CCME 2014). Cadmium toxicity decreases as water hardness increases. This relationship is well-established, and is incorporated into the B.C. working cadmium WQG (B.C. MOE 2006), the newer Canadian cadmium WQG for the protection of aquatic life (CCME 2014) and a recently released draft B.C. WQG. The current B.C. working WQG is based on the previous version of the Canadian guideline, and is therefore out of date.

Cadmium toxicity is also influenced by dissolved organic carbon (DOC). As with hardness, cadmium toxicity declines as DOC increases. However, DOC levels in the Designated Area tend to be low (~2 mg/L), and exert only a small influence on cadmium toxicity. Teck developed a mechanistic cadmium toxicity model using the

biotic ligand model (Annex G). This model provides the most robust assessment of cadmium effects, and confirmed that DOC and other toxicity-modifying factors in the Elk Valley exert only a small influence on cadmium toxicity, and that a hardness relationship is appropriate for setting a water-quality benchmark.

The available toxicological literature was reviewed to develop a species-sensitivity distribution of cadmium effects to aquatic biota (Annex G). These toxicity data were normalized to Elk Valley conditions using a hardness-equation approach, comparable to that used by CCME in the most recent update of the Canadian WQG for cadmium (CCME 2014).

The water-quality benchmark for cadmium is defined using the following hardness equation, which was developed to protect the lowest observed endpoint for the most sensitive species in the cadmium species-sensitivity distribution:

$$Benchmark\ (\mu g/L) = 10^{0.83*\log 10(hardness)-2.53}$$

This relationship is almost identical to the updated long-term Canadian WQG for total cadmium. The two equations use the same slope of 0.83, differing only in intercept. The Canadian WQG uses an intercept of 2.46 instead of 2.53, which yields a higher cadmium value at a given hardness (see Table 8-7).

Table 8-7. Cadmium benchmarks at different hardness levels, compared with the Canadian WQG.

Hardness level (mg/L as $CaCO_3$)	Benchmark concentration (µg/L)[1]	Canadian WQG (µg/L)[2]
100	0.14	0.16
150	0.19	0.22
200	0.24	0.28
250	0.29	0.34
300	0.34	0.37

Note[1]: Calculated using benchmark equation.
Note[2]: Canadian WQG was calculated from the guideline equation in CCME 2014.

The Canadian WQG intercept is based on a species-sensitivity distribution, representing a hazard concentration to 5% of species of 0.09 µg/L at a hardness of 50 mg/L as CaCO3. Currently, B.C. MOE does not endorse the use of species-sensitivity distributions and associated hazard concentrations to define protective thresholds. Consequently, the intercept was adjusted using the geometric mean of the most sensitive species in the distribution, the water flea *Daphnia magna*. The cadmium benchmark was applied as a dissolved value consistent, with understanding that the next version of the B.C. WQG for cadmium will apply to the dissolved fraction.

8.3 Long-term Water Quality Targets

Long term water quality targets were developed following the process described in Section 8.1 and illustrated in Figure 8-1. Results of the initial implementation plan modelling were compared to WQGs or benchmarks providing the same level of protection. For those Order stations that showed predicted concentrations at or below the WQG or benchmark, the respective value was selected as the long term target for that order station (Section 8.3.1). If expected future conditions did not meet WQGs or benchmark values providing the same level of protection, then an integrated assessment was completed in parallel with adjustments to the initial

implementation plan to achieve long-term targets that are achievable and protective of aquatic ecosystem health in the MU (Sections 8.3.2 and 8.3.3). The end result was long-term targets for all six MUs, which are summarized in Section 8.3.4.

8.3.1 Comparison with Water Quality Guidelines and Benchmarks

Pursuant to the Order, site-specific water-quality objectives (SSWQOs) were calculated using approved methods to support the long-term target setting process (see Annex F). These calculations confirmed that the B.C. WQGs are applicable for the natural background water quality conditions in the Designated Area. This finding confirmed that development of water quality benchmarks for the Designated Area would require different methods than those prescribed for calculating SSWQOs.

Current water-quality conditions and predicted concentrations from the initial implementation plan were compared with B.C. WQGs (nitrate and sulphate) and a cadmium benchmark value that has margin of safety comparable to the Canadian WQG. For those Order stations that showed predicted future concentrations at or below the WQG or benchmark, the respective value was selected as the long term target for that Order station.[4] The results of this comparison are presented below:

- Current and predicted future concentrations of selenium, nitrate and sulphate are less than the B.C. WQG; therefore, these guideline values were set as the long-term targets for Order station LK-2 in Lake Koocanusa (MU-6).
- Current and predicted future concentrations of cadmium in Lake Koocanusa are less than the cadmium benchmark, which provides a margin of safety that is comparable to the Canadian WQG. Therefore, this benchmark was set as the long-term target for Order station LK-2 in Lake Koocanusa (MU-6).
- Selenium concentrations in the Elk and Fording rivers (MU-1 to MU-5) are currently above the WQGs, and are expected to remain so in the future. Therefore, long-term targets for selenium in these MUs were defined using an integrated assessment.
- Nitrate levels in the Elk River upstream of the Fording River (MU-3) are currently below the B.C. WQG, and are projected to remain so for the future. Nitrate levels in the Elk River downstream of the Fording River (MU-4 and MU-5) are currently above the B.C. WQG during winter; however, long-term concentrations with the initial implementation plan are predicted to be below the guideline. Therefore, long-term targets at Order stations in these MUs were set at the current WQG of 3 mg/L of NO_3-N.
- Nitrate levels in the Fording River (MU-1 and MU-2) are currently above the WQGs, and are expected to remain so in the future. Therefore, long-term targets for nitrate in these MUs were defined using an integrated assessment.
- Sulphate concentrations in the Elk and Fording rivers are currently below the B.C. WQG[5] for the protection of aquatic life, and are predicted to remain so in the future in MU-2 to MU-5. Therefore, the long-term target was set to the WQG at Order stations in these MUs.
- Sulphate concentrations at Order station FR4 in MU-1 are predicted to reach the B.C. WQG in 2030. The potential for sulphate to exceed the long-term target in MU-1 will be managed through monitoring and adaptive management (see Chapter 11). If required, sulphate treatment can be implemented (see Section 8.5). The long-term sulphate target for MU-1 at Order station FR4 was set to B.C. WQG (i.e., 429 mg/L) and an integrated assessment was completed to confirm that this target will protect aquatic health in MU-1.
- Current and estimated future concentrations of cadmium in the Elk and Fording rivers (MU-1 to MU-5) are less than the benchmark, which provides a margin of safety that is comparable to the Canadian WQG. Therefore, this benchmark was set as the long-term target for Order stations in these MUs.

[4] For cadmium, future concentrations were estimated by scaling measured concentrations to reflect the relative (i.e., percent) changes predicted by the Model. This approach was used because the geochemistry of cadmium release from waste spoils cannot be modelled with sufficient resolution to allow model predication to be used directly.

[5] A sulphate benchmark value of 429 mg/L applies at hardness levels >250 mg/L as $CaCO_3$.

8.3.2 Integrated Assessment Methods

The integrated assessment provides a methodology to evaluate the level of protection afforded to aquatic life in MUs that include different water quality conditions in mainstem rivers, mine-influenced tributaries and tributaries not influenced by mining. It assesses the regional (i.e., MU scale) influence of local-scale water-quality conditions.

This section includes a summary of the integrated assessment methodology. The full methodology is presented in Annex H.

8.3.2.1 Division of Management Unit into Subunits

Each MU was divided into subunits to facilitate evaluation of potential effects in on-channel and off-channel habitat areas in the mainstem river and mine-influenced tributaries. The Elk and Fording River mainstems and Michel Creek were subdivided, where appropriate, to account for longitudinal variability in constituent concentrations.

Tributaries not influenced by mining that are likely to be ephemeral were not included in the integrated assessment, because quality of aquatic habitat in these areas will be low and their inclusion would bias the influence of tributaries. Upstream tributary areas isolated from the Fording or Elk River mainstems, such as those in upper Kilmarnock Creek (MU-1) and upper Line Creek (MU-2), were not incorporated into the integrated assessment for fish because they are not accessible to fish in downstream areas in the mainstem Fording or Elk rivers or Michel Creek; nor are they a source of benthic drift to downstream areas. They were also excluded to avoid a reference area bias (i.e., dilution of effect through the inclusion of unconnected reference areas).

8.3.2.2 Define Available Habitat

The total area of aquatic habitat present in each subunit was quantified, as well as that which is likely to be accessible to fish. These areas were calculated using GIS map layers, with consideration of CanFor stream classifications, stream magnitude and stream slope.

Proposed mine development activities were taken into account, as were water management activities related to the initial implementation plan that will result in loss of habitat. Affected subunits include:

- Cataract, Swift and Clode creeks in MU-1
- West Line Creek and a small portion of upper Line Creek in MU-2
- Leask and Wolfram creeks in MU-3
- Gate and Bodie creeks in MU-4.

Cataract, Swift, Leask and Wolfram creeks are not fish-accessible, with the possible exception of the last 20 metres of Swift Creek. The lower portions of Clode, Gate and Bodie creeks are fish-accessible, as is a small length of lower West Line Creek and the small area of upper Line Creek affected by the operations of the West Line Creek water treatment plant. Aquatic habitat in Lake Mountain Creek will be lost as part of development of the proposed Fording River Operations' Swift Project.

Compensation planning for lost habitat in West Line Creek and Line Creek is underway. Offsets for lost habitat in the other creeks will be developed, if and as required, during permitting and detailed design of the relevant components of the initial implementation plan. Similarly, compensation habitat for Lake Mountain Creek is being developed as part of the Swift Project, since disturbance of this creek occurs as a result of mining rather than water management activities.

Habitat that will be removed, and that is expected to be subject to habitat offsets, was not included in the integrated assessment.

8.3.2.3 Define Constituent Concentrations

Constituent concentrations in tributaries and other subunits unaffected by mining were set to background conditions, as described in Chapter 4. They are assumed to remain unchanged over time.

Selenium and nitrate concentrations in mine-influenced subunits were calculated using a two-stage process. First, concentrations in mine-influenced subunits were defined based on predicted long-term performance of the initial implementation plan. Long-term concentrations were estimated using the Model, which is described in Annex D.1. The Model is designed to simulate regional conditions in the Designated Area, and is used to predict concentrations in the Elk and Fording River mainstems.

The Model does not accurately predict concentrations in all mine-influenced tributaries; however, it can more reliably predict relative changes in water quality in these areas, because this is strongly correlated with changes to waste-rock volume. As such, predictions for current and long-term conditions were used to proportionally scale values observed in 2013 to provide an estimate of long-term concentrations in mine-discharge tributaries (i.e., long-term concentration in a mine-discharge tributary = current observed concentration × modelled long-term concentration ÷ modelled current concentration).

Long-term concentrations in all mine-influenced subunits were then scaled to reflect concentrations at the Order station. For example, if long-term predictions for the initial implementation plan indicate that a mine-discharge tributary has a concentration twice that predicted at the Order station, the concentration in the tributary was set to twice the long-term target concentration. This approach allows for an explicit evaluation of how changes to concentrations at an Order station could affect concentrations in different subunits, as an approximation of what could occur as a result of applying different levels of water treatment. Potential effects in each subunit and across the MU as a whole were then assessed, as per Step 4

Sulphate and cadmium concentrations in mine influenced subunits were defined using a similar process. Concentrations were based on the predicted performance of the initial implementation plan, with tributary concentrations being from 2013 observed values to reflect the relative changes predicted by the Model.

Sulphate concentrations in MU-2 to MU-4 are predicted to remain below the long-term target concentrations at the Order stations; therefore, integrated effects were assessed for the maximum predicted concentrations. Sulphate concentrations in MU-1 are predicted to reach the long-term target at Order station FR4; therefore, integrated effects were assessed for predicted conditions in mainstem reaches and in mine-influenced tributaries where the sulphate concentration at FR4 is equal to the long-term target concentration.

Estimated future cadmium concentrations are less than the long-term targets at all Order stations. Future concentrations were estimated by scaling measured concentrations to reflect the relative (i.e., percent) changes predicted by the Model. This approach was used because the geochemistry of cadmium release from waste spoils cannot be modelled with sufficient resolution to allow model predication to be used directly. This approach is expected to over-estimate future concentrations, because cadmium levels do not show a consistent increasing trend with increasing mine activity and waste-rock deposition. Statistical trends at mainstem river stations tend to be relatively flat, although increasing and decreasing statistical trends have been observed at individual locations (Zadlik and Minnow 2013). Temporal trends in tributaries have also been inconsistent, demonstrating no clear or consistent response to mining activity.

8.3.2.4 Quantitative Integrated Assessment

For selenium and nitrate in the Fording River, potential effects on sensitive aquatic receptors in each subunit were assessed by comparing constituent concentrations with WQGs and Level 1 and 2 benchmarks. Effect sizes were quantified using the underlying dose-response relationships, when available. Results were expressed either as a categorical result (e.g., < Level 1 benchmark), or as a percentage potential effect on the receptor organism and most sensitive life-history endpoint (e.g., an 8% effect on *C. dubia* reproduction).

A similar approach was used for nitrate in the Elk River, and for sulphate and cadmium in MU-1 to MU-4. The calculated concentrations defined in Step 3 were compared to WQGs or equivalent values (e.g., the sulphate and cadmium benchmarks outlined in Sections 8.2.4 and 8.2.5). Concentrations above WQGs or equivalent values were then compared to Level 1 and Level 2 benchmarks, or the underlying dose-response curves.

The nitrate benchmarks applicable to the Elk River are described in Appendix F, as are the sulphate benchmarks used in this evaluation. Cadmium benchmarks used to evaluate potential effects in areas where concentrations may exceed the WQG or equivalent are outlined in Appendix G.

Potential effects calculated from a dose-response curve (i.e., expressed as a percentage) were then spatially integrated using an area-weighted approach, to identify the percent effect across the entire MU (e.g., a 5% integrated effect to *C. dubia* reproduction across MU-1). This value was then compared to the Level 1 and Level 2 critical-effect sizes (i.e., 10 and 20%) to assess protection of aquatic life.

The area-weighted approach assumes that all available habitats are of equal value and receive equal use. The calculation involves multiplying the percent effect in each subunit by the habitat present in the subunit, adding all of the resulting values, and then dividing by the total habitat available in the MU. A sensitivity analysis of the area-weighted approach using fish telemetry data for WCT in the upper Fording River (MU-1) indicated that potential effects were not underestimated compared to a weighting based on observed fish use (Annex H).

Categorical results could not be spatially integrated, because they are not numerical values.

8.3.2.5 Qualitative Assessment of Interactive Effects

Effects on higher-level sensitive receptors (e.g. birds, fish and amphibians) may occur as a result of direct effect and indirect effects related to changes in food availability. Similarly, effects on benthic invertebrates can be expressed through changes to the population of the most sensitive species, or more broadly through changes to the community as a whole (as a result of effects on multiple species). In recognition of these potential pathways, a qualitative evaluation was completed in each subunit to assess whether effects on multiple sensitive endpoints could result in community-level effects.

For benthic invertebrates, potential population-level responses were assessed based on predicted effects on the most sensitive invertebrate species tested. Potential changes in community structure or function were evaluated with reference to predicted effects on the next most sensitive species. The results of these evaluations were integrated, as shown in Table 8-8, to generate a categorical effect score of 1 to 5, for which the categories are defined in Table 8-9.

Table 8-8. Integration of potential effects to benthic invertebrates.

Endpoint and level of predicted effect		Most sensitive species endpoint[1]		
		≤10%	10 to 20%	>20%
Community endpoint (Next most sensitive species)	≤10%	1	2	3
	10 to 20%	n/a	3	4
	>20%	n/a	n/a	5

Note[1]: n/a = non-applicable scenario (e.g., a community level alteration cannot occur without a response to the most sensitive species); colour-coded categorical scores are defined as per Table 8-9.

The scoring system in Table 8-8 is based on the following rationale:

- Effect sizes of ≤10% represent negligible potential for population-level effects.
- Effect sizes of 10 to 20% represent a possibility of population-level effects, although measurable or ecologically meaningful changes in invertebrate populations are unlikely (Suter et al. 1995).
- Effect sizes of >20% present a potential for measurable and ecologically meaningful population-level effects (Suter et al.1995).
- Effects on the most sensitive invertebrate test species may result in changes to diversity of benthic invertebrates, but is unlikely to change general function, structure or abundance of the larger community.
- When more than the most sensitive species is potentially affected, changes to community function, structure and/or overall abundance are possible, particularly when effect sizes exceed 20%.

Potential effects on fish, birds and/or amphibians were evaluated in a similar fashion, considering direct effects on the most sensitive species and life-history endpoint (e.g., brown trout reproduction), and indirect effects that may occur through reduced food supply (i.e., benthic invertebrate abundance).

Table 8-9. Definition and interpretation of categorical effect scores.

Score	Definition	Interpretation
0	Within the WQG	No effect
1	≤10% effect on any endpoint	No population effect
2	10 to 20% effect to sensitive invertebrate species endpoint	Potential effects to populations of sensitive invertebrate species that are not expected to be measurable or ecologically meaningful*
3	*Invertebrates*: >20% effect to sensitive species or 10 to 20% effect to multiple endpoints. *Fish birds and/or amphibians*: 10 to 20% direct effect or <10% direct effect with >20% effect to food supply	*Invertebrates:* Potential effect to populations of the most sensitive species, or potential effects to multiple species that are not expected to be measurable or ecologically meaningful* *Fish, birds and/or amphibians:* Potential effect to populations of the most sensitive species that are not expected to be measurable or ecologically meaningful, but that require consideration within the context of other stressors and verification through follow-up monitoring*
4	*Invertebrates*: >20% effect to sensitive species with 10 to 20% effect to other species *Fish, birds and/or amphibians*: >20% direct effect or 10 to 20% direct effect with >20% effect to food supply	*Invertebrates*: Potential effect to populations of multiple species *Fish, birds and/or amphibians*: Potential effect to populations of one or more sensitive species**
5	>20% effect to a multiple endpoints	Potential effect to populations of multiple species, with potential changes to community structure

Note*: Unlikely to be distinguishable from changes that occur as a result of natural variation or to affect the maintenance of an ecologically effective and self-sustaining population.
Note**: Must be interpreted with caution when applied to local, subunit scale effects to mobile species.

Categorical effect scores were assigned following the scoring system outlined in Table 8-10. This scoring system was developed based on similar rationale to that outlined above, considering:

- For fish, effect sizes of 10 to 20% are unlikely to be measurable or ecologically meaningful (Suter et al. 1995), but require additional consideration within the context of multiple stressors (Mebane 2010).
- At an indirect effect size >20%, benthic community structure and function could be impaired, which could limit food availability.
- Integrated effects are likely to become more severe as indirect and direct effects individually increase.

Table 8-10. Integration of potential effects on fish, birds and/or amphibians.

Endpoint and Level of Predicted Effect		Direct (Most sensitive of direct endpoints)[2]		
		≤10%	10 to 20%	>20%
Indirect (Food Supply)[1]	≤20%	1	3	4
	>20%	3	4	5

Note[1]: Indirect effect defined based on invertebrate community endpoint.
Note[2]: Colour-coded categorical scores are defined in Table 8-9.

8.3.2.6 Evaluation of Integrated Effects

The evaluation of integrated effects combines the results of the previous two steps (the quantitative integrated assessment and the qualitative assessment of interactive effects) to assess the integrated effect for the MU in question. This evaluation was completed using the following integrated effects assessment criteria, which are derived from the corresponding critical-effect sizes:

- For the protection of benthic invertebrate community structure and abundance (noting that protection at the community level is required to maintain ecosystem function, including the production of food for higher-level organisms):
  - a predicted integrated effect size of <20% across the MU on the community endpoints (if dose-response information is available)
  - concentrations less than the Level 2 benthic community benchmark in all mainstem subunits of the Elk and Fording rivers
  - integrated effect scores of 3 or less for benthic invertebrates in the mainstem subunits of the Elk and Fording rivers.
- For the protection of fish, bird, and amphibian populations:
  - a predicted integrated effect size of <10% across the MU to the most sensitive life-history endpoint, based on the best estimate of the underlying dose-response curve (if available)
  - concentrations less than the Level 1 benchmark for the most sensitive life-history endpoint in all mainstem subunits of the Elk and Fording rivers
  - integrated effect scores of <3 in mainstem subunits of the Elk and Fording rivers
  - for selenium effects to fish and bird reproduction, a predicted integrated effect size of <20% for the most sensitive receptor endpoint across the MU, based on an upper-bound estimate of the underlying dose-response curve.

Benthic invertebrate criteria focused on maintaining effect sizes <20% for the most sensitive species and life-history endpoint to be protective by preventing measurable and ecologically meaningful changes to benthic communities. Lower effect sizes were used for fish because multiple stressors are present. The same rationale was applied to birds and amphibians, given their longer life spans and lower reproductive output relative to benthic invertebrates.

If all integrated assessment criteria are met, then predicted conditions are expected to be protective of aquatic health in the MU. Exceeding one or more of these integrated assessment criteria for an MU does not necessarily mean that aquatic health would not be protected; however, it does require consideration of any such exceedances to evaluate the level of risk and to factor this into the selection of long-term targets that are protective of aquatic health.

The integrated assessment was used to derive long-term targets for selenium in MU-1 to MU-5[6] and nitrate in MU-1 and MU-2. Level 1 benchmarks were used as the initial candidate long-term target concentration assigned at each Order station in question. The initial target was then adjusted downwards, if required, to meet the integrated assessment criteria for the MU.

Target levels were also evaluated to determine if they could be achieved with the initial implementation plan. If required, target levels and the initial implementation plan were evaluated iteratively to derive a target value that is both protective and achievable. This step was required in only one instance, which was to set the long-term selenium target in the lower Fording River (MU-2). The level of risk associated with integrated assessment criteria that could not be met in MU-2 was evaluated and factored into the long-term target selection.

Integrated assessments were also completed for sulphate (MU-1 to MU-4), cadmium (MU-1 to MU-4) and nitrate in the Elk River (MU-3 to MU-4). This was done to identify the level of integrated effects associated with either the maximum predicted long-term concentrations for the initial implementation plan (cadmium and sulphate in MU-2 to MU-4) or the long-term target when set to the WQG (nitrate and sulphate in MU-1), as discussed in Section 8.3.1.

8.3.3 Integrated Assessment Results

8.3.3.1 Selenium

The integrated assessment results for selenium are presented in Table 8-11. Results of the integrated assessment of selenium in the upper Fording River (MU-1) indicate that a long-term target of 57 µg/L will meet the integrated assessment criteria.

In the lower Fording River (MU-2), the Level 1 selenium benchmark of 19 µg/L could not be achieved with the initial implementation plan. Through an iterative process of evaluating target levels and the initial implementation plan, a long-term selenium target of 40 µg/L was derived that is both protective and achievable. This is further documented in Section 8.5.3.5 and shown in Figure 8-8.

The long-term target value of 40 µg/L in MU-2 is expected to protect fish populations, although with a lower margin of safety than a level 1 (10%) effect size. The predicted integrated effect size to sensitive fish species is 13% across the MU. Selenium concentrations in all sections of the lower Fording River are lower than the Level 2 benchmark for the most sensitive life-history endpoint, and the predicted upper bound integrated effect size for sensitive fish species is <20%. A predicted integrated effect size of 13% (17% upper bound) is considered unlikely to affect sensitive fish populations in the lower Fording River for a number of reasons:

- As discussed in Section 8.2.2.3, the targeted critical effect size of 10% is associated with a margin of safety, and effect sizes of <20% for egg survival are unlikely to affect a fish population.
- The target meets the assessment criteria for all other aquatic and aquatic feeding biota that are sensitive to selenium (i.e., westslope cutthroat trout, birds and benthic invertebrates).
- There is limited potential for multiple-stressor interactions in MU-2: sulphate and cadmium concentrations are <WQGs and the integrated effect to fish from nitrate is predicted to be ~2% (see Annex H).
- In contrast to the upper Fording River, in which the fish population is isolated because of Josephine Falls, fish in the lower Fording River can freely move into the Elk River (MU-3 to MU-5), where selenium concentrations and effect sizes are lower.

In the Elk River (MU3 to MU5), the long-term target of 19 µg/L meets the integrated assessment criteria for all of these MUs.

[6] Although there are no tributaries in MU-5 that are influenced by Teck operations, an integrated assessment was completed for this MU to identify long-term selenium target that is above the B.C. WQG.

8.3.3.2 Nitrate

Results of the integrated assessment for nitrate in the Fording River MUs are presented in Table 8-12. The integrated assessment criteria for nitrate in MU-1 and MU-2 were met for the long-term target of 11 mg/L of NO_3-N at the Order stations.

Results of the integrated assessment for nitrate in the Elk River MUs are presented in Table 8-13. The long-term nitrate target in Elk River MUs is equal to the WQG of 3 mg as NO3-N mg/L. The integrated assessment criteria were met in MU-3 and MU-4, with nitrate concentrations in most habitats at or below the long-term target (see Annex H).

During the Coal Mountain Operations (CMO) Phase II environmental assessment, efforts will be directed to refining nitrate predictions for predictions of local effects in Wheeler Creek. As outlined in Annex H, nitrate concentrations in Wheeler Creek may become elevated in future, although not to the extent of affecting environmental protection for the MU-4, since Wheeler Creek represents <3% of the total available habitat. Updates will reflect, to the extent possible, the influence of new blasting practices on nitrogen mobilization (discussed in Chapter 6).

8.3.3.3 Sulphate

Results of the integrated assessment for sulphate in the are presented in Table 8-14. In MU-1, most but not all integrated assessment criteria were met (Table 8-14). For example, the integrated effect sizes for fish (the most sensitive receptor), amphibians and benthic invertebrates met the assessment criteria. However, only approximately 34% of the mainstem Fording River was predicted to be less than the Level 1 benchmark, although 100% of this area was below the Level 2 benchmark. A sulphate target level of 429 mg/L at FR4 is expected to be protective of aquatic health in MU-1 because integrated effect sizes were <10% for all receptors and 98% or more of the MU met Level 2 benchmarks for fish, amphibians and benthic invertebrates. Follow-up monitoring and toxicity testing will be used to verify this conclusion and updated the toxicity benchmarks as appropriate. Sulphate concentrations in the upper Fording River will be adaptively managed as described in Chapter 11, as will the sulphate targets and timeframes. If necessary, sulphate treatment can be implemented (see Section 8.5).

Sulphate concentrations in the lower Fording River (MU-2) and throughout the Elk River (MU-3 to MU-5) are predicted to remain below the B.C. WQG in the long-term without mitigation. Maximum predicted long-term sulphate concentrations met all integrated assessment criteria in these MUs.

8.3.3.4 Cadmium

Cadmium concentrations in the Fording River (MU 1 and MU-2) and the Elk River (MU-3 to MU-5) are estimated to remain below the long-term target in the long-term without mitigation. Maximum predicted long-term cadmium concentrations met all integrated assessment criteria in these MUs.

Predictions of cadmium concentrations are uncertain. Efforts are underway to improve the quantitative understanding of the geochemical release of cadmium from waste rock, allowing improvement of model predictions. This information will be used during implementation to adaptively manage cadmium concentrations if and as necessary.

Table 8-11. Results of integrated assessment for selenium in the Elk and Fording rivers

Assessment criteria		Management Unit (maximum monthly selenium concentration at Order station)				
Description	Goal	MU-1 (57 µg/L)	MU-2 (40 µg/L)	MU-3 (19 µg/L)	MU-4 (19 µg/L)	MU-5 (19 µg/L)
Protection of Fish						
Integrated effect size for most sensitive endpoint	Best estimate of <10% (with upper bound estimate of <20%)	9%[1] (12%)[2]	13% (17%)	5% (8%)	8% (11%)	7% (10%)
Proportion of management unit with concentrations <Level 1 benchmark for most sensitive endpoint	100% in river mainstem	100% (96%)[3]	0% (27%)	100% (99%)	100% (93%)	100% (100%)
Maximum effect score in Fording River mainstem	2	1	3	1	1	1
Protection of Birds						
Integrated effect size for most sensitive endpoint	<10%	6%	5%	3%	4%	4%
Proportion of management unit with concentrations <Level 1 benchmark for most sensitive endpoint	100% in river mainstem	100% (95%)	100% (100%)	100% (99%)	100% (99%)	100% (100%)
Maximum effect score in Fording River mainstem	2	1	1	1	1	1
Protection of Benthic Invertebrates						
Integrated effect size for community endpoint	<20%	-[4]	-	-	-	-
Proportion of management unit with concentrations <Level 2 benchmark for the community endpoint	100% in river mainstem	100% (98%)	100% (100%)	100% (100%)	100% (100%)	100% (100%)
Maximum effect score in Fording River mainstem	3	1	1	1	1	1
Achievable by initial implementation plan	Yes	Yes	Yes	Yes	Yes	Yes

Note: Derived from information contained in Annex H. See Table 8-9 for definition of effect scores. Bolded values do not meet the criteria.
Note[1]: % Integrated effect size for most sensitive endpoint in the MU.
Note[2]: Upper bound estimate of integrated effect size.
Note[3]: % of mainstem subunit area below criteria, with % of area in the MU below criteria shown in parentheses.
Note[4]: not applicable, because dose-response curves not available.

Table 8-12. Results of integrated assessments for nitrate in the Fording River (MU-1 and 2).

Assessment criteria		Nitrate concentration of 11 mg/L of NO3-N at Order station	
Description	**Goal**	**MU-1**	**MU-2**
Protection of Fish			
Integrated effect size for most sensitive endpoint	Best estimate of <10%	~4%	~6%
Proportion of management unit with concentrations <Level 1 benchmark for most sensitive endpoint	100% in river mainstem	100% (93%)[(b)]	100% (98%)
Maximum effect score in Fording River mainstem	2	1	1
Protection of Amphibians			
Integrated effect size for most sensitive endpoint	<10%	~1%	~1%
Proportion of management unit with concentrations <Level 1 benchmark for most sensitive endpoint	100% in river mainstem	100% (100%)	100% (100%)
Maximum effect score in Fording River mainstem	2	1	1
Protection of Benthic Invertebrates			
Integrated effect size for community endpoint	<20%	~3%	~5%
Proportion of management unit with concentrations <Level 2 benchmark for the community endpoint	100% in river mainstem	100% (100%)	100% (100%)
Maximum effect score in Fording River mainstem	3	3	3
Achievable by initial implementation plan	Yes	Yes	Yes

Note: Results shown at hardness of 360 mg/L as CaCO3. Percentage of mainstem subunit area below criteria, with % of area in the MU below criteria shown in parentheses.

Table 8-13. Results of Integrated Assessments for Nitrate in the Elk River (MU-3 and MU-4).

Assessment criteria		Nitrate long-term target concentration of 3 mg/L of NO_3-N at Order station	
Description	**Goal**	**MU-3**	**MU-4**
Protection of Fish			
Integrated effect size for most sensitive endpoint	Best estimate of <10%	—	—
Proportion of MU with concentrations <Level 1 benchmark for most sensitive endpoint	100% in river mainstem	100% (100%)	100% (97%)
Maximum effect score in Elk River mainstem	2	0	0
Protection of Amphibians			
Integrated effect size for most sensitive endpoint	<10%	—	—
Proportion of MU with concentrations <Level 1 benchmark for most sensitive endpoint	100% in river mainstem	100% (100%)	100% (98%)
Maximum effect score in Elk River mainstem	2	0	0
Protection of Benthic Invertebrates			
Integrated effect size for community endpoint	<20%	—	—
Proportion of MU with concentrations <Level 2 benchmark for the community endpoint	100% in river mainstem	100% (100%)	100% (98%)
Maximum effect score in Elk River mainstem	3	0	0

Note: — = not applicable, because dose-response curve not available. See Table 8-9 for effect score categorization. Percentage of mainstem subunit area below criteria, with % of area in the MU below criteria shown in parentheses.

Table 8-14. Results of Integrated Assessments for Sulphate in the Elk and Fording Rivers.

Assessment criteria		FR4 at long-term target of 429 mg/L	Based on maximum concentration Oredicted for the initial implementation plan		
Description	**Goal**	**MU-1**	**MU-2**	**MU-3**	**MU-4**
Protection of Fish					
Integrated effect size for most sensitive endpoint	Best estimate of <10%	~9%	~4%	~0%	~1%
Proportion of MU with concentrations <Level 1 benchmark for most sensitive endpoint	100% in river mainstem	34% (56%)	100% (100%)	100% (100%)	100% (99%)
Proportion of MU with concentrations <Level 2 benchmark for most sensitive endpoint		100% (98%)	100% (100%)	100% (100%)	100% (99%)
Maximum effect score in Fording / Elk River mainstem	2	3	1	0	0
Protection of Amphibians					
Integrated effect size for most sensitive endpoint	<10%	~8%	~4%	~0%	~1%
Proportion of MU with concentrations <Level 1 benchmark for most sensitive endpoint	100% in river mainstem	34% (61%)	100% (100%)	100% (100%)	100% (98%)
Proportion of MU with concentrations <Level 2 benchmark for most sensitive endpoint	100% in river mainstem	100% (98%)	100% (100%)	100% (100%)	100% (98%)
Maximum effect score in Fording / Elk River mainstem	2	3	1	0	0
Protection of Benthic Invertebrates					
Integrated effect size for community endpoint	<20%	~4%	~2%	~0%	~1%
Proportion of MU with concentrations <Level 2 benchmark for the community endpoint	100% in river mainstem	100% (98%)	100% (100%)	100% (100%)	100% (98%)
Maximum effect score in Fording / Elk River mainstem	3	1	1	0	0

Note: Bolder values do not meet assessment criteria. See Table 8-9 for effect score categorization. Percentages for mainstem river are shown in brackets. Percentage of mainstem subunit area below criteria, with % of area in the MU below criteria shown in parentheses.

Table 8-15. Results of Integrated Assessment for Cadmium in the Elk and Fording Rivers

Assessment criteria		Based on maximum concentration estimated for the initial implementation plan			
Description	**Goal**	**MU-1**	**MU-2**	**MU-3**	**MU-4**
Protection of Fish					
Integrated effect size for most sensitive endpoint	Best estimate of <10%	-(a)	-	-	-
Proportion of MU with concentrations <Level 1 benchmark for most sensitive endpoint	100% in river mainstem	100% (100%)	100% (100%)	100% (100%)	100% (98%)
Maximum effect score in Fording / Elk River mainstem	2	1	0	0	0
Protection of Amphibians					
Integrated effect size for most sensitive endpoint	<10%	-	-	-	-
Proportion of MU with concentrations <Level 1 benchmark for most sensitive endpoint	100% in river mainstem	100% (100%)	100% (100%)	100% (100%)	100% (100%)
Maximum effect score in Fording / Elk River mainstem	2	1	0	0	0
Protection of Benthic Invertebrates					
Integrated effect size for community endpoint	<20%	-	-	-	-
Proportion of MU with concentrations <Level 2 benchmark for the community endpoint	100% in river mainstem	100% (100%)	100% (100%)	100% (100%)	100% (98%)
Maximum effect score in Fording / Elk River mainstem	3	1	0	0	0

Note: Bolder values do not meet assessment criteria. See Table 8-9 for effect score categorization. Percentages for mainstem river are shown in brackets. Percentage of mainstem subunit area below criteria, with % of area in the MU below criteria shown in parentheses.

8.3.4 Summary of Long-term Water Quality Targets and Timeframes

Long-term targets for each MU-and Order station are summarized in Table 8-16.

Table 8-16. Summary of long-term water-quality targets.

Management Unit	Order stations	Selenium (µg/L)[1]	Nitrate (mg/L NO_3-N)[2]	Sulphate (mg/L)[3]	Cadmium (µg/L)[4]
1	FR4	57	11	429	0.39
2	FR5	40	11	429	0.39
3	ER1	19	3	429	0.24
4	ER2	19	3	429	0.24
5	ER3, ER4	19	3	429	0.24
6	LK2	2	3	308	0.19

Note: Hardness dependent targets for nitrate (MU-1 & 2 only), sulphate and cadmium are shown for the following average hardness levels as mg/L as $CaCO_3$: Fording River 360; Elk River 200; and Lake Koocanusa 150.
Note[1]: The long-term selenium target for MU-6 is specified in Ministerial Order M113. Targets in MUs 1-5 are site-specific.
Note[2]: Nitrate targets in MUs 3-6 are equal to the B.C. WQG for the protection of aquatic life. The Target in MUs 1-2 is a site-specific harndess based equation; target values shown are for a representative hardness level of 350 mg/L as $CaCO_3$.
Note[3]: Sulphate targets are equal to the B.C. WQG for the protection of aquatic life. The target for hardness levels greater than 250 mg/L as $CaCO_3$ is equal to the guideline for hardness levels of 180-250 mg/L as $CaCO_3$.
Note[4]: Cadmium targets are equivalent to the Canadian WQG for the protection of aquatic life (CCME 2014), but expressed as a dissolved concentration. The cadmium target is a hardness-based equation; target values shown are for representative hardness levels of 360 mg/L as $CaCO_3$ in the Fording River, 200 mg/L as $CaCO_3$ in the Elk River and 150 mg/L as $CaCO_3$ in Lake Koocanusa.

Long-term targets for nitrate in the Elk River and Lake Koocanusa are set equal to the B.C. WQG of 3 mg/L of NO_3-N for the protection of aquatic life. Long-term targets for nitrate in the Fording are set to a hardness-dependent value of 11 mg/L of NO_3-N, expressed at a hardness of 360 mg/L as $CaCO_3$. They can be adjusted to other hardness levels using the following equation:

$$Nitrate\ Target\ in\ the\ Fording\ River\ (mg\ as\ N/L) = 10^{1.0003*\log 10(hardness)-1.52}$$

Targets for sulphate are set to the B.C. WQG for the protection of aquatic life. Site-specific testing at hardness >250 mg/L as $CaCO_3$ indicates that the guideline of 429 mg/L for hardness between 181 and 250 mg/L as $CaCO_3$ can be extended to apply as an target at higher hardness levels.

The long-term water-quality target for cadmium at all Order stations is defined using the following hardness equation, which was developed to protect the lowest observed endpoint for the most sensitive species in the cadmium species-sensitivity distribution:

$$Cadmium\ Target\ (\mu g/L) = 10^{0.83*\log 10(hardness)-2.53}$$

This relationship is almost identical to the updated, long-term Canadian WQG for total cadmium, which was released in 2014 (CCME 2014). This target is used in place of the current B.C. working WQG, which is based on the previous version of the Canadian WQG, and so is not considered current. Because the MOE does not endorse the use of species-sensitivity distributions and associated hazard concentrations to define protective thresholds, the intercept was adjusted to be consistent with MOE methods. The cadmium target was applied as a dissolved value consistent, with the consensus understanding that the next version of the B.C. WQG for cadmium will apply to the dissolved fraction.

The initial implementation plan is predicted to meet the long-term water-quality targets for all MUs within the timeframes summarized in Table 8-17. These timeframes are approximate, because they are based on model predictions.

Table 8-17. Expected timeframe to achieve long-term targets based on model predictions.

Management Unit	Order stations	Selenium	Nitrate
1	FR4	2022	2019
2	FR5	2023	2019
3	ER1	2014	2014
4	ER2	2023	2028[1]
5	ER3, ER4	2014	2019, 2014
6	LK2	2014	2014

Note[1]: Additional measures (updates to blasting practices) are planned to reduce nitrate concentrations. These measures, while not quantifiable at this time, are anticipated to reduce nitrate concentrations and may result in the long-term target being met earlier.

8.4 Multiple-Stressor Analysis

A qualitative multiple-stressor analysis was completed to assess potential interactions among Order constituents and other stressors (e.g., potential changes to calcite levels, water flows or nutrient status). The results of the multiple-stressor analysis were used to confirm the conclusions of the constituent-specific analyses, including selection of long-term target concentrations for selenium and nitrate. Full details of the qualitative multiple-stressor analysis can be found in Annex H.

8.4.1 Approach

Conceptual site models presented in Chapter 4 identify the following physical stressors to aquatic biota in the Elk and Fording River watersheds:

- changes to water flow
- formation of barriers that limit connectivity
- calcite formation
- release of suspended sediments, which may elicit effects through direct contact or via deposition on existing habitats.

Chemical stressors consist of changes to the concentrations of the four Order constituents, as well as potential changes to nutrient status related to the release of phosphorus from the active water treatment facilities that are included in the initial implementation plan.

The potential for these stressors to act in combination and produce greater levels of effect that those predicted for individual Order constituents was evaluated qualitatively using a lines of evidence approach. More specifically, the potential for mixture effects to occur among selenium, nitrate, sulphate and cadmium was evaluated through examination of the following:

- theoretical potential for interaction based on mechanisms of action of each Order constituent
- results of standardized site-specific toxicity testing that evaluates the toxicity of mixtures representative of mine-influenced waters

- results of toxicity testing using amended waters (i.e., spiking tests) to evaluate how increasing individual substances (in the context of other substances held at stable and site-relevant concentrations) influences magnitude of response.

The potential for interactive effects among the Order constituent and other stressors was then evaluated in consideration of the following:

- the small effect sizes upon which the water-quality benchmarks are based
- existing best management practices that are being used to control sediment releases from mine areas
- existing permit limits that regulate sediment releases from each operation with the goal of protecting downstream environments
- existing regulatory protocols that require compensation for disturbed habitats
- projected changes in water flows related to the initial implementation plan
- the medium and long-term calcite targets that are outlined in Chapter 7 of the Plan.

It is acknowledged that quantitative approaches are available for evaluating integrated effects from multiple chemical stressors. However, such approaches and models are only reliable when the mechanisms of toxicity are well understood, including knowledge of specific interactions among multiple constituents (as is the case for some pesticides - Rider and LeBlanc 2005). For the Order constituents, the mechanistic understanding of toxicity, both individually and in combination, is not known to a level to support such an approach. Furthermore, the Order constituents found in site waters exhibit a high degree of intercorrelation in exposure (i.e., similar concentration profiles over space and time), which limits the degree to which potential causal factors can be discriminated. Downes 2010 recognizes that prediction of the effects of multiple stressors is challenging because direct causes of an environmental alteration are difficult to distinguish from factors that merely correlate with responses, making it difficult to disentangle their effects in ways allowing correct prediction for the future.

Staztner and Bêche (2010) caution against the over-quantification of multiple stressor models where a mechanistic understanding of responses is lacking. They conclude that multiple-stressor evaluations of freshwater communities using quantitative or index-based methods should only be used in association with stressors for which mechanistic a priori predictions on their effects are possible. This view is supported by Rider and LeBlanc 2005, who conclude that indiscriminate application of a quantitative model in the absence of a sound mechanistic basis "increases the uncertainty associated with predicting mixture toxicity." Gregorio et al. 2013 identified an additional uncertainty in mixture assessment for aquatic ecosystems; specifically, mixture effect predictions have been shown to be consistent only when these models are applied for a single species, rather than for communities as represented in a species sensitivity distribution. The application of a specific model can therefore lead to over- or underestimations, depending mainly on the slope of the dose–response curves of the individual species. It is for these reasons that a qualitative approach was used.

8.4.2 Results

An evaluation of individual physical and chemical stressors is provided below, following by a qualitative evaluation of multiple stressors in MUs in the Elk and Fording River (MU-1 to MU-4). Based on this information, conclusions are rendered on how the findings of the constituent-specific analyses previously discussed may be affected, if at all, by multiple stressor considerations. Residual uncertainties inherent in multiple-stressor analysis will be addressed with through on-going monitoring and adaptive management, which are presented in Chapters 10 and 11 of the Plan.

8.4.2.1 Physical and Chemical Stressor Evaluation

The initial implementation plan may result in a loss of water flow in several mine-influenced tributaries. Mining activity associated with the FRO Swift Project will also result in the loss of Lake Mountain Creek. Compensatory habitats will be developed for the affected areas, if and as required, as part of permitting and detailed design.

While compensatory habitats do not eliminate the potential for multiple-stressor effects at a local subunit scale where habitat loss may occur, they are expected to prevent habitat loss at the MU scale; hence, eliminating this potential pathway from contributing to multiple-stressor effects at a regional scale.

As outlined in Chapter 7, the objective of calcite management is to protect aquatic habitat and to manage calcite to achieve acceptable long-term conditions. The narrative objective for calcite management is to understand and manage mine-related calcite formation such that streambed substrates in the Elk and Fording rivers and their tributaries can support abundant and diverse communities of aquatic plants, benthic invertebrates, and fish comparable to those in reference areas. Based on this commitment, calcite formation is not expected to contribute to effects to aquatic receptors in the long-term, and would not result in levels of effects beyond those predicted in the individual constituent evaluations outlined above.

The release of suspended sediments from operational mine sites is controlled by the effluent limits included in the waste discharge permits issued by MOE. All active mine discharges are subject to these permit conditions, and use best management practices to maintain suspended sediment concentrations in discharged waters below these limits. These practices will continue in the future, thus limiting the amount of suspended sediment released to the Elk and Fording rivers and their contribution to multiple-stressor effects.

The use of biological treatment will result in the release of phosphorus to the Elk and Fording rivers. However, the nutrient status of the Elk River is not expected to change with the development of the initial implementation plan (see Annex I2). In addition, as outlined in Chapter 6, treatment technologies will be selected and implemented in such a manner as to prevent undesirable effects related to eutrophication in the Fording River, Line Creek, Michel Creek and other large water courses. Consequently, changes to total phosphorus concentrations are not expected to contribute to multiple-stressors effects at a regional scale, although monitoring will be required to support the selection of treatment technology during detailed design of active water treatment facilities.

A mixture effect can occur when individual constituents combine to produce a level of effect that differs from what would be expected to occur when considering constituents individually. For example, water hardness reduces the toxicity of a number of constituents (e.g., cadmium and sulphate), and, as such, has been incorporated into relevant WQGs. This type of effect is called an antagonistic response. Another effect is the potential for individual constituents to combine in a manner that is additive or synergistic (more than additive), to create a greater effect than would otherwise be expected for the individual constituents.

The potential for mixture effects of selenium, nitrate, sulphate and cadmium was evaluated through examining various lines of evidence:

- the potential for interaction that considers the mechanisms of actions of the different stressors and the benchmark effect sizes; and
- results of site-specific toxicity testing of the combined toxicity of mixtures.

Results of the evaluation are outlined in Annex H, and are summarized below.

The four constituents appear to have different mechanisms of action:

- Sulphate appears to act primarily on the iono-regulatory organs of freshwater organisms, such as the gill, and may either exert stress as a result of general osmoregulatory pressure in conjunction with other components of total dissolved solids.
- Although the specific mechanism-of-action is uncertain, nitrate may exhibit toxicity following uptake and conversion to nitrite, which can then impair oxygen transport. In the Elk Valley, nitrate is not likely to contribute meaningfully to the osmotic pressure that may be important for sulphate toxicity, because it is present at low concentrations relative to the total ionic content of mine-influenced waters.
- Cadmium appears to exhibit adverse effects primarily at the gill, as a result of binding to enzyme receptors in the chloride cells, but is not likely to influence oxygen carrying capacity or otherwise impair respiratory function.
- Selenium produces adverse effects following dietary accumulation of seleno-amino acids into protein-rich tissues and, in particular, the yolk of egg-laying vertebrates, where oxidative stress can occur following mobilization of these materials during embryo-larval development.

Although mechanisms-of-action have not been definitively determined, particularly for sulphate and nitrate, the available information suggests that identical mechanisms-of-action do not occur among the four Order constituents.

The long-term targets for sulphate and cadmium provide a margin of safety for protection of aquatic life that is comparable to WQGs. Considering that WQGs reflect the goal that all forms of aquatic life, at all aquatic life-cycle stages, are to be protected indefinitely, it is expected that there is negligible potential for mixture effects at guideline concentrations.

Results of mixture testing of site waters (Golder and Nautilus 2013) did not indicate additive or synergistic effects (Annex H). Where effects were observed in spiked or amended samples, the level of effect was attributable to concentrations of a single constituent. A possible exception is when nitrate concentrations above 40 mg of NO3-N mg/L and sulphate concentrations above 930 mg/L occur in combination (Golder and Nautilus 2013); however, these are well above target concentrations.

Based on this evaluation, mixture effects at target concentrations are considered unlikely. Uncertainties in potential mixture effects will be evaluated during Plan implementation through an ecotoxicology supporting study (see Chapter 10) and considered in adaptive management (see Chapter 11).

8.4.2.2 Upper Fording River (MU-1)

Based on the considerations outlined above, multiple-stressor effects in the mainstem of the upper Fording River would be driven primarily through interactions among the four Order constituents, since potential effects from physical stressors and changes to nutrient levels are expected to be minor. Lines of evidence that inform the evaluation of chemical stressors in the mainstem and associated off-channel areas are as follows:

- Nitrate and cadmium concentrations in mainstem areas are predicted to be below Level 1 benchmarks for all organisms (Annex H).
- Selenium concentrations are also predicted to be at or below Level 1 benchmarks in mainstem areas (Annex H).
- Level 1 benchmarks were defined based on 10% responses to sensitive organisms and life stages tested in the laboratory, which is a level expected to provide adequate protection against population-level responses in a multiple-stressor context (Mebane 2010).
- Sulphate concentrations may exceed Level 1 benchmarks for fish and amphibians in some portions of the upper Fording River in the long-term, although predicted concentrations remain below Level 2 benchmarks (Annex H).

- Sulphate predictions include an element of conservatism, as the Elk Valley Water Quality Model tends to overestimate sulphate concentrations (Annex D1).
- Presence or absence of amphibians is strongly linked to habitat characteristics, with a preference for shallow water, off-channel areas containing emergent vegetation (Minnow 2013). The majority of these areas are predicted to have lower sulphate concentrations, below Level 1 benchmarks.

Based on the above, the potential for multiple-stressor effects is considered unlikely. However, this conclusion is associated with residual uncertainty. Fish are the most sensitive receptor to selenium and sulphate. As concentrations of both constituents are close to (selenium) or over (sulphate) their respective Level 1 benchmarks, it is theoretically possible that response addition for these two constituents could yield a combined effect size of greater than 20%. Follow-up monitoring, additional toxicity testing with sulphate and adaptive management will, therefore, be used to address this residual uncertainty.

Mine-influenced tributaries in MU-1 can be placed into one of three groups with respect to potential multiple-stressor responses.

Group 1 includes tributaries where effects attributable to multiple stressors are likely. Porter Creek and Greenhills Creek fall in this category, based on predicted sulphate and selenium effects to fish. The predicted response sizes for both selenium (>20%) and sulphate (40%) exceed Level 2 benchmarks. These mine influenced tributaries also currently exhibit calcite formation at levels greater than reference conditions (Annex K), which may increase the potential for localized impairments.

Group 2 includes tributaries where effects attributable to multiple stressors are unlikely. In these tributaries, concentrations of all constituents are predicted to meet Level 1 benchmarks. Lower Henretta Creek and Dry Creek fall in this category.

Group 3 consist of intermediate tributaries where effects attributable to multiple stressors may occur. Kilmarnock Creek falls in this category, based on potential effects to invertebrates. There is no fish accessible habitat in Kilmarnock Creek; however, exceedances of Level 1 invertebrate benchmarks are predicted for both nitrate and selenium.

Together, Groups 1 and 3 represent <3% of the total available habitat in MU-1. Given the small size of these areas, they are not expected to contribute to multiple-stressor effects at the MU scale. Group 1 and 3 tributaries will be managed, as applicable, through local effects monitoring.

8.4.2.3 Lower Fording River (MU-2)

Similar to MU-1, multiple-stressor effects in the mainstem of the lower Fording River would be driven primarily through interactions among the four Order constituents, since potential effects from physical stressors and changes to nutrient levels are expected to minor. Lines of evidence that inform the evaluation of chemical stressors in the mainstem and associated off-channel areas are as follows:

- Sulphate and cadmium concentrations in mainstem areas are predicted to remain at or below WQGs, providing protection for all organisms including fish (Annex H).
- Nitrate concentrations in mainstem areas are predicted to remain below the Level 1 benchmarks for all organisms (Annex H), with effect sizes to fish being in the order of only a few percent (Annex H).
- Selenium concentrations are predicted to exceed Level 1 benchmarks for fish in most mainstem areas. The predicted level of response is 13% for reproduction of sensitive fish species. However, selenium concentrations are predicted to remain below Level 2 benchmarks for fish in all mainstem areas of MU-2 (Annex H).

- The predicted effect size for selenium requires evaluation of the potential for response addition to assess whether combined responses from selenium and other chemical stressors could exceed the 20% threshold for ecologically significant responses. Given that cadmium and sulphate are predicted to contribute a negligible response (because they are below WQGs) and nitrate effect sizes are small (as previously noted), combined effect sizes remain below 20%.

Based on the above, it is unlikely that effects from multiple stressors in MU-2 will be greater than those suggested by the constituent-specific evaluations outlined above.

Tributaries directly connected to the lower Fording River include Line Creek and various reference tributaries. Nitrate, cadmium and sulphate concentrations in Line Creek are predicted to be below Level 1 benchmarks (nitrate and cadmium) or WQGs (sulphate), with small potential effect sizes (e.g., 1% or less for nitrate – Annex H). Accordingly, potential effects attributable to selenium in the constituent-specific evaluation are expected to be representative of potential combined effects from multiple stressors, given that Line Creek will also be subject to calcite management due to its size.

8.4.2.4 Elk River (MU-3 and MU-4)

As in the Fording River, multiple-stressor effects in the mainstem of the Elk River would be driven primarily through interactions among the four Order constituents, since potential effects from physical stressors and changes to nutrient levels are expected to minor or absent. However, predicted concentrations of selenium, nitrate, sulphate and cadmium are all expected to remain below Level 1 benchmarks, as outlined in Annex H. These results suggest a negligible potential for multiple-stressor effects in the Elk River mainstem and associated off-channel habitats.

Mine-influenced tributaries in the Elk River can be placed into one of two groups with respect to potential multiple-stressor responses.

Group 1 includes tributaries where effects attributable to multiple stressors are likely. Thompson, Erickson, EVO Dry and Wheeler creeks fall in this category. In these watercourses, concentrations of selenium and nitrate or sulphate are predicted to be elevated relative to Level 1 benchmarks (Annex H). Calcite formation is also occurring or may occur in the future. The four tributaries collectively contribute 14 ha of total habitat, which represents <3% of the available habitat in MU-3 and MU-4.

Group 2 includes tributaries where effects attributable to multiple stressors are unlikely. Carbon, Six Mile, Snowslide, Grace and Harmer creeks fall into this category. In Carbon, Six Mile and Snowslide creeks, predicted concentrations of the Order constituents are below Level 1 benchmarks. In Harmer and Grace creeks, selenium concentrations are predicted to exceed Level 1 benchmarks for fish; however, sulphate and cadmium concentrations are expected to remain below WQGs, and nitrate levels are predicted to remain below Level 1 benchmarks for fish, amphibians and the benthic community endpoint. Given their size, these watercourses would also be targeted for calcite management.

As previously noted, tributaries in Group 1 represent <3% of the total available habitat in MUs 3 and 4. Given the small size of these areas, they are not expected to contribute to multiple-stressor effects at the MU scale. Group 1 tributaries will be managed, as applicable, through local effects monitoring.

8.5 Initial Implementation Plan

An initial implementation plan was developed to meet short- and long-term water-quality targets at Order Stations for selenium, nitrate, sulphate and cadmium. Medium term targets were then identified based on the initial implementation plan to demonstrate progress from short to long term targets. AWTFs and diversions are identified as the technologies that can reliably and efficiently reduce concentrations of selenium and nitrate from mine sites (Chapter 6). Other options based on emerging technologies and management approaches will continue to be evaluated, with the intention of incorporating them through an adaptive management process when appropriate (Chapter 11).

The initial implementation plan was developed by evaluating a range of treatment and diversion options, identifying an efficient approach (generally, the least treatment required to achieve a concentration), and iterating until the targets were met at the Order stations. The sections that follow describe:

- the planning basis, i.e., the decisions and assumptions that are the foundation of the plan
- the Elk Valley Water Quality Planning Model (the Model), a regional, forward-looking planning model that predicts water quality in the Designated Area with or without the implementation of mitigation measures
- the iterative process used to ensure that plan meets targets at the Order stations.

In developing an initial implementation plan that mitigates the combined effects of all mines in the Elk Valley and incorporates existing water quality for areas not influenced by mining, the Plan addresses cumulative effects to water quality in the Elk Valley and Lake Koocanusa.

8.5.1 Planning Basis

The initial implementation plan was developed based on a set of decisions (e.g., what sources to target for treatment, where to evaluate diversions, and how quickly plants could be constructed) and assumptions (e.g., effluent quality from treatment plants, release rates, and collection efficiency). These constituted the basis on which the initial implementation plan was formed. They are reflected in the water-quality planning model and are subject to refinement over time, as described in Table 8-18.

Table 8-18. Planning basis, rationale and adaptive management considerations.

Input	Planning basis	Rationale	Adaptive management
Mine plan	EVWQP mine plans.	These represent most current understanding of the resource and how it will be mined.	Mine plans are updated periodically, and the implementation plan will also be updated periodically to accommodate changes.
Management options	AWTF and water management.	Based on current information, these can be relied upon to achieve the targets.	Other mitigation and source control options will continue to be evaluated, to reduce reliance on AWTFs in the long term where alternate options provide favourable outcomes.
Sources targeted for management, in sequence	LCO West Line Creek, GHO Swift, GHO Cataract, FRO Kilmarnock, EVO Bodie, EVO Gate, EVO Erickson, FRO Clode, FRO North Spoil, FRO Swift Pit, GHO West Spoil, GHO Greenhills Creek, LCO Dry Creek, LCO Line Creek. These will total ~80% of the waste rock in the valley in 2034.	By targeting the largest sources, water quality can be managed regionally and efficiently.	As mine plans are updated, the sources targeted will be evaluated and updated if required.
Timing of AWTFs	At a planning level, commission AWTFs two years apart.	Two-year spacing of AWTFs allows an efficient construction team, and some opportunity to learn from previous AWTFs.	Through monitoring of receiving water quality, effects, and what is achieved by the first two AWTFs, the timing of future AWTFs may be updated. As R&D measures are incorporated, the reliance on AWTFs may be reduced.
Phasing of AWTFs	Build individual AWTFs in more than one phase if total treated volume is >30,000 m3/day and the waste rock is not all in place when the first phase is required.	Makes efficient use of implementation teams, and offers the opportunity to learn from previous AWTFs and implement the most efficient technologies available.	Through monitoring of receiving water quality, effects, and what is achieved by the first two AWTFs, the timing of future AWTFs will be updated. As R&D measures are incorporated, the reliance on AWTFs may be reduced.
Clean water diversions and sizing	Upper Line, Main Line, Horseshoe, Kilmarnock, Brownie, Erickson, South Gate Creeks were included.	These sources may have a regional influence. The specific water management constructed will be evaluated with more site-specific data.	Detailed evaluation and design with a local-scale model during development planning for each watershed. May result in different diversions to achieve the targets.
Sizing of water management	Flows for May were assumed for diversions that have an influence in spring. LCO sized for low flows because influence is in winter.	Sized for May as an estimate for planning purposes; June is typically double the flow.	Detailed evaluation and design with a local-scale model during development planning for each watershed. May result in different diversions and sizes implemented.
Effluent quality – Selenium	Se = 20µg/L or 95% removal if influent is >500 µg/L	Planning basis for EVWQP is biological treatment.	Technologies will continue to be explored and evaluated in advance of each AWTF design.
Effluent quality – Nitrate	N = 0.3 mg/L of NO3-N	Planning basis for EVWQP is biological treatment.	Technologies will continue to be explored and evaluated in advance of each AWTF design.

Input	Planning basis	Rationale	Adaptive management
Effluent quality – Phosphorus	P = 0.1 mg/L, except for the West Line Creek AWTF where P = 0.3 mg/L	Planning basis for EVWQP is biological treatment (same as LCO WLC). Subsequent plants incorporate additional phosphorus removal.	Technologies will continue to be explored and evaluated in advance of AWTF design. The phosphorus limits of the system will continue to be evaluated and will be considered for treatment technology selection for each AWTF.
Effluent quality – Sulphate and Cadmium	Removal of cadmium and sulphate is not currently required to meet long-term water-quality targets	Current concentrations and expected trends are below long-term targets without mitigation.	AWT technologies that remove cadmium and sulphate are being evaluated and piloted and could be used for future AWTFs, if required.
% of time treatment plants operational	Assumed operational 100% of the time to develop the initial implementation plan treatment capacities	Treatment facilities will be designed to meet the required removal of CIs to achieve the water-quality targets of the Plan. This will be part of the design process for each individual treatment facility. As an example the WLC Se AWTF, although intended to be operational 100% of the time, has been designed so that it can be operational 95% of the time and still achieve the selenium and nitrate load reduction targets for the facility.	Based on lessons learned through the implementation and operation of treatment facilities, and as new treatment technology becomes available, facility up-time will be re-evaluated and fed into the adaptive management process to achieve the water-quality targets of the Plan.
Collection (intake) efficiency	FRO North Spoil, Kilmarnock 70% GHO Greenhills Creek 70% FRO Clode Creek, Swift/Cataract 80% EVO Erickson Creek 90% GHO West Spoil, LCO WLC and Main Line Creek, EVO Bodie, Gate Creeks, Pit dewatering 95% LCO Dry Creek consistent with EAC commitment	The amount of water available to capture and treat is site-specific. These estimates reflect best engineering judgement based on knowledge of site conditions.	Site specific investigations in advance of design will be conducted and estimates of water available will be updated.
Modelled flow conditions	All scenarios are run under monthly low, average and high flow conditions.	The plan is intended to meet the target under a range of flow conditions. Without treatment, the limiting flow condition is low flows. As more treatment is added to the system, the limiting flow condition is high flows.	Modelled flow conditions will continue to be updated based on monitoring data.
Geochemical release rates	Average release rates used for planning purposes.	These reflect a best engineering judgement. The 95% confidence limit on the mean rate is also used to understand sensitivity to release rates.	Geochemical release rates will continue to be updated with current monitoring information. Detailed local scale models will be developed and data collected to support them as required.

8.5.2 The Elk Valley Water Quality Planning Model

The Model is a regional planning and assessment tool that estimates concentrations of selenium, nitrate, sulphate, hardness and phosphorus. It was calibrated and refined using historical information (Annex D.1).

The Model's performance is gauged by how well it simulates historical conditions, with a focus on Order stations on the Fording and Elk rivers. It was not designed, nor is it suitable, for predicting concentrations of constituents at the individual catchment scale. To support mitigation evaluation and/or design efforts in specific catchments, Teck will develop appropriate catchment-scale water balance and water-quality models.

The Model reflects the current understanding of regional hydrology and release rates of selenium, sulphate and nitrate from waste rock, based on the conceptual model below (Figure 8-3).

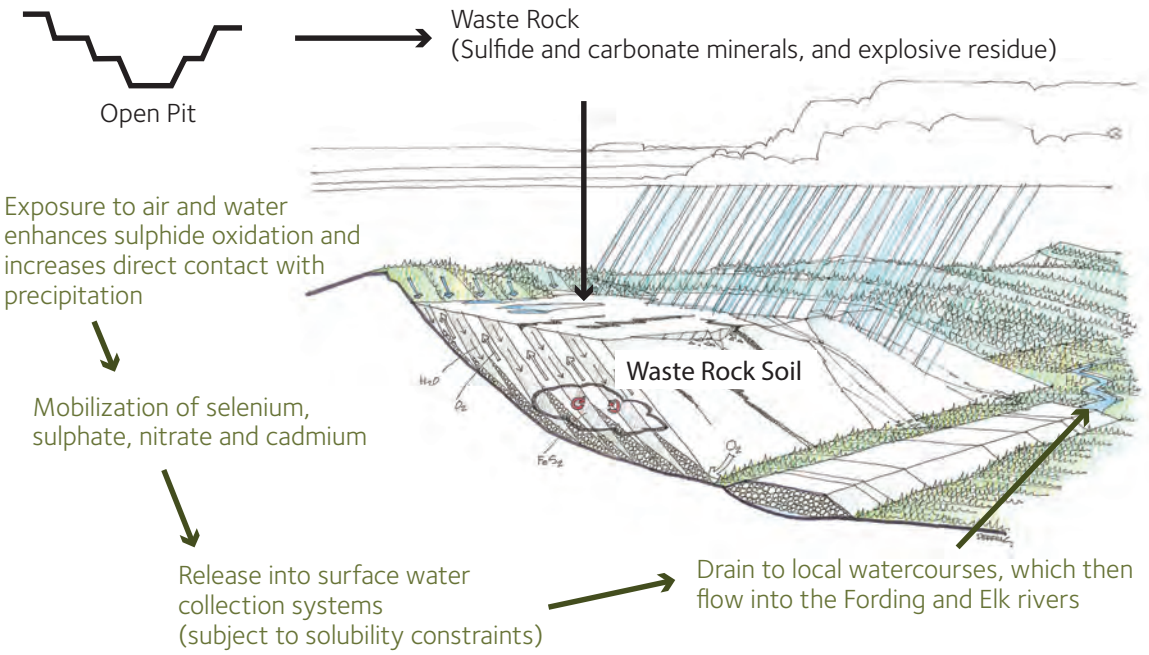


Figure 8-3. Conceptual model of selenium, sulphate, cadmium and nitrate release and transport.

The main model inputs are:

- the EVWQP mine plan (described in Annex D.5: Site Conditions Report), primarily waste-rock schedules for each drainage and minesite topography
- geochemical release rates for selenium, sulphate, and nitrate, based on observed water quality and historical waste-rock volumes
- regional surface water flows based on monitored data where available, or a flow model based on analog hydrographs.

As with any model, input assumptions and predictions of future conditions have uncertainty, which was considered by measuring model error (the average absolute difference observed between individual simulated and measured data points over the entire calibration period) and bias (the average difference observed between the individual simulated and measured data points over the entire calibration period).

The Model exhibits a positive bias, meaning that it tends to over-predict measured concentrations. From a planning perspective, this bias was deemed problematic only for predicted selenium concentrations in Lake

Koocanusa (LK2). Because there are limited data at LK2 to correct for bias, the station immediately upstream (ER5) was used. The average over-prediction at ER5 is 1 µg/L, which if not corrected would falsely generate long-term concentrations above the long-term target. To correct for bias, loads at ER5 were reduced by the amount of bias in each month before the mass balance is calculated in the lake. Bias correction at LK2 allows the model to more accurately reflect expected concentrations. Bias was not corrected at other Order stations. See Annex D.5 for details.

During implementation, Teck will compare water-quality and flow-monitoring data to model predictions to check the calibration and update it if necessary. Improvements in geochemical and hydrologic inputs will be used to update the model as discussed in Chapter 11. New site-specific tools will be developed to support evaluation and design of mitigation measures, such as AWTFs and water management.

8.5.3 Development of the initial implementation plan

As discussed in Chapter 6, the initial implementation plan consists of AWTFs supported by diversions and water management (conveyance of mine influenced water to treatment plants). The many possible combinations of treatment and diversions at various locations at different times resulted in an iterative approach to developing the initial implementation plan.

Even with a good understanding of the sources of constituents in the Elk Valley and a focus on AWTFs and diversions, the possible combinations of options are very numerous. It is important that the plan be efficient in achieving water-quality targets at the Order stations (i.e., generally with the least amount of treatment). Teck used the following planning strategies to guide the development of the initial implementation plan:

- Focus on treating constituents that are currently above guideline (Se, N), and determine near-term actions based on monitoring data (i.e., in-stream concentrations are currently above guidelines, waste rock is already in place).
- Select the location of the next AWTF according to current receiving environment concentrations relative to targets and waste-rock volume in place.

The optimal AWTF will receive sufficient flow to run at full capacity all year. If this is insufficient to achieve targets, then add capacity at the highest concentration sources. During implementation, AWTF capacities will be refined during design and permitting, through more detailed local hydrological analysis and geochemistry.

The tasks in this process are described in more detail herein. Additional information is provided in Annex D2: Water Quality Modelling for the initial implementation plan.

8.5.3.1 Task 1 – Select From Available Management Options

A wide range of management options were evaluated as described in Chapter 6, to determine which would be incorporated into the initial implementation plan. From that evaluative process, three options were identified to examine in detail (geomembrane covers, diversions, water treatment), and AWTFs and diversions were deemed suitable for developing the initial implementation plan.

8.5.3.2 Task 2 – Determine Sequence and Timing of Treatment

The sequencing of AWTFs was determined by location in the watershed (mitigation upstream in the system benefits all downstream management units) and the volume of waste rock. The Upper Fording River was selected as the next treatment site after West Line Creek, because this is where the highest concentrations of selenium and nitrate occur relative to long-term targets, and treatment in the most-upstream MU benefits all areas downstream. Second, sources were targeted for treatment in order of waste-rock volume, given the correlation between volume and water quality (Figure 8-4).

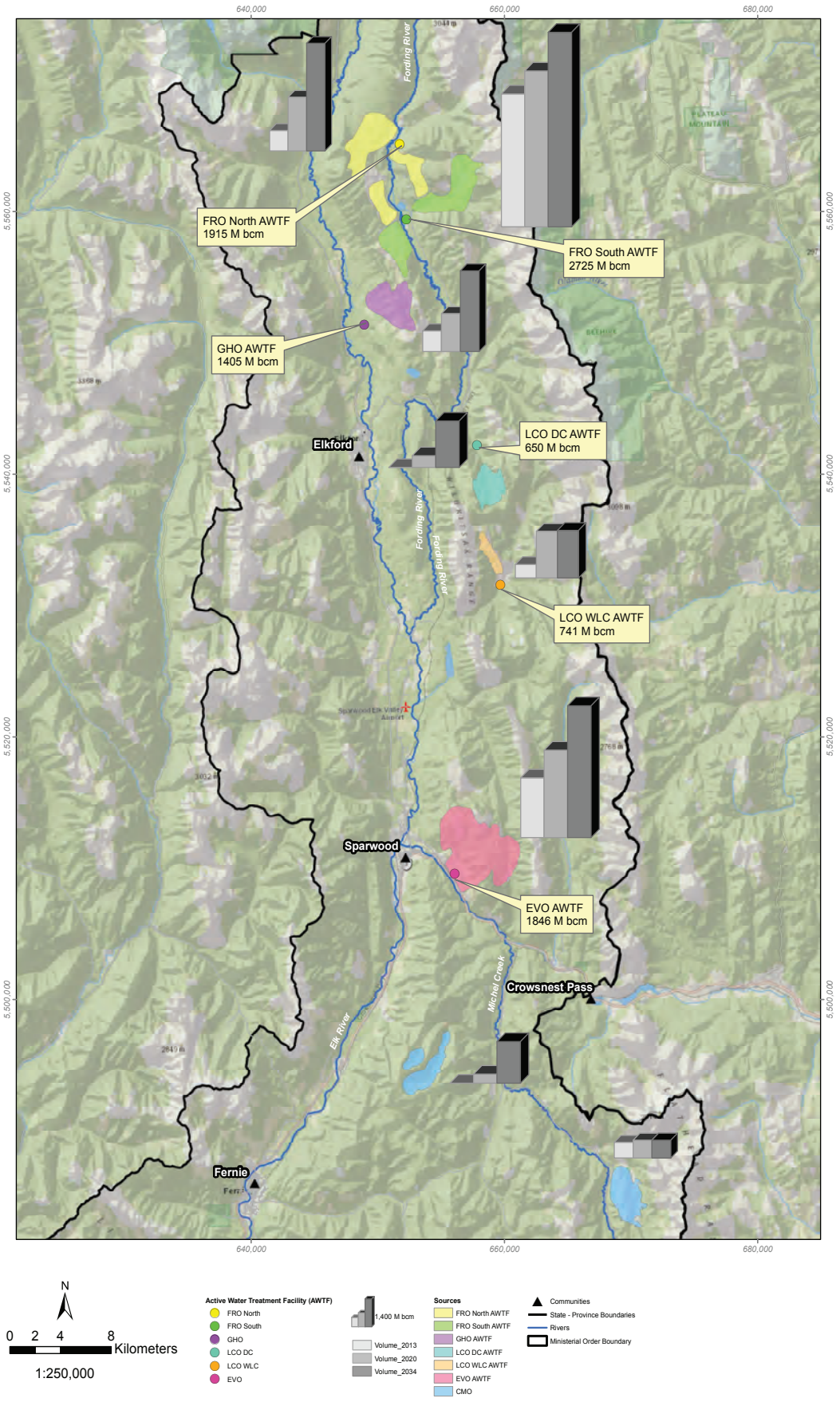


Figure 8-4. Volumes and timing of waste rock at each operation.

8.5.3.3 Task 3 – Estimate Treatment Required

As planning progressed, results were used to develop a relationship between total treatment volume and in-stream concentration. This relationship was then used to estimate the treatment required in different parts of the system to achieve the targets at the Order stations. Figure 8-5 is an example of the relationship for the Fording River downstream of Greenhills Creek (FR4). Relationships at other stations and hydrographs for other AWTFs are provided in Annex D2: Water Quality Modelling for the initial implementation plan.

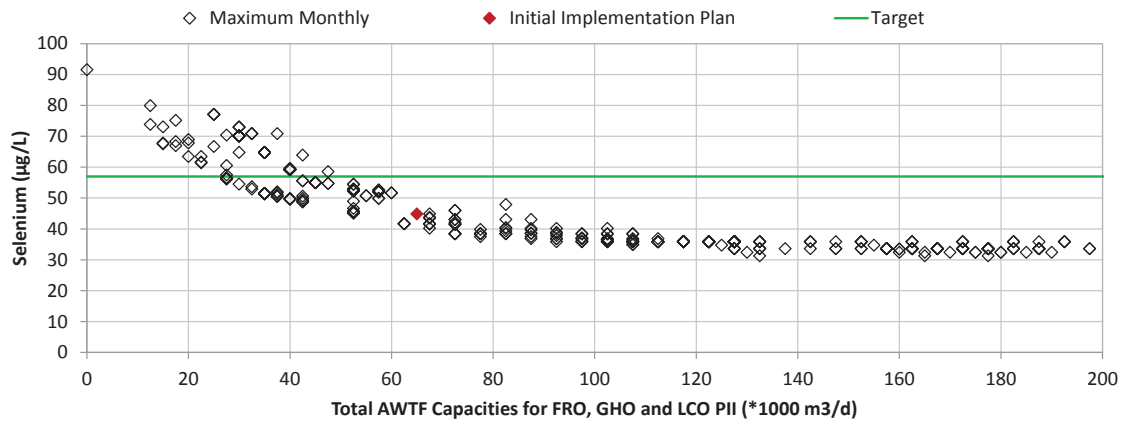


Figure 8-5. Example relationship between treated volume and selenium concentration at the Fording River downstream of Greenhills Creek (FR4).

As treatment volume increases, there is decreasing influence on selenium removed because additional capacity will be utilized only for a few months of the year (Figure 8-6).

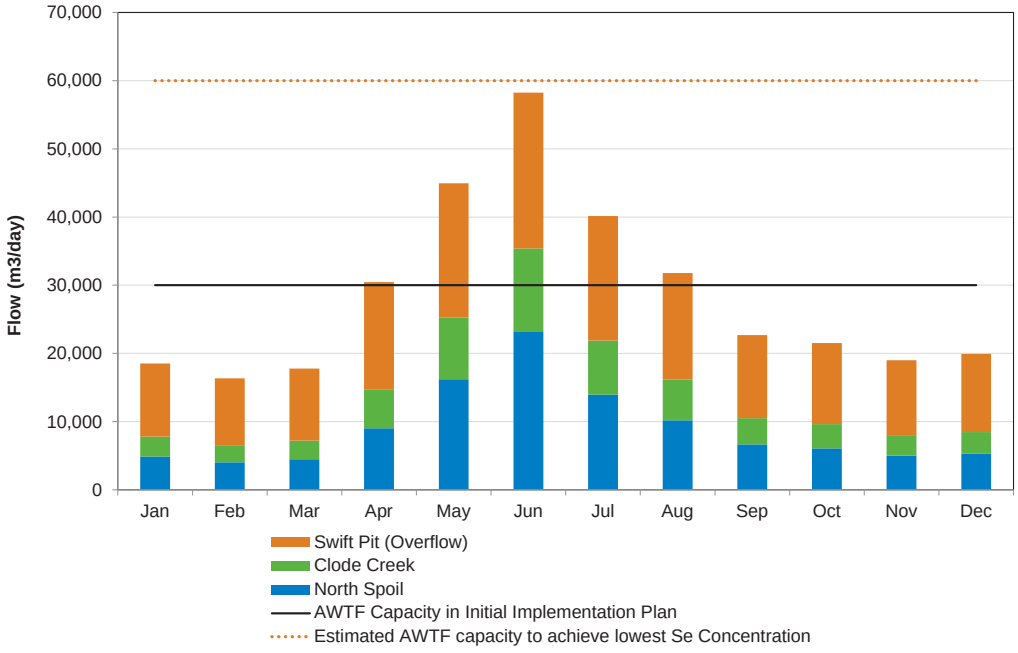


Figure 8-6. Modelled hydrograph of available inflows for an AWTF in the upper Fording River.

8.5.3.4 Task 4 – Allocate Treatment Capacity by Location

A relationship between treatment volume and selenium removed was established for each potential AWTF. This relationship was primarily driven by waste-rock volume and the hydrograph that represents flow available for treatment. By inspecting the relationship at each AWT facility, capacity can be allocated to the location where it has the most impact. Figure 8-7 presents an example. Relationships at other stations are provided in Annex D2: Water Quality Modelling for the initial implementation plan.

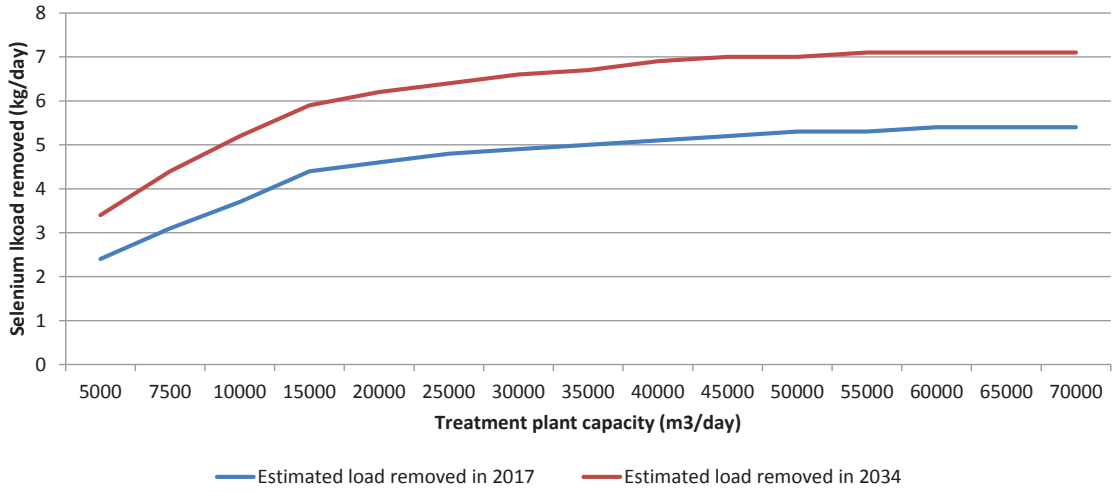


Figure 8-7. Relationship between active water treatment volume and selenium load removed at FRO South.

From these two primary relationships, the treatment volume at each location was estimated and used as inputs to the water-quality model, until targets were met at the Order stations and the initial implementation plan was defined. In practice, this meant estimating total treatment volume to meet each target at each location, and distributing capacity based on the relationship between volume and load removed.

8.5.3.5 Task 5 – Compare Results to Targets

Through the development process, two patterns emerged: the limiting constituent is selenium, and the limiting locations are FR4 and FR5, ER2, MC1 and LK2. The mouth of Michel Creek (MC1) is not an Order station, but was evaluated to define an initial implementation plan. The approach was to work from upstream to downstream, estimating the treatment volume required to achieve the following goals:

- Meet the target at FR4 (MU-1) by adjusting the treatment volume upstream.
- Attempt to meet the initial target at FR5 (MU-2), which is lower than MU-1 because it is downstream of Josephine Falls and more fish species may be present. Based on the current planning basis plus extending treatment to other sources, the Level 1 benchmark for selenium is not technically achievable, as discussed below. The target for FR5 still protects aquatic life in MU-2 based on the results of the integrated assessment (see Section 8.3).
- Meet the Level 1 benchmark at MC1, by adjusting EVO treatment volume. An evaluation of treatment opportunities at CMO Phase 2 determined that it is more efficient to increase treatment at EVO.
- Meet the long-term target at LK2 by adding treatment at the most efficient locations, based on the relationship between treatment volume and selenium removed.

The relationship between treatment volume and maximum monthly concentrations under high flows at FR5 (Figure 8-8) indicates that the Level 1 benchmark is not achievable for MU-2. The selected target of 40 µg/L is protective and achievable. To achieve a lower selenium target concentration would require approximately double the treatment capacity upstream, with a corresponding small change in the margin of safety for

protection of aquatic life. A doubling of treatment capacity would require a change from biological to membrane technologies, because biological plants are not suited to running well below capacity for sustained periods. Risks and uncertainties associated with membrane technology are discussed in Chapter 6.

The next two planned AWTFs are independent of the target at FR5. The next plant in the implementation plan (FRO-S) is being constructed as quickly and on as large a scale as reasonable. The next plant at EVO is downstream of FR5. Through the Regional Aquatic Effects Monitoring Program, the MU will continue to be monitored and information gathered to confirm the level of protection.

At all stations except FR5, the Level 1 benchmark is achieved by the initial implementation plan.

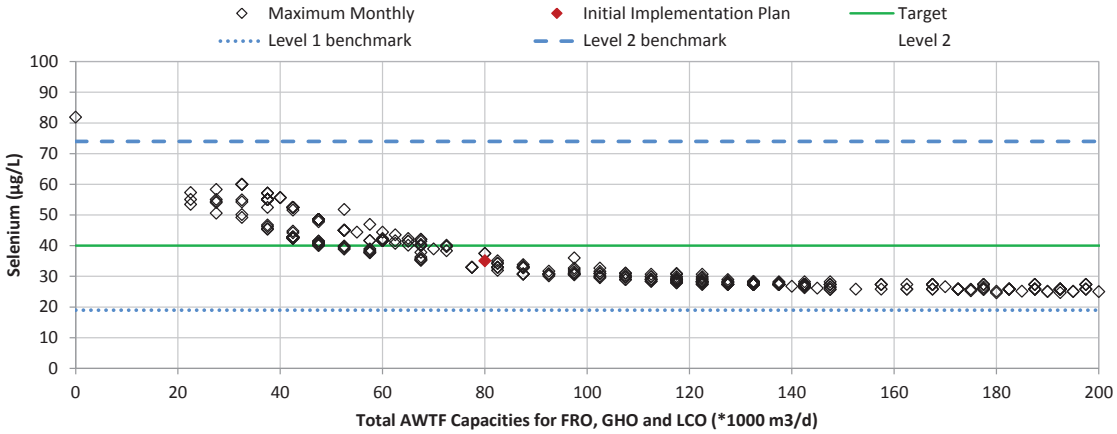


Figure 8-8. Relationship between treated volume and selenium concentration at the Fording River at the Mouth (FR5).

8.5.3.6 Task 6 – initial implementation plan

The initial implementation plan allows Teck to meet the targets established in the Plan. It is summarized in Table 8-19, which lists the sources targeted for treatment and the estimated year and quarter for each treatment project.

Table 8-19. Initial implementation plan

Sources targeted for treatment	Year	Total water volume treated[1] (m3/day)	Associated diversions (to be evaluated during detailed design)[1]	Associated conveyance of mine- influenced water (to be evaluated during detailed design)	AWTF Name
West Line Creek	Q2 2014	7 500		Convey Line Creek to the AWTF. Discharge to Line Creek.	LCO West Line Creek (Phase 1)
Swift, Cataract and Kilmarnock creeks	2018	20 000	Diversion of Upper Brownie and Kilmarnock watersheds, estimated at 45 000 m^3/day	Convey Swift, and Cataract and the mine influenced portion of Kilmarnock to the AWTF. Discharge to the Fording River.	FRO South
Bodie, Gate and Erickson creeks	2020	30 000	Diversion of Upper Erickson watershed, estimated 14 000 m^3/day and South Gate Creek, estimated 3 500 m^3/day.	Convey mine influenced water from Erickson to the AWTF. Discharge to Erickson Creek.	EVO (Phase 1)
Clode creek, North spoil and Swift Pit	2022	15 000		Convey mine influenced water to the AWTF. Discharge to the Fording River	FRO North (Phase 1)
EVO Erickson	2024	20 000		Convey mine influenced water from Erickson to the AWTF. Discharge to Erickson Creek.	EVO (Phase 2)
GHO West Spoil (Thompson, Leask and Wolfram creeks), Greenhills Creek	2026	7 500		Convey mine influenced water to the AWTF. Discharge to Thompson Creek.	GHO
LCO Dry Creek	2028	7 500		Conveyance of bypass water and treated effluent to the Fording River.	LCO Dry Creek
FRO Swift pit	2030	15 000		Convey mine influenced water to the AWTF. Discharge to the Fording River.	FRO North (Phase 2)
Line Creek	2032	7 500	Diversion of Upper Line Creek, Horseshoe and No Name Creeks, estimated at 35 000 m^3/day.	Convey mine influenced portion of Line Creek to the AWTF. Discharge to Line Creek.	LCO West Line Creek (Phase 2)

Note[1]: AWTF and Diversion sizes are estimated for planning purposes. These sizes will be refined based on site specific information developed during detailed design. Based on preliminary evaluation, Brownie, Kilmarnock and Line Creek diversions have a measurable influence on treatment plant efficiency and they others do not. Diversions are planned to be operational at the same time as the associated AWTF.

The Model predicts a range of future water-quality concentrations at each Order station when the initial implementation plan has been implemented. The Model produces results on a monthly basis, and the annual range of predictions is defined by seasonal (monthly) variability, and by running the model under low, average and high flow conditions for each month.

Time-series graphs of predicted selenium concentrations (Figure 8-9) and nitrate concentrations (Figure 8-10) are shown for an Order station in each MU. The graphs plot the maximum monthly and average annual concentration for each year simulated.

The general pattern is for concentrations to gradually increase until sufficient mitigation is in place upstream to stabilize and reverse the trends, and then achieve concentrations that are below long-term water-quality targets. The timeframes for stabilizing water-quality trends and meeting long-term targets varies for each Order station, depending on its location relative to mitigation measures, and to the timing of such measures.

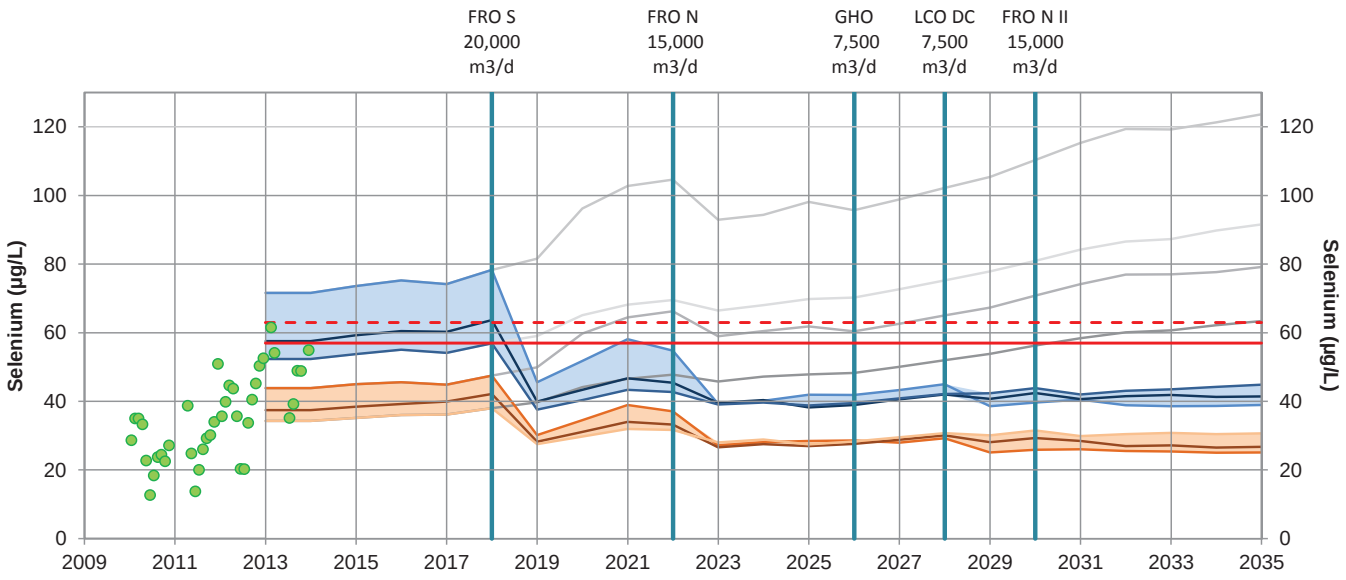
The initial implementation plan defines the timeframes for achieving short-term stabilization and long-term concentrations.

The water quality modelling results are presented as time series plots and, for context, include historical observations (green points) and commissioning dates (vertical lines) for the active water treatment facilities according to the initial implementation plan. Long term and short term targets, or level 1 and level 2 benchmarks as appropriate, are included for reference. The blue band indicates the predicted envelope of maximum monthly average concentrations under low, average or high flows. The orange band indicates the predicted envelope of annual average concentrations under the same range of flows. Grey lines are the predictions without mitigation.

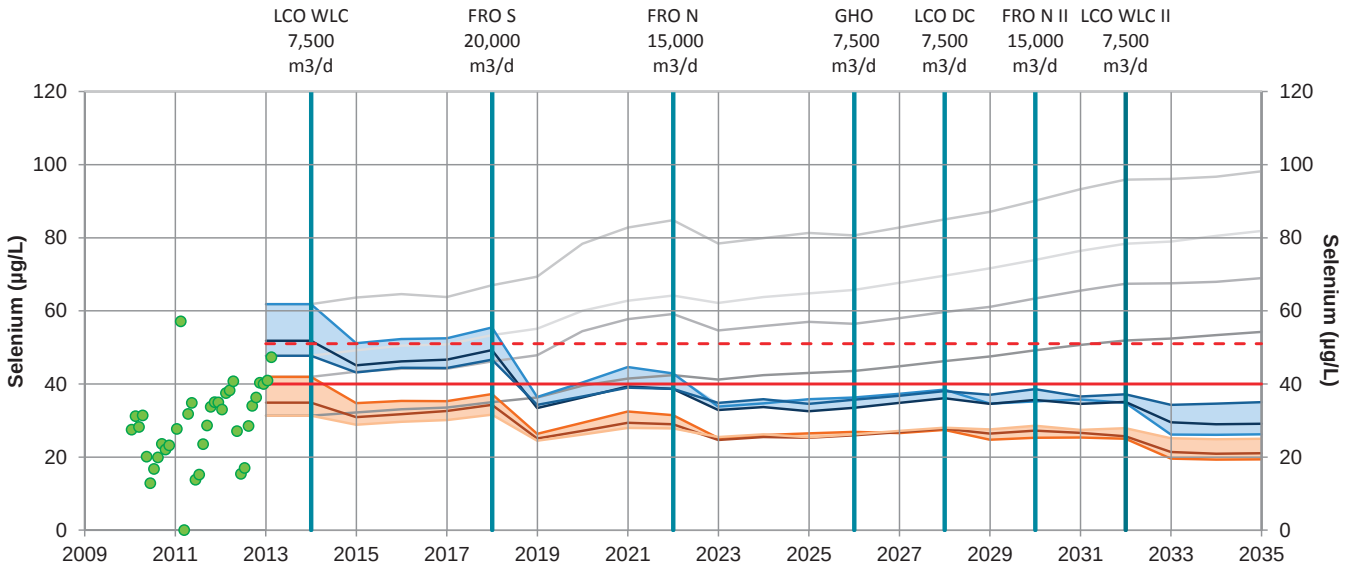
The legend below applies to all time series plots in this chapter.

- Predicted Maximum Monthly Concentration Under Low Flow Conditions without Mitigation
- Predicted Maximum Monthly Concentration Under High Flow Conditions without Mitigation
- Predicted Annual Average Concentration Under High Flow Conditions without Mitigation
- Predicted Annual Average Concentration Under Low Flow Conditions without Mitigation
- Predicted Maximum Monthly Concentration Under Low Flow Conditions and Initial Implementation Plan
- Predicted Maximum Monthly Concentration Under Average Flow Conditions and Initial Implementation Plan
- Predicted Maximum Monthly Concentration Under High Flow Conditions and Initial Implementation Plan
- Predicted Annual Average Concentration Under Low Flow Conditions and Initial Implementation Plan
- Predicted Annual Average Concentration Under Average Flow Conditions and Initial Implementation Plan
- Predicted Annual Average Concentration Under High Flow Conditions and Initial Implementation Plan
- Observed
- Long-term Target
- Short-term Target

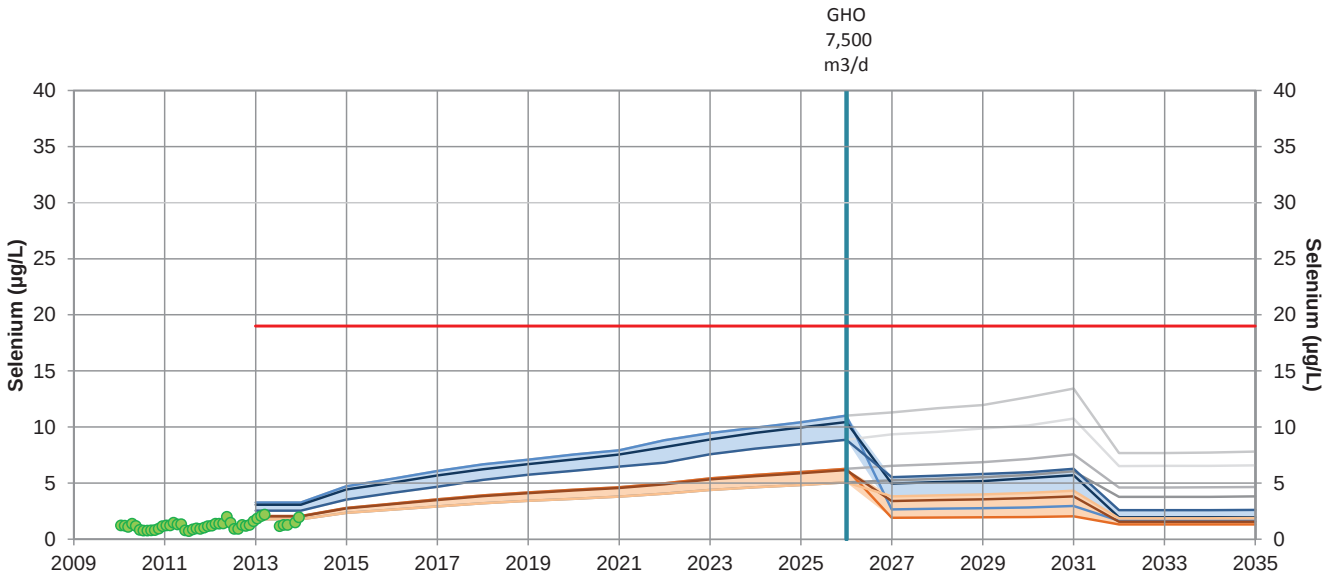
a. Fording River downstream of Greenhills Creek (FR4):



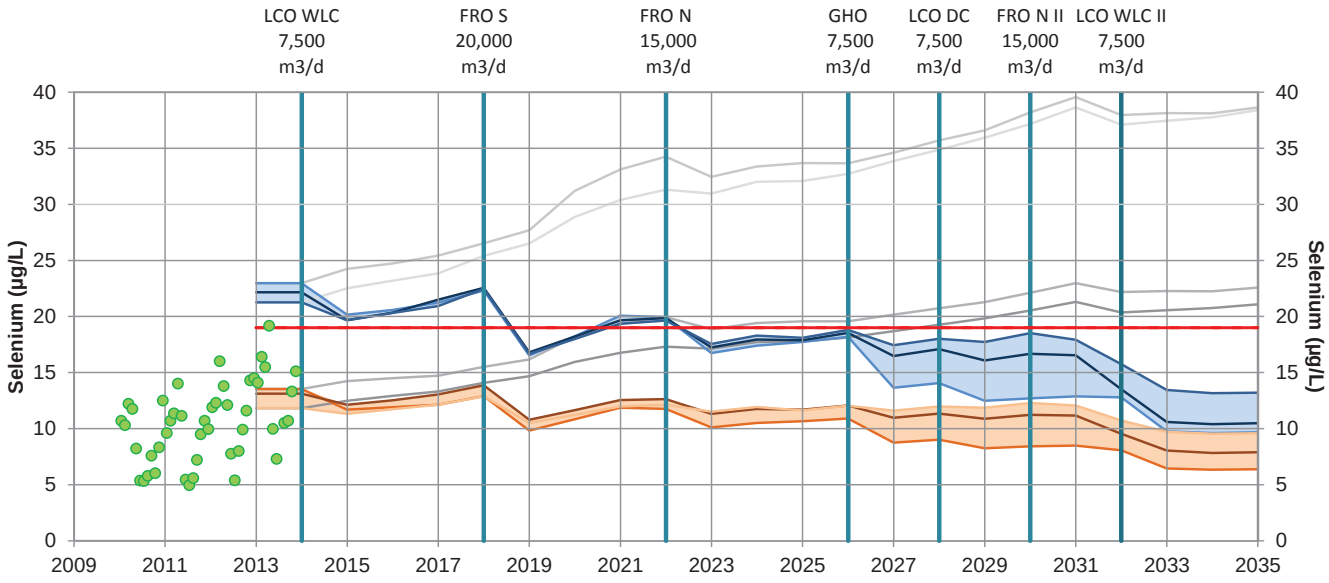
b. Fording River at the Mouth (FR5):



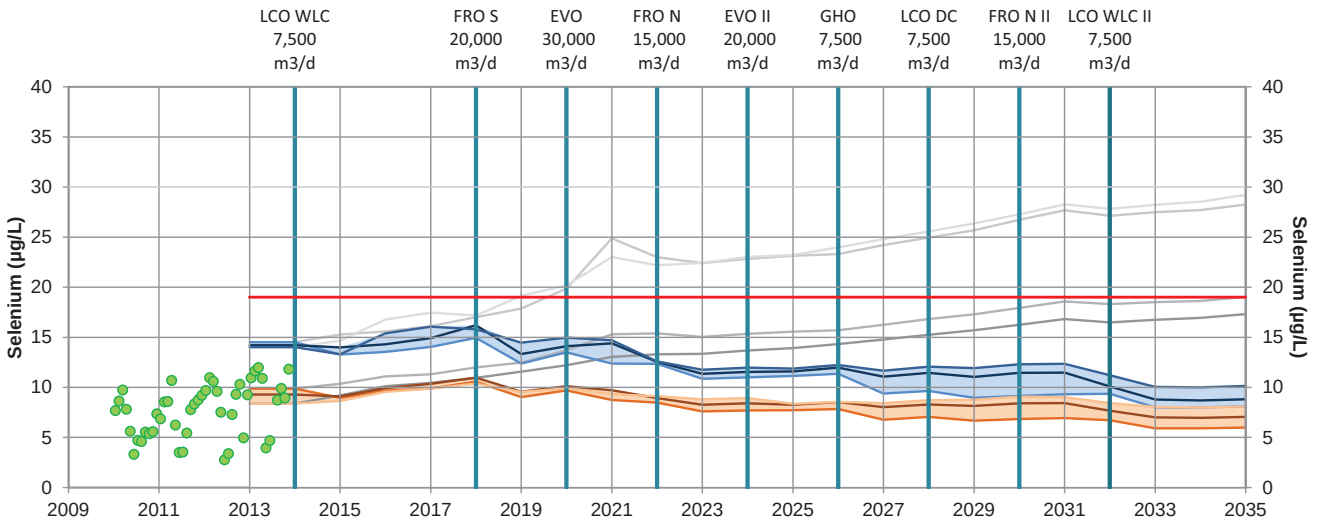
c. Elk River downstream of GHO and upstream of Fording River (ER1):



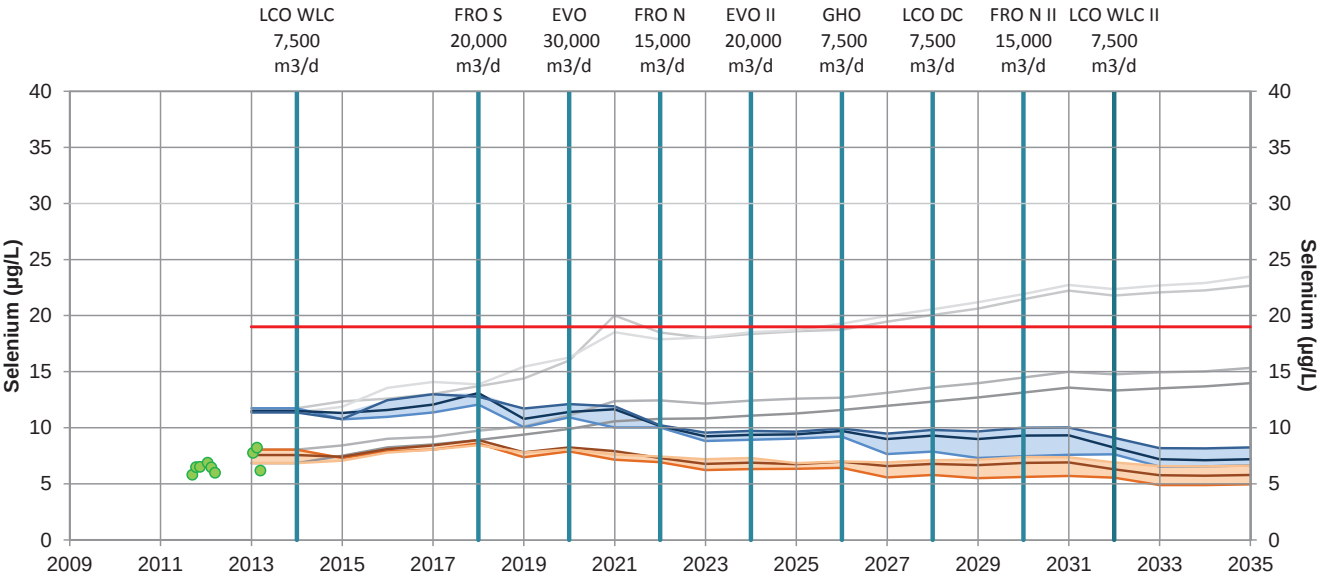
d. Elk River downstream of the Fording River (ER2):



e. Elk River downstream of Michel Creek (ER3):



f. Elko Reservoir (ER4):



g. Lake Koocanusa (LK2)

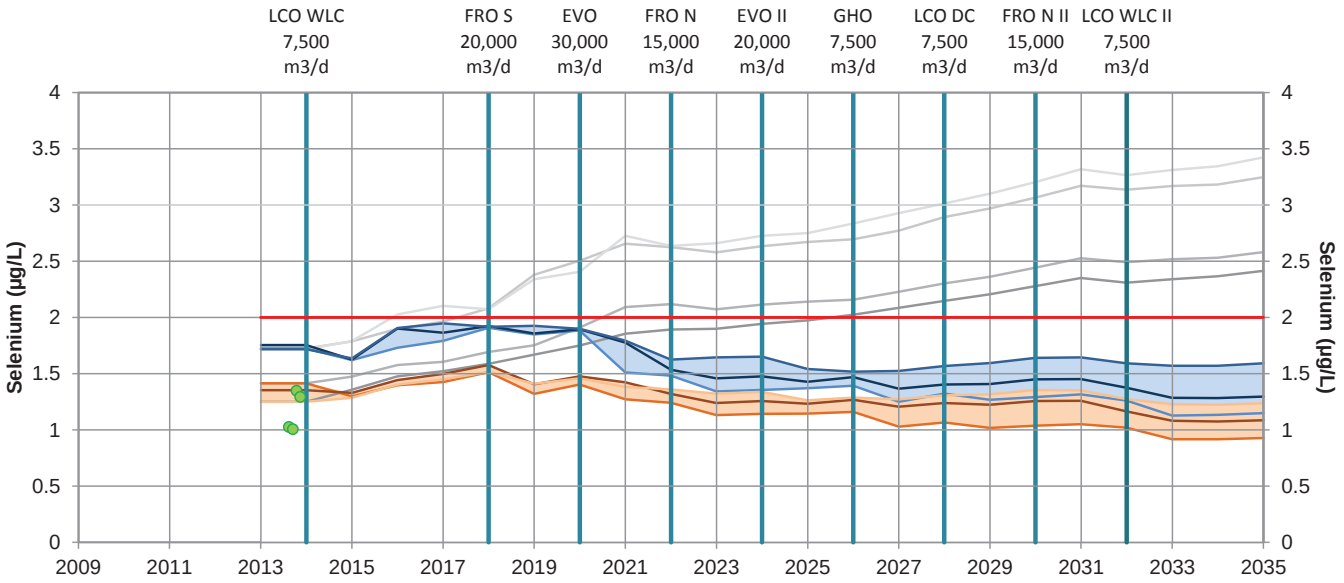
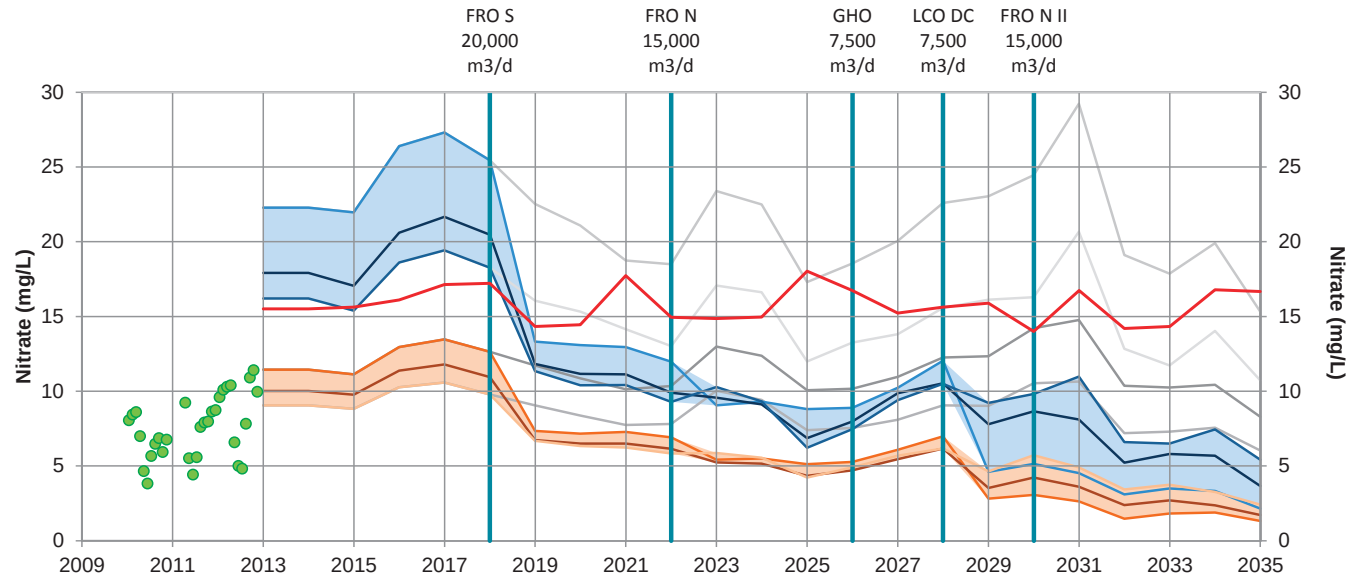
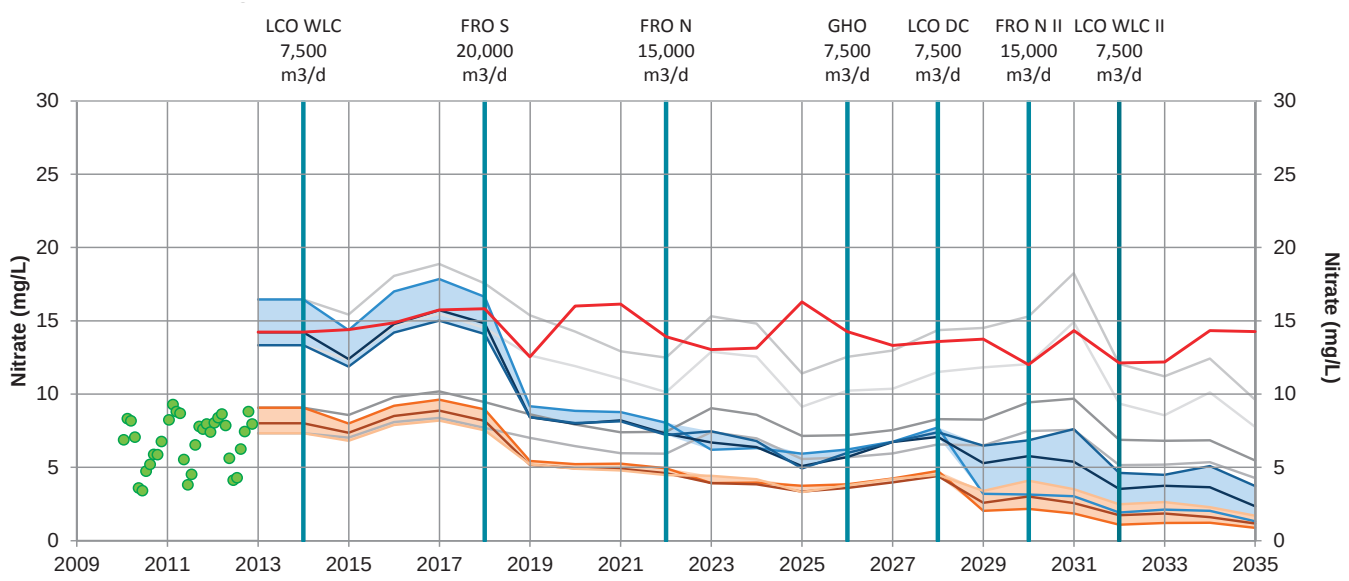


Figure 8-9. Selenium concentration projections at Order stations.

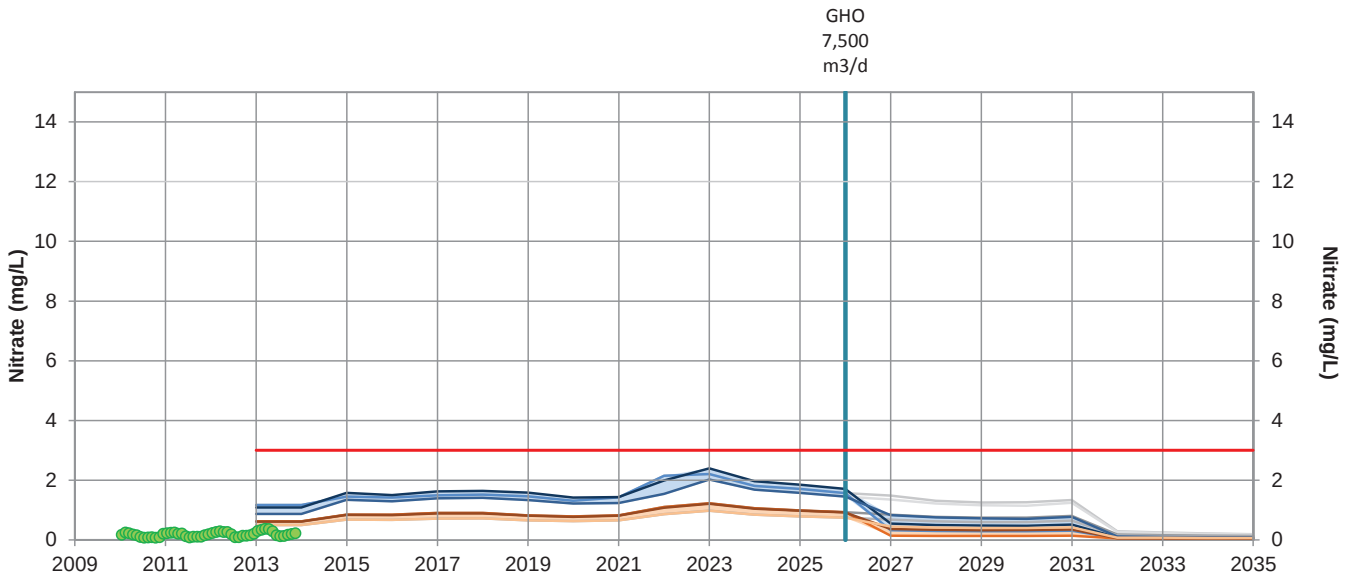
a. Fording River downstream of Greenhills Creek (FR4):



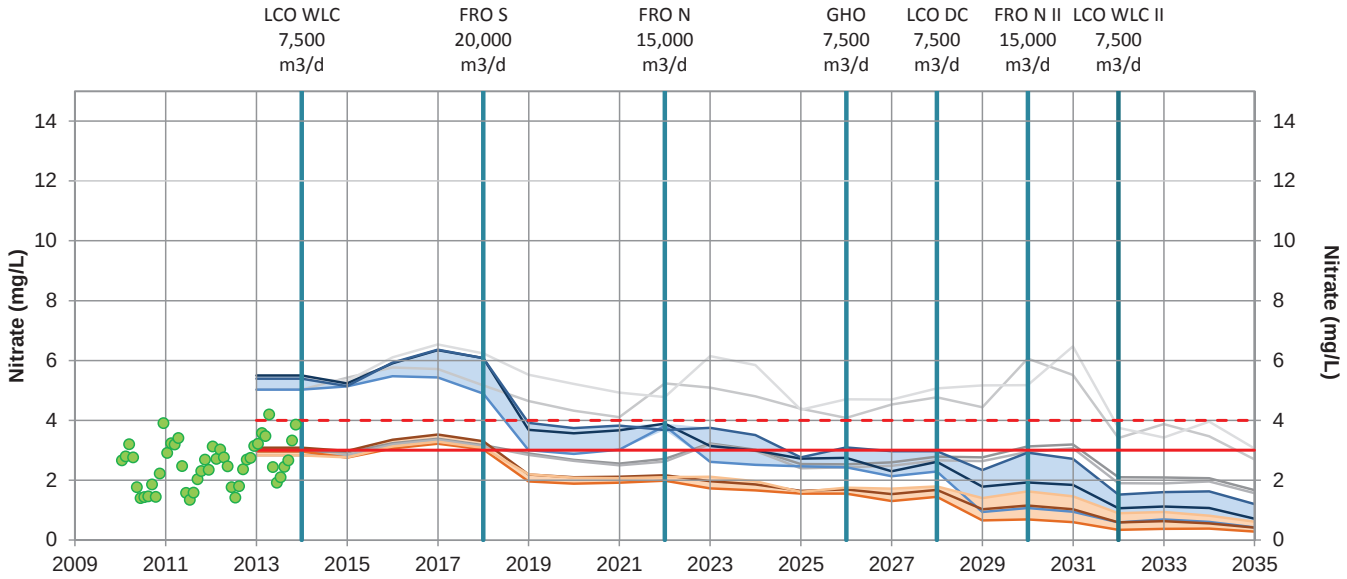
b. Fording River at the mouth (FR5):



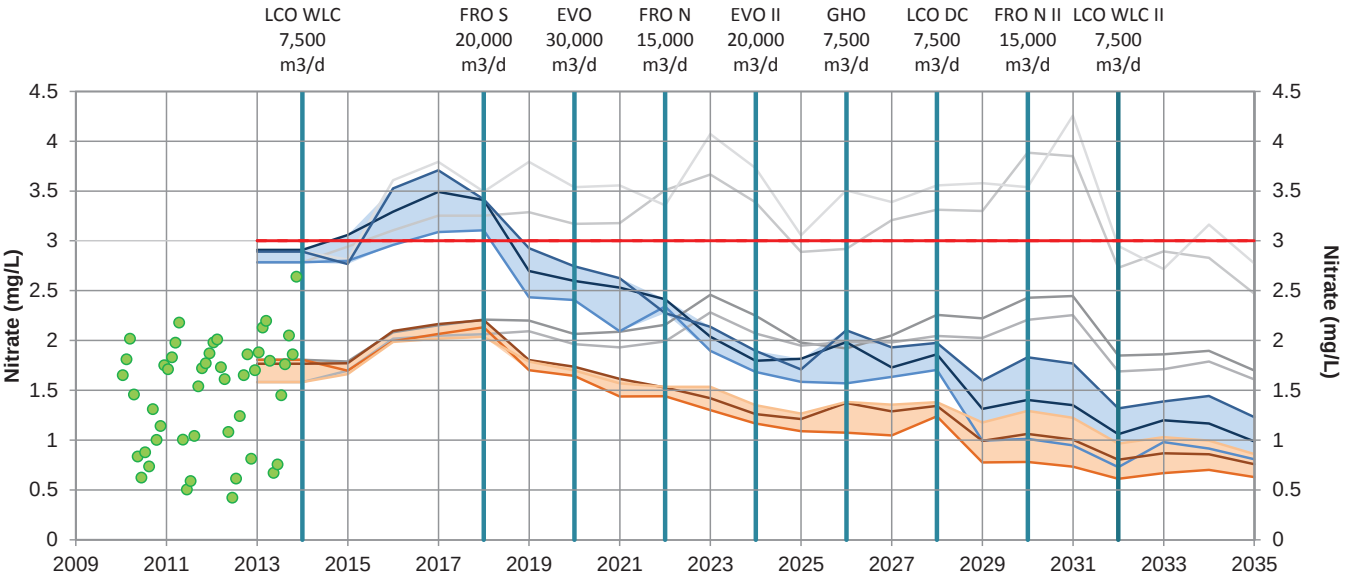
c. Elk River downstream of GHO and upstream of Fording River (ER1):



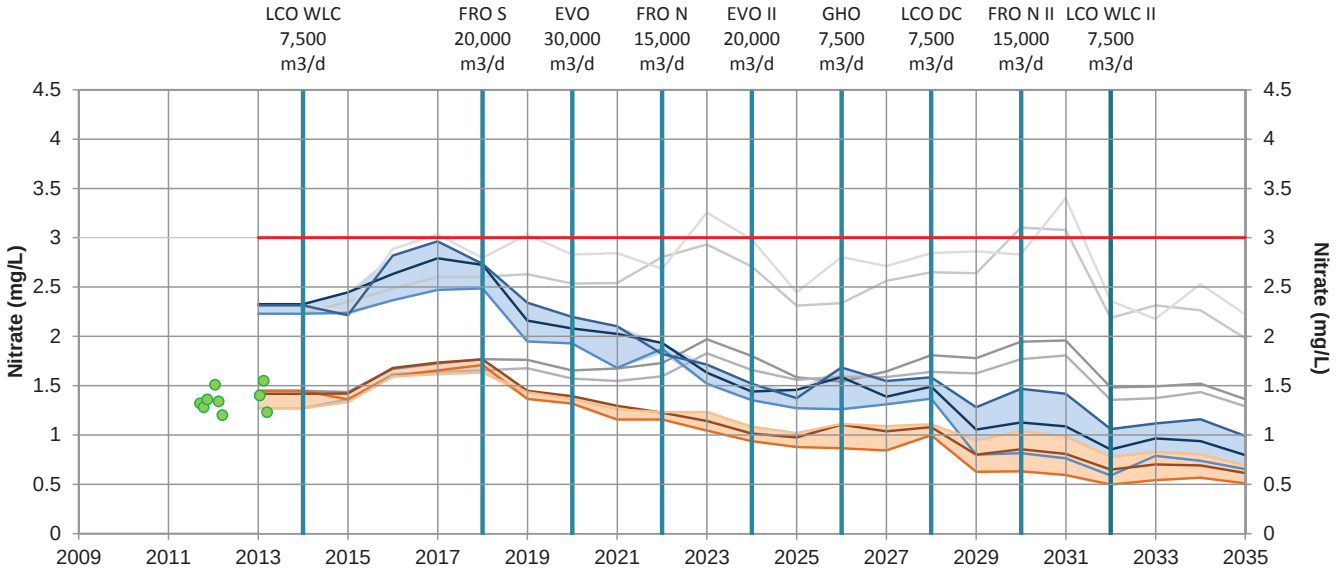
d. Elk River downstream of the Fording River (ER2):



e. Elk River downstream of Michel Creek (ER3):



f. Elko Resvoir (ER4):



g. Lake Koocanusa (LK2):

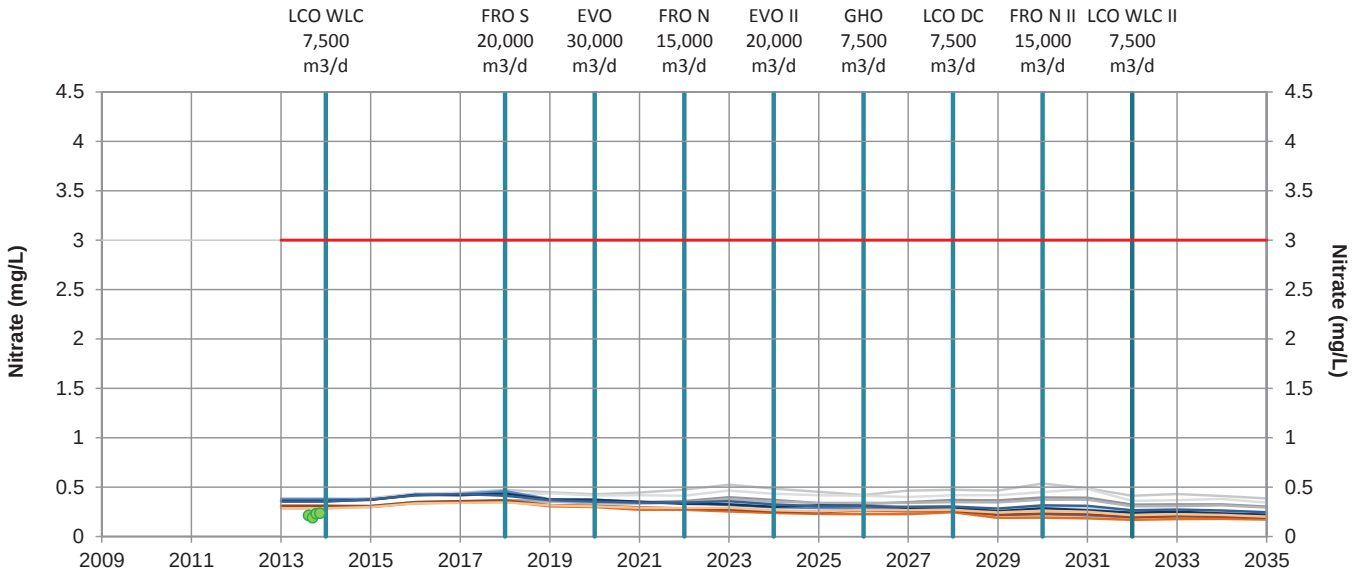


Figure 8-10. Nitrate concentration projections at selected Order stations.

The seasonal pattern of selenium levels is shown in Figure 8-11. The same pattern applies to nitrate. Without treatment, concentrations are highest in the winter low-flow period and lowest in June during the spring freshet. This pattern gradually changes with the progressive implementation of water treatment, which operates at fixed hydraulic capacity and can treat a greater proportion of the flow during low-flow periods than during the freshet. The initial implementation plan includes capacities high enough to treat much of the mine-influenced water during low-flow months. As a result, maximum concentrations become more consistent through the year, and the month with the highest concentrations may shift to a higher-flow month. When results in Figure 8-11 are reviewed over time and spatially, the flow condition and the month with the highest concentration vary with the volume of upstream water treated.

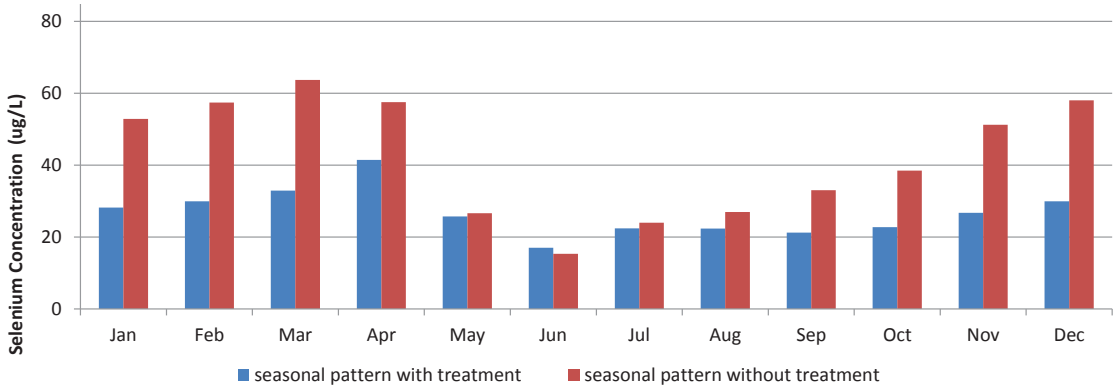
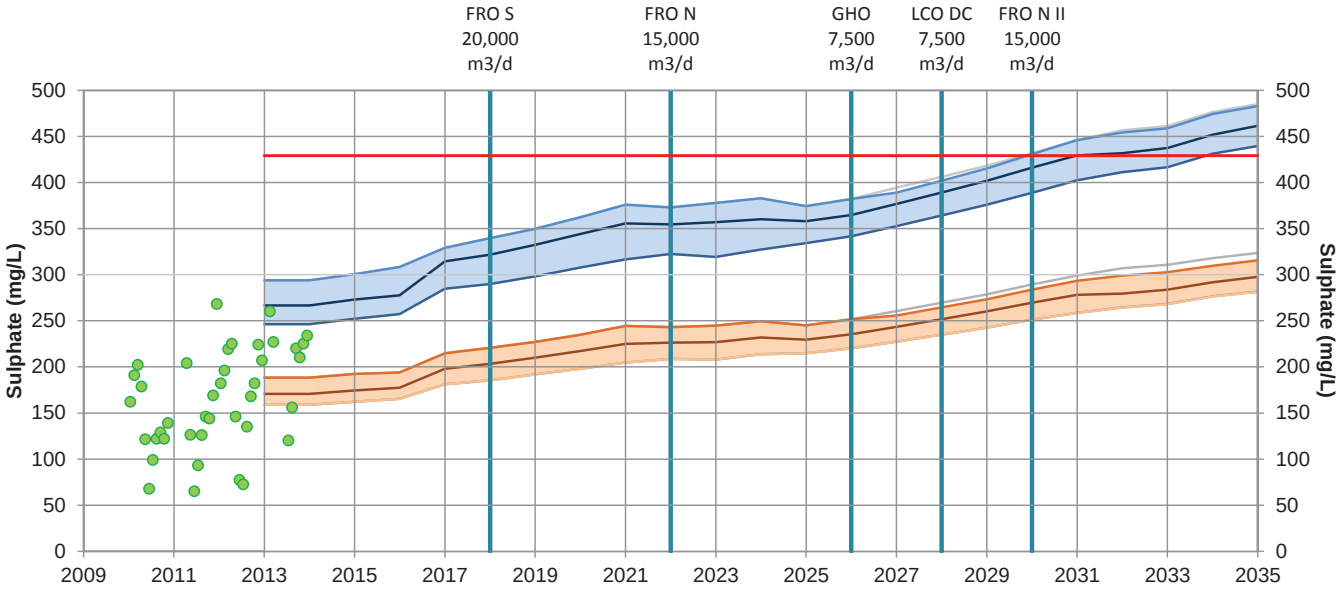


Figure 8-11. Example of monthly concentrations with and without treatment (FR4, untreated in 2017 and treated in 2034).

Sulphate concentrations are projected to remain within long-term targets throughout the system, except at FR4 late in the planning period (Figure 8-12, showing highest-concentration Order stations in the Elk and Fording Rivers). Sulphate is currently below guideline at the Order stations, and projections indicate it will remain below targets until 2030. The integrated assessment indicates that the concentrations will remain protective of aquatic life at least until 2030, and additional toxicity testing at high hardness is planned to support the finalization of the target. The model tends to overpredict sulphate concentrations, and the technology that treats for sulphate has challenges associated with it (Chapter 6). If mitigation were required for sulphate, it would be considered for the FRO-North plant (currently planned for 2021) and initial predictions are that with 100 mg/L effluent concentrations, sulphate concentrations would remain below the target (Figure 8-13).

Cadmium was not modelled, but current concentrations are within targets and are expected to remain so (Chapter 4). Cadmium trends will continue to be monitored and adaptively managed during plan implementation. Technologies that remove these constituents will be evaluated and implemented if required.

a. Fording River downstream of Greenhills Creek (FR4):



b. Elk River downstream of Fording River (ER2):

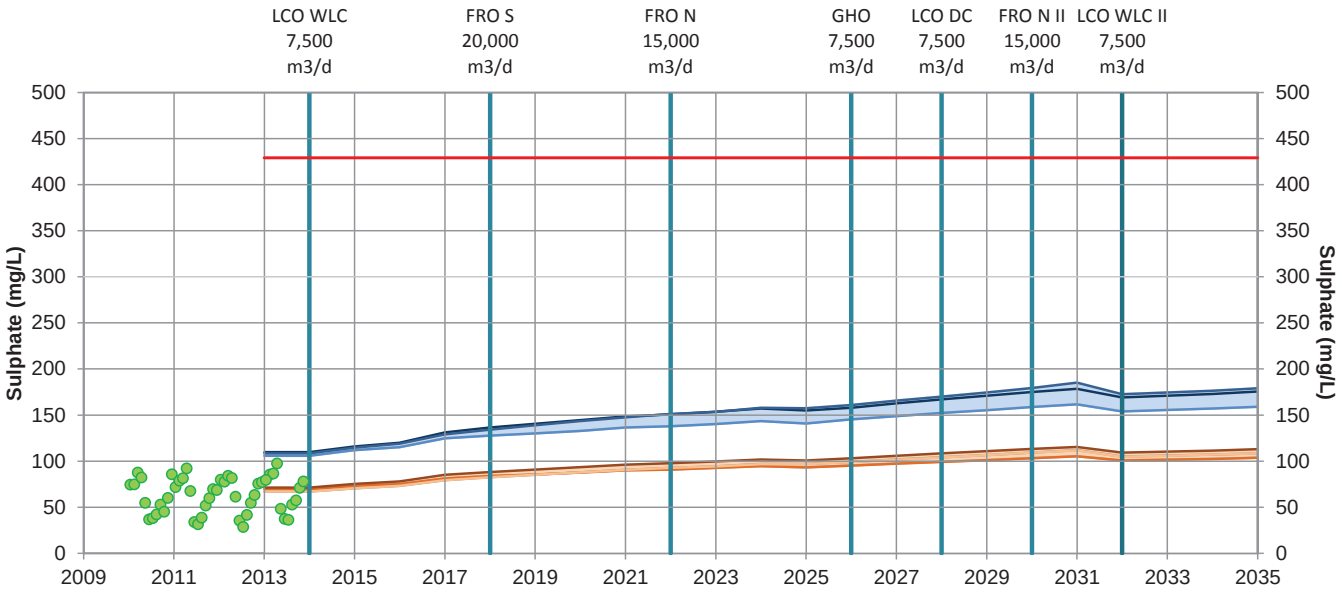


Figure 8-12. Sulphate concentration projections at Order stations FR4 and ER2.

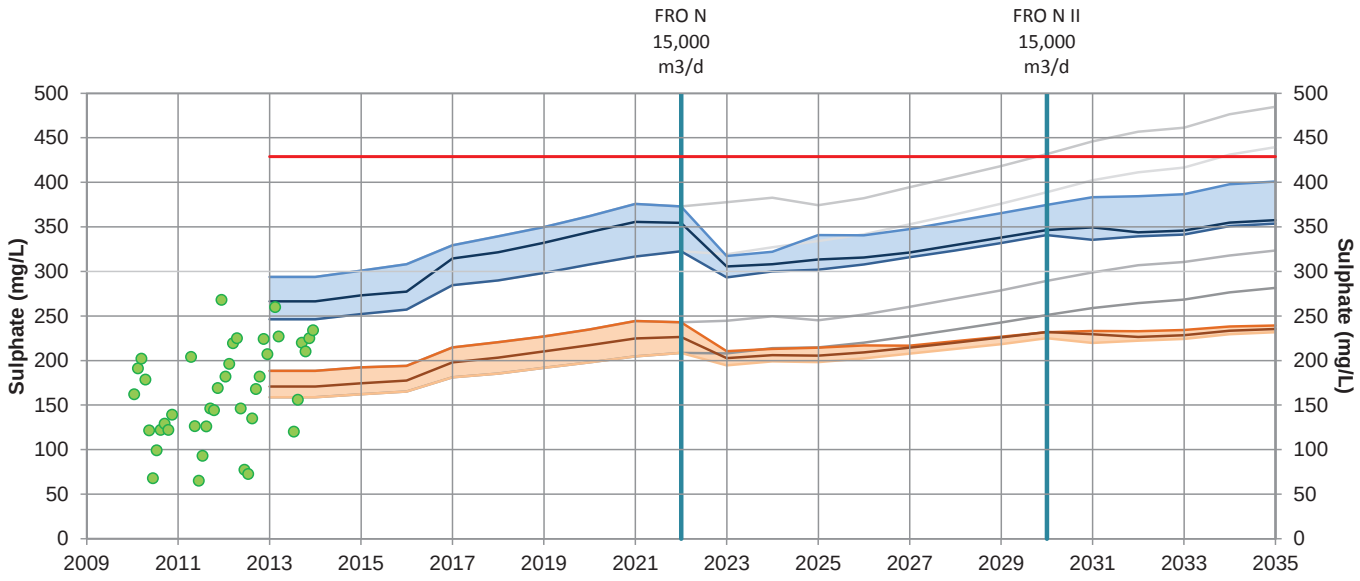


Figure 8-13. Sulphate concentration projections at Order station FR4, with treatment for sulphate.

8.6 Short- and Medium-Term Targets

The first step toward achieving environmental management objectives and outcomes for the Designated Area is the establishment of short-term concentration targets and timeframes. Short-term targets are not required where current (2013) concentrations of selenium, nitrate, cadmium, and sulphate meet B.C. WQGs, or if current and future concentrations are predicted to remain within long-term targets. Therefore, short-term targets are defined as the maximum monthly concentrations measured in 2013 for selenium at Order stations FR4, FR5, and ER2, and for nitrate at ER2 and ER3.

Short-term targets are based on technical and financial achievability, with timeframes defined by the initial implementation plan. Until the FRO South AWTF is operating, maximum modelled concentrations for selenium and nitrate are anticipated to increase.

8.6.1 Short-term Targets

Short-term targets for selenium are required at Order stations FR4 and FR5 (Table 8-20). Concentrations at other Order stations are predicted to remain within long-term targets or are predicted to meet long-term targets at the same time that maximum 2013 concentrations are met. Short term targets in the Fording River are predicted to be attained once the FRO-South AWTF is operational. At ER2, short term targets are achieved by 2023 (although concentrations are expected to get below short term targets in 2019, they increase again before 2023 at which time they are expected stay below the short term target). Water treatment facilities at Line Creek, Fording River and Greenhills affect water quality at the ER2 monitoring location. Management options, including water treatment, are prioritized on a regional basis targeting the areas where the largest benefits can be realized. Section 8.4 discusses the anticipated timing for development of future facilities. The implementation sequence of Line Creek, Fording River South, Elkview and then Fording River North has larger benefits to the watershed overall but does not keep selenium levels at ER2 consistently below the short term target until 2023 when the Fording River North treatment facility is anticipated to be operational.

Table 8-20. Short-term targets for total selenium.

Order station (EMS#)	Order station description	Short-term target[1]	Immediate action	Estimated target attainment (year)
Fording River				
FR4 (0200378)	Fording River downstream of Greenhills Creek	≤63 µg/L	Design, build, and operate FRO AWTF	2019
FR5 (0200028)	Fording River at the mouth	≤51 µg/L	Operate WLC AWTF and FRO AWFT	2019
Elk River				
ER1 (E206661)	Elk River downstream of Greenhills Operation	Not applicable[2]	Environmental Monitoring	Not applicable[2 and 3]
ER2 (0200027)	Elk River downstream of Fording River	≤19 µg/L	Environmental Monitoring	2023
ER3 (0200393)	Elk River downstream of Michel Creek	Not applicable[3]	Environmental Monitoring	Not applicable[2 and 3]
ER4 (E294312)	Elk River at Elko Reservoir	Not applicable[2]	Environmental Monitoring	Not applicable[2 and 3]
LK2 (E294311)	Lake Koocanusa south of the mouth of the Elk River	Not applicable[2]	Environmental Monitoring	Not applicable[2 and 3]

Note[1]: Analytical laboratories typically set an acceptable Quality Assurance/Quality Control Relative Percent Difference limit of ±20%. To account for imprecisions in analytical procedures, a 10% tolerance limit of the target is proposed.
Note[2]: Current (2013) concentrations meet B.C. WQGs, or current and predicted future concentrations remain below long-term targets.
Note[3]: Short-term target for stabilization and attainment year is not applicable because the long-term target is achieved at the same time that maximum 2013 concentration is achieved.

Short-term targets for nitrate are required at Order station ER2 (Table 8-21). Concentrations at other Order stations are predicted to remain within long-term targets or are predicted to meet long-term targets at the same time that maximum 2013 concentrations are met. Short term targets in the Elk River (ER2) are predicted to be attained once the FRO-South AWTF is operational.

Table 8-21. Short-term targets for nitrate.

Order station (EMS#)	Order station description	Short-term target[1]	Immediate actions	Estimated target attainment (year)
Fording River				
FR4 (0200378)	Fording River downstream of Greenhills Creek	Not applicable[3]	Design, build, and operate AWTF	Not applicable[3]
FR5 (0200028)	Fording River at the mouth	Not applicable[3]	Operate WLC AWTF	Not applicable[3]
Elk River				
ER1 (E206661)	Elk River downstream of Greenhills Operation	Not applicable[2]	Environmental Monitoring	Not applicable[2 and 3]
ER2 (0200027)	Elk River downstream of Fording River	≤4 mg/L as N	Environmental Monitoring	2019
ER3 (0200393)	Elk River downstream of Michel Creek	Not applicable[3]	Environmental Monitoring	Not applicable[3]
ER4 (E294312)	Elk River at Elko Reservoir	Not applicable[2]	Environmental Monitoring	Not applicable[2 and 3]
LK2 (E294311)	Lake Koocanusa south of the mouth of the Elk River	Not applicable[2]	Environmental Monitoring	Not applicable[2 and 3]

Note[1]: Typically analytical laboratories set an acceptable Quality Assurance/Quality Control Relative Percent Difference limit of ±20%. To account for imprecisions in analytical procedures, a 10% tolerance limit of the monthly average was established.
Note[2]: Current (2013) concentrations meet B.C. WQGs, or current and predicted future concentrations remain below long-term targets, or long-term target is met with the implementation of the first treatment plant upstream of the Order station (applies to FR4 and FR5).
Note[3]: Short-term target for stabilization and attainment year are not applicable because the long-term target is achieved at the same time that maximum 2013 concentration is achieved.

Concentrations of sulphate and cadmium at the Order stations are currently within B.C. WQGs, and future concentrations are not expected to exceed long-term targets (except at FR4, as discussed above). Therefore, short-term targets are not required for sulphate or cadmium.

8.6.2 Medium-Term Targets

Medium-term concentration targets and time frames are set to demonstrate progressive reduction in water-quality concentrations from short to long term targets. Medium-term targets are set at the same locations as short-term targets, i.e., where current or projected concentrations of selenium, nitrate, sulphate and cadmium are above BC WQGs. Therefore, medium-term targets are defined as the maximum monthly concentrations for selenium at Order stations FR4, FR5, and ER2, and for nitrate at ER2.

For selenium in the Fording River at Order Stations FR4 and FR5 (Table 8-22), long-term targets are projected to be achieved very shortly after the short term targets (and with the next treatment plant after the short term targets are achieved). For that reason, the medium term targets are set equal to the long term targets.

Table 8-22. Medium-term targets for total selenium.

Order station (EMS#)	Order station description	Medium-term target[1]	Estimated target attainment (year)
FR4 (0200378)	Fording River downstream of Greenhills Creek	≤57 µg/L	2022
FR5 (0200028)	Fording River at the mouth	≤40 µg/L	2023

In the Elk River at ER2, the long term nitrate target is 3 NO_3-N mg/L met by 2028 (although as of yet unquantified reductions due to improvements in blasting practices are expected to improve this timing) and the short term target is 4 NO_3-N mg/L in 2019. An intermediate concentration of 3.5 NO_3-N mg/L in 2025, after the second phase of the EVO treatment plant is installed is selected as the medium term target and timeframe.

Table 8-23. Medium-term targets for nitrate.

Order station (EMS#)	Order station description	Medium-term target[1]	Estimated target attainment (year)
ER2 (0200027)	Elk River downstream of Fording River	3.5 NO3-N mg/L	2025

Concentrations of sulphate and cadmium at the Order stations are currently within B.C. WQGs, and future concentrations are not expected to exceed long-term targets (except at FR4, as discussed above). Therefore, medium-term targets are not required for sulphate or cadmium

Chapter 9
Social and Economic Considerations

Chapter Overview

This chapter examines the social and economic importance of water and water quality to the Elk Valley, and reviews the anticipated costs and benefits of mitigation measures proposed in the Plan on 12 social-economic valued components and indicators that cover key areas of concern for residents.

Concordance with Ministerial Order and Terms of Reference

Chapter 9 satisfies Section B.6 of Schedule C of Ministerial Order M113 and Section 3.8(e) and Section 3.10(a) and (b) of the Elk Valley Water Quality Plan Terms of Reference.

Chapter Highlights

- **Water has significant social and economic value in the Valley.** In the Elk Valley, Water sources including the Elk and Fording rivers and Lake Koocanusa support recreation, tourism and other economic activities. In addition, groundwater is the primary source of drinking water for residents.
- **Mining is the major source of economic activity in the East Kootenays.** Teck's five steelmaking coal operations directly or indirectly contribute 6,440 jobs to the East Kootenay economy. Approximately one in five (20%) of the total jobs in the region East Kootenay depend on Teck's mines.
- **Impact of mitigation and water-quality targets on key social and economic values assessed.** This chapter, and the supporting report by Ernst & Young, examines the costs and benefits of targets and mitigation measures for water quality (selenium, cadmium, nitrate, and sulphate) and calcite management in terms of 12 key social-economic valued components, which were refined with input from public consultation:
  1. Gross domestic product (GDP)
  2. Local business opportunities
  3. Investment
  4. Jobs
  5. Tax and resource revenue-sharing
  6. Personal income generation
  7. Availability of housing
  8. Sustainable community population
  9. Physical health
  10. Use of aquatic environment
  11. Skills training, apprenticeships and education
  12. Availability and access to community services.
- **The Elk Valley Water Quality Plan is anticipated to be protective of key social and economic values.** The Plan will provide a framework for decision-makers from the B.C. Ministry of Environment to review proposals for steelmaking coal mining and other activities in the Elk Valley. By meeting water-quality and calcite targets that protect the environment and human health, the Plan will support the continued use of water for recreation, tourism and fishing.

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9.1 Introduction

Maintaining water quality is integral to the social and economic fabric of the Elk Valley. Clean drinking water is essential for human health, and fresh water provides opportunities for recreation, tourism and related economic activity. At the same time, Teck's five coal-mining operations in the Elk Valley provide significant benefits to the local and provincial economy. They create employment, generate significant economic output, and provide tax revenue to all levels of government.

The Order requires Teck to address the economic and social costs and benefits of addressing risks to the environment through water treatment. This chapter, and the appended report by Ernst & Young, addresses this requirement. Based on a representative scenario, it assesses the costs and benefits of meeting selected targets for water quality (selenium, cadmium, nitrate and sulphate), and calcite management.

The Plan proposes scientifically supported water-quality targets that will maintain aquatic and human health. Chapter 6 assesses the most viable water management options and identifies active water treatment and clean-water diversion as the approaches that will be taken under the initial implementation plan. Chapter 8 sets out short-, medium- and long-term water quality targets and the initial implementation plan. Chapter 7 describes a similar process for managing calcite. Notably, Achieving these targets will require an increase in capital and operating costs. This chapter examines the social and economic importance of water and water quality to the region, and reviews the anticipated costs and benefits of the Plan for 12 social-economic "Valued Components and Indicators" identified for the Elk Valley (see Section 9.3).

9.2 The Importance of Water in the Elk Valley

The 220-km Elk River originates in the Elk Lakes, which are fed by numerous glaciers, and runs through the communities of Elkford, Sparwood, Hosmer, Fernie and Elko near the Continental Divide of the Rocky Mountains. It flows through the Elk Valley in a southwesterly direction, joining the Kootenay River in Lake Koocanusa. There are several tributaries to the Elk River, including Cadorna Creek, Forsyth Creek, Michel Creek, Fording River, Coal Creek, Lizard Creek, Morrissey Creek and Wigwam River.

9.2.1 Ktunaxa Nation

The Ktunaxa Nation has identified a balanced vision for development which emphasizes environmental protection with the promotion of economic growth. The Ktunaxa Nation vision for economic growth is diverse, emphasizing the wage economy, entrepreneurial business development and rights-based revenue sharing alongside the promotion of a rights-based subsistence economy which supports opportunities for traditional subsistence harvesting and knowledge transfer.

Each of these activities requires use of water within the Elk Valley. The Ktunaxa Nation has indicated Teck's five operations in the Elk Valley have the potential to provide substantial opportunities for Ktunaxa Nation and Ktunaxa citizen participation in the wage economy, business development and rights based revenue sharing. The Ktunaxa Nation has also identified the Elk River as supporting traditional subsistence practices and affording other commercial opportunities, such as guiding and outfitting, for Ktunaxa citizens.

The Plan's scientifically supported water quality targets are protective of these interests.

9.2.2 Recreation

The Elk Valley region contains pristine wilderness areas such as the Elk Lakes Provincial Park. With more than 40 km of trails along the Elk River and in the surrounding mountains, combined with its abundant wildlife, the area has some of the densest wildlife populations in North America.

Elk Valley residents and tourists engage in outdoor activities throughout the year. In the summer, these include hiking, mountain biking, horseback riding, whitewater rafting, wildlife viewing, boating, kayaking, canoeing and fishing. In the fall, activities include hunting deer, moose, mountain goat, bighorn sheep, bear, and elk. Winter activities include downhill and cross-country skiing, snowmobiling, ice fishing, and river fishing on unfrozen sections of the Elk River.

The two most popular outdoor recreational activities in the area are water-based: swimming and beach activities, at 73% and 70% respectively.[1] Fernie hosts an annual swim, drink and fish festival on the Elk River in September. Fernie has one sanctioned boat launch, but water users often access waterways from non-sanctioned areas of the river.

9.2.3 Tourism

The Kootenay Rockies region, which encompasses the Elk Valley or East Kootenay, is a popular tourist destination. It received 1.6 million overnight tourist visits in 2010, and generated $522 million in related spending.[2] A majority of the tourists (76%) visiting the Kootenay Rockies region are from Alberta and other parts of B.C.

The Elk Valley, in the southeast corner of the region, is an all-season destination for recreation tourism. Local service industries provide meaningful economic returns to Elk Valley communities. In 2013, activity peaked at Elk Valley visitor centres during July to September, representing approximately 64% of total annual visitors. However, many tourists do not stop at visitor centres, but travel straight to the ski hills and mountains. Approximately 80% of visitors responding to Tourism Fernie's winter survey indicated that skiing was their primary reason for visiting. In the summer, the primary reason for visiting is to attend a summer event or to go biking.[3]

Table 9-1. 2013 Elk Valley visitor centre statistics.[4]

	Jan-Mar	Apr-Jun	July-Sep	Oct-Dec	Total
Elkford	84	166	597	92	**939**
Fernie	596	3,097	7,990	697	**12,380**
Sparwood	2,691	11,969	34,776	5,216	**54,652**
Total Visitors	3,371	15,232	43,363	6,005	**67,971**

Nearly half of all B.C.-resident travellers stayed with friends and family. Other Canadian residents spent most of their visits in non-paid accommodation (private cabins, RVs, condos, etc.). US residents spent more time in hotels and motels than travellers from other regions. Total room revenue in 2012 for the Kootenay Rockies region was $81 million.[5] In the Elk Valley area, room revenue is generated from both business-related travel and tourists. For some accommodation providers, Teck and its contractors and consultants are the top customers.

[1] 2012 In Market Research Report – Summary of Tourism Regions
[2] Destination BC – Regional Tourism Profile Kootenay Rockies, April 2013
[3] Tourism Fernie Visitor Surveys, 2013
[4] Tourism BC
[5] Destination BC – Regional Tourism Profile Kootenay Rockies, April 2013

9.2.4 Fishing

The Elk River provides world-class fly fishing, which in 2009 enabled Fernie to host the 7th Annual Fly Fishing Canada National Fly Fishing Championship. The Elk River is home to one of the largest remaining populations of wild, genetically pure westslope cutthroat trout, a species renowned for its willingness to rise to dry flies even in the most trying conditions. The river also hosts populations of large bull trout. The fishing season runs from mid-June to mid-October. Catch and release is mandatory for many of the fish in the Elk River, but some can be kept if they meet weight and species requirements.

The Elk River is very accessible to anglers. Local highways and forest service roads run parallel to the Elk River from Elko to Elkford and its tributaries throughout the valley. It is one of seven fisheries deemed "classified waters" in southeastern B.C., which means anglers need a special licence to fish. Classified waters are regulated and have a specific number of angler days assigned to guides, of which there are approximately 20 offering services in the Elk Valley, each offering expertise, equipment and intimate knowledge of the local rivers. Since 2005, the allocated rod days for Elk river guides have remained the same at 2,950 days per year, with a relatively stable average of 1,875 or 63% utilized over the past five years.[6] Non-guided anglers also make extensive use of the river, with an estimated 9,000 non-guided angler days used during each season.

9.2.5 Drinking Water

Most Elk Valley residents obtain drinking water from municipal water systems provided by the City of Fernie, District of Sparwood and District of Elkford. These sources are drawn from wells operated by the municipalities, and are subject to regular testing.

Although a complete inventory is not available, approximately 250 private properties between Elkford and Fernie, and outside the municipal systems, draw water for drinking and other purposes from private wells or surface water sources. While surface water from the Elk or Fording Rivers is not a primary source of drinking water in the region, the potential exists for groundwater sources to be influenced by surface water. Teck undertook a groundwater-testing program as part of the development of this Plan. Only a small number of wells exceeded the screening guideline for selenium, and no health-based benchmarks were not exceeded. Chapter 5 provides more information on Teck's groundwater testing program and human health assessment.

9.3 Valued Components and Indicators

A structured process was used to establish Valued Components and Indicators to be evaluated in this analysis. Seventy-five potential, wide-ranging components were identified through consideration of other global socio-economic assessments, previous environmental assessments in the Elk Valley, and Teck's knowledge of potential issues of importance to Communities of Interest (COIs), as informed by ongoing engagement with COIs. This engagement includes a Communities of Interest advisory panel that brings together COIs from across the Valley to discuss concerns and interests directly with Teck on a bi-annual basis. Using a rigorous framework, these components were then evaluated for relevance and importance:

- **Relevance** was determined by whether an indicator might be expected to change under a treatment scenario, if there was suitable information available to assess the component, and if it was the most appropriate component to assess in a given area.
- **Importance** was estimated in the context of Teck's current understanding of community concerns, and whether a COI identified a component as important.

[6] B.C. Ministry of Forest, Lands and Natural Resource Operations – Fish and Wildlife Branch.

Indicators were determined for top 12 components, and the proposed list of components and indicators was published for feedback from stakeholders during the first phase of consultation on the Plan. Minor changes were made to streamline the components and indicators, and to reflect the feedback received. A summary of the results is discussed below.

The sections that follow summarize impacts on selected Valued Components and Indicators. These summaries are based on trends and judgments from quantitative modelling by Ernst & Young. Several implementation scenarios were modelled, though little variation in socio-economic factors was observed. A representative scenario was selected for this assessment, based on its similarity to the proposed implementation plan. A more thorough discussion of the Ernst & Young analysis is provided in Annex M.

9.3.1 Gross Domestic Product

The five steelmaking coal mines operated by Teck in the Elk Valley make a significant contribution to the provincial and national GDP. They are expected to contribute $4.5 billion or 2.0% of B.C.'s $230 billion GDP in 2014. As the Plan will not reduce employment or production at those operations, there should be it is anticipated that there would be a negligible impact on GDP as a result of its implementation. Economic activity generated by construction of water treatment capacity and other mitigation activities, as outlined in Chapter 8, may generate a small increase in GDP. The Plan should not affect other water uses that generate GDP, such as tourism.

9.3.2 Local Business Opportunities

Teck's operations in the Elk Valley generate approximately $1.4 billion in local procurement spending, creating significant opportunities for local business. The Plan will have a minimal impact on this. Construction of water treatment facilities and other mitigation activities could slightly increase procurement spending for local businesses. The Plan will have no impact on local businesses that rely on the use of the Elk or Fording rivers or Lake Koocanusa, such as tourism or sport fishing.

9.3.3 Investment

As with Section 9.3.2, the Plan will have minimal impact on local investment related to existing mining operations, with construction of water treatment facilities and other mitigation activities offering a potential increase in local and regional investment as a result of additional procurement.

9.3.4 Jobs

Teck is the single largest employer in the region, directly or indirectly contributing 6,440 jobs to the East Kootenay economy. Approximately one in five (20%) of all jobs in the East Kootenay are dependent on Teck. On a provincial and national scale, considering direct and indirect employment and spinoffs, Teck is projected to support 15,240 jobs in B.C. and 19,020 jobs in Canada in 2014.

Due to the capital-intensive nature of the mining industry, for every one job created at Teck, another 2.7 jobs are created elsewhere in the provincial economy. Teck's Elk Valley operations support $1.8 billion in wages and benefits across B.C. and $2.6 billion Canada-wide (including B.C.).

The Plan will support continued, sustainable mining in the Elk Valley and provide a regulatory framework that will enable consideration of the extension of operations. As a result, it is expected that there will be no reduction in East Kootenay employment currently supported by Teck's operations as a result of implementation of the Plan. Construction of treatment facilities would temporarily increase employment, and ongoing plant operations would create a small increase in jobs: for example, the Line Creek treatment facility requires approximately a dozen staff. The Plan will not reduce employment related to other water uses such as tourism and sport fishing.

9.3.5 Tax and resource revenue-sharing

The Plan will increase Teck's operating and capital costs due to the need to build and operate treatment facilities and other mitigation measures. Teck has invested $105 million in construction of the West Line Creek Active Water Treatment Facility (AWTF), and anticipates investing approximately $600 million in water treatment and mitigation over five years. This will reduce taxes, royalties and revenue-sharing with the governments of B.C. and Canada and First Nations, including an approximate $65 million in Mineral Resource Taxes over the five years. The impact on local governments is expected to be negligible.

9.3.6 Personal Income Generation

The Plan will support continued, sustainable mining in the Elk Valley, and will provide a regulatory framework that will enable consideration of extensions to operations. As a result, no reduction is anticipated of existing East Kootenay employment with or supported by Teck. It will have no effect on wages and personal incomes connected with those jobs. The Plan will not reduce personal incomes related to other water uses, such as tourism and sport fishing.

9.3.7 Availability of housing

The proposed staging of the initial implementation plan will maintain a construction labour force at a level similar to that required to build the West Line Creek AWTF. It will have a negligible effect on housing availability.

9.3.8 Sustainable community population

The Plan will have a negligible impact on population. It supports ongoing, sustainable mining in the region without compromising non-mining activities.

9.3.9 Physical health

Physical health is considered in the context of consumption of fish caught in the Elk Valley watershed, and of potential effects on drinking water. As outlined in Chapter 5, monitoring and assessment indicates that current and projected concentrations of selenium and other constituents of interest in fish in the Elk and Fording rivers do not pose health risks, even for people who eat fish frequently.

Municipal water systems within the Elk Valley are tested regularly by municipalities to ensure water quality. Testing shows that, with the exception of one of the District of Sparwood's three wells, municipal water systems are not affected by mining-related water-quality constituents. That well has exhibited elevated selenium concentrations and was temporarily taken out of service until concentrations decreased to a level that meets water-quality guidelines. The District is establishing a replacement well located at a distance outside the influence of mine-affected surface water.

Drinking-water quality for all municipal water users in the Elk Valley is expected to remain unaffected throughout implementation of the Plan. If drinking water is affected by mining activities, Teck will provide drinking water that meets provincial WQGs to communities.

A small number of private wells in the Elk Valley have recorded a potential influence related to selenium from surface waters. Teck is working with individual owners to provide alternative water sources as necessary. The majority of private well users remain unaffected. Chapter 5 provides more details on the human health assessment conducted as part of the development of the Plan.

9.3.10 Use of aquatic environment

The main considerations for use of the aquatic environment include eating fish caught in the Elk Valley watershed, and swimming in the Fording and Elk rivers and Lake Koocanusa (i.e., continued "fishability" and "swimmability").

Monitoring and assessment indicate that current concentrations of selenium, cadmium, nitrate, sulphate and calcite will not affect human health and aquatic life in the Fording and Elk rivers and Lake Koocanusa. The Plan outlines mitigation measures that will ensure that these constituents do not reach levels that have a measurable effect on fish populations, thus protecting the "fishability" of the watershed.

Recreational swimming in the Elk and Fording rivers and Lake Koocanusa currently poses no human health risks. This will continue to be the case during implementation of the Plan.

9.3.11 Skills training, apprenticeships and education

Levels of skills training and apprenticeships supported through Teck's operations should continue under the Plan, as production and employment will be maintained. The staged development of water treatment facilities could create additional demand for specialized construction workers and operators. This could, in turn, increase the type of skills training and/or number of apprenticeships offered in the region.

9.3.12 Availability and access to community services

The Plan will support continued, sustainable mining in the Elk Valley and is expected to have a negligible impact on Teck's level of community investment or access to publicly funded community services. staged construction of treatment facilities and other water quality measures will help mitigate a potential influx of temporary residents or a spike in demand for community services such as health care, education or emergency services.

9.4 Summary

As detailed in the Plan, it has been determined that Teck can achieve water quality and calcite targets that will maintain aquatic and of human health, thereby supporting the continued use of the water for recreation, tourism and fishing. The social-economic analysis indicates that the proposed water quality and calcite targets in the Plan should be economically and socially protective for both B.C. and the Elk Valley region.

Chapter 10
Monitoring

Chapter Overview

This chapter describes monitoring that will be undertaken, through the Regional Aquatic Effects Monitoring Program (RAEMP) and supporting studies, to assess environmental conditions, confirm that the objectives of the Plan are met, identify the need for adaptive management actions, and refine planning tools in the use of the Plan.

Concordance with Ministerial Order and Terms of Reference

Chapter 10 satisfies Section B.14 and B.16 of Ministerial Order M113 and Section 3.11 (last paragraph) and Section 3.13 of the Elk Valley Water Quality Plan Terms of Reference.

Highlights

- **Teck will implement ecosystem monitoring and ecotoxicology assessment programs to evaluate progress on meeting Plan objectives.** The monitoring program will be used to confirm that the Plan is achieving its objectives of protecting aquatic ecosystem health, managing bioaccumulation of constituents, and protecting human health and groundwater. It will also be used to refine planning tools and inform adaptive management.
- **Ecosystem monitoring will include a range of sample types and endpoints throughout the Designated Area.** Monitoring will include surface water quality, sediment, calcite formation, fish, benthic invertebrates (e.g., insects) and periphyton (e.g., algae and bacteria).
- **Results will be provided to government agencies and Ktunaxa Nation Council, and will be publicly available on the Plan website.** Surface water quality data will be evaluated and compared to predicted water quality concentration and targets. Results of these evaluations will be summarized and made available at www.teck.com/ElkValley.

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10.1 Introduction

Teck will update the RAEMP, the aquatic ecosystem monitoring program, to include additional monitoring to address objectives specified under the Terms of Reference for the Plan and existing Environmental Management Act (EMA) permits for Teck's mine operations. Data from the RAEMP, along with data from the groundwater sampling program, will be used to confirm that the Plan is achieving the four environmental management objectives and outcomes specified in the Order:

- protection of aquatic ecosystem health
- management of bioaccumulation of contaminants in the receiving environment (including fish tissue)
- protection of human health
- protection of groundwater.

Regular cycles of the RAEMP are required under the existing EMA permits and the program's objectives are similar to those of the Plan. They include:

- Assess effects of effluent discharges from mine operations, separately and cumulatively, on the aquatic ecosystems within the Elk River watershed.
- Evaluate water chemistry changes for key constituents of concern
- Assist in understanding whether management and mitigation actions are working as expected.

The RAEMP entails a comprehensive evaluation of aquatic ecosystem health. It measures a broad range of constituents in environmental media, including those specified by the Order (selenium, cadmium, nitrate and sulphate) and also measures calcite formation and aquatic effects. The data collected, and reports developed, for the program to evaluate effects to aquatic ecosystem health will be used to meet both objectives of the Plan and Teck's existing permits. Specific to the Plan, monitoring results will be used to assess environmental conditions, confirm objectives are met, identify and inform the need for adaptive management actions, and refine the tools (e.g., the Elk Valley Water Quality Planning Model and selenium-bioaccumulation model) used in development of the Plan.

10.2 Regional Aquatic Effects Monitoring

The RAEMP is the foundation for monitoring and evaluating changes in the aquatic environment throughout the Designated Area. The program is being developed with input from the B.C. MOE and Ktunaxa Nation Council. It will be carried out in accordance with EMA permits and requirements associated with the Plan. The RAEMP will build on information collected in watershed-wide monitoring programs in 2006, 2009, 2012 and in numerous supporting studies.

The RAEMP is intended to be flexible, resource-efficient, and ecologically sustainable (e.g., by using non-lethal sampling method). It is designed to provide scientifically and statistically robust monitoring of spatial and temporal effects on water quality, water uses, and aquatic biota representative of the Designated Area. It integrates physical, chemical and biological information to assess aquatic ecosystem health. It provides a regional assessment of conditions based on relevant and representative species and endpoints.

Detailed design of the RAEMP will be completed in 2014, with implementation intended for 2015. Its development is guided by a process routinely employed by the U.S. Environmental Protection Agency, commonly referred to as the data quality objective (DQO) process (US EPA 2006). The process follows a logical progression that includes:

- decisions based on an identified need for information (e.g., characterization of the environment and monitoring changes)
- assembling available information
- evaluating the quality of the data
- developing a plan for collecting additional information to adequately address relevant concerns.

The design is adaptive, and can be modified to advance the understanding of watershed conditions over time. This may include the addition of monitoring stations to support the investigation and reporting of conditions at a local scale (e.g., tributaries). The technical and management approach guided by the RAEMP considers the following principles:

- coordination of program development, data interpretation and reporting with the Provincial government (MOE and MFLNRO) and the Ktunaxa Nation Council
- careful evaluation of assumptions and uncertainties associated with data and conceptual site models
- an iterative approach that evolves in response to learnings to advance understanding and reduce uncertainties
- monitoring to assess and document environmental conditions
- proactive guidance of site-specific management and mitigation decisions.

The RAEMP is a multi-year program involving multiple rounds of data gathering and evaluation. An interpretive report will summarize results for each three-year monitoring cycle. This report will evaluate available data to determine if mine-related chemical and physical changes are resulting in effects to the aquatic ecosystem. Spatial and temporal data patterns will be evaluated to link observed biological responses to specific mine-related sources, thereby assisting in identifying appropriate mitigation and management activities.

In addition to the RAEMP and in consultation with MOE, Teck may determine that a focused evaluation of specific issue(s) is required at a local scale. In this case, Local Aquatic Effects Monitoring Programs (LAEMPs) will be established, as required, under conditions associated with EMA permits for mine operations. These monitoring programs will evaluate issues that are expected to have only localized effects, if any, or those requiring more sample-intense or more frequent monitoring than is associated with the RAEMP (e.g., impact of water diversion changes on water quantity, treatment plant influence on downstream conditions, etc.). The scope and monitoring frequency of LAEMPs will be developed on a case-by-case basis, and the information will be reported independently as required under EMA permits. The data collected as part of these programs will support interpretation and reporting for the RAEMP, when applicable.

Data are also periodically collected for baseline characterizations associated with Environmental Assessments (EAs) as required for applications to extend mining operations. Other supporting studies may also be completed to fill data gaps or to address uncertainties. Data from baseline monitoring and supporting studies will be used, when applicable, to support the RAEMP, to inform future monitoring and the assessment of the Plan's environmental objectives and outcomes.

Figure 10-1 depicts the connections between the different monitoring components described above, and shows how data collected within these programs will be used to evaluate management measures in the Designated Area. This collective approach relies on several steps, including:

- initial identification of data needs
- data review
- collection of additional data
- iterative evaluation of data to guide subsequent activities
- identification of sources and actions most appropriate for the Designated Area.

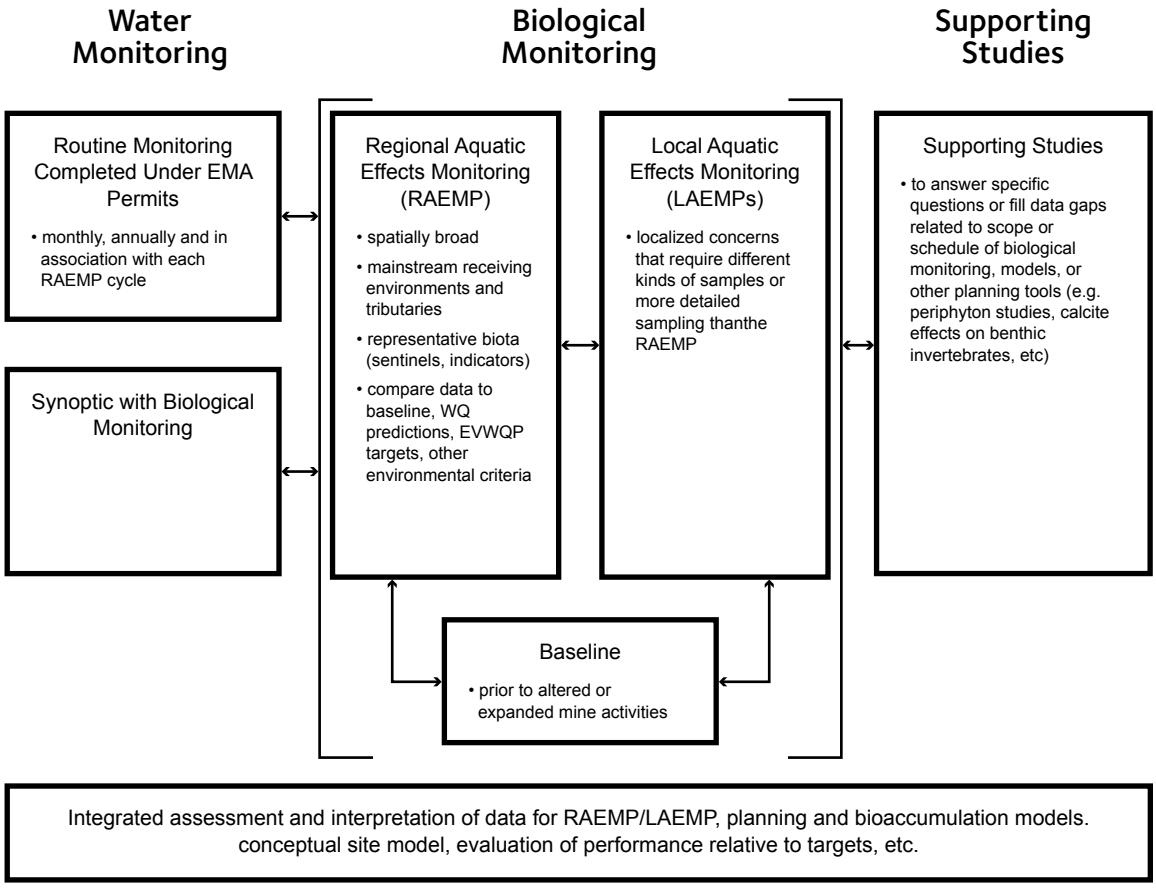


Figure 10-1. Framework of aquatic ecosystem monitoring programs.

Table 10-1 provides an overview of near-term aquatic ecosystem monitoring and supporting studies. Components monitored within the RAEMP may change between cycles, in response to data and evaluation from previous monitoring cycle. Design of future cycles will:

- incorporate learnings from previous cycles to recommend modifications to the monitoring scope or frequency, or the need for supporting studies
- identify hypothesis (as applicable) relevant to pathways and receptors in the conceptual site model(s)
- identify performance criteria for measurement and analyses (i.e., quality assurance and quality control) of each sample type
- specify methods for each of the receptors and media being monitored.

Table 10-1. Conceptual overview of the aquatic ecosystem monitoring program.

Monitoring	RAEMP Cycle 1				RAEMP Cycle 2		
	2013	2014	2015	2016	2017	2018	2019
Elk River Watershed							
Surface water quality and quantity							
Sediment quality				TBD			
Calcite				TBD			
Periphyton – Tissue					TBD		
Periphyton – Biomass and chlorophyll-a							TBD
Benthic invertebrates – Tissue					TBD		
Benthic Invertebrates – Community structure				TBD			
Fish - Tissue							
Fish – Population and health				TBD			
Ecotoxicology					TBD		
Groundwater				TBD			
Supporting Studies	Completed on an as required basis						
Lake Koocanusa							
Water quality							
Sediment quality			TBD				
Plankton – Tissue					TBD		
Plankton – Community structure					TBD		
Plankton – Productivity					TBD		
Benthic invertebrates – Tissue			TBD		TBD		
Benthic invertebrates – Community structure					TBD		TBD
Fish – Tissue					TBD		
Supporting studies	Completed on an as required basis						

Conceptual overview only: All RAEMP monitoring components will be evaluated at the end of each monitoring cycle (represented by bold line between years) to confirm monitoring design for future cycles based on the DQO process.
Note: TBD = To be determined based on monitoring data evaluation

As shown in Table 10-1, the aquatic ecosystem monitoring program collects and evaluates data to verify if environmental management objectives and outcomes are being met. These may include:

- water quality
- substrate sampling (sediment quality and calcite)
- periphyton sampling (primary productivity and tissue concentrations)

- benthic invertebrate sampling (tissue concentrations and community structure)
- fish sampling (tissue concentrations and fish health and/or population status).

Order constituents that bioaccumulate in tissues will be monitored in representative aquatic biota as per the conclusions of the screening-level ecological risk assessment of trace elements discussed in Chapter 4.

The sections that follow provide an overview of monitoring activities routinely evaluated or planned under the RAEMP. Table 10-2 links these monitoring endpoints to the environmental management objectives and outcomes.

Table 10-2. Monitoring to address the plan objectives.

Objective	Monitoring							
	Surface water	Groundwater	Sediment	Calcite	Periphyton	Plankton	Benthic invertebrates	Fish
Protection of aquatic ecosystem health								
Management of bioaccumulation of contaminants in the receiving environment								
Protection of human health								
Protection of groundwater								

The conceptual site model (see Chapter 4) identifies chemical and physical stressor pathways that link mining activities with potential effects on aquatic and aquatic-dependent receptors. Therefore, the CSM is an important tool for guiding development and communication of monitoring activities. Monitoring will focus on the media and receptors identified in the CSM, taking into account the relative ecological importance or likelihood of occurrence of specific interactions. For example, potential mine effects on primary productivity in the Elk River watershed will be more evident through monitoring of periphyton than aquatic macrophyte growth, because periphyton is found throughout the watershed, but aquatic macrophytes are sparsely distributed.

Pathways and receptors differ among specific stressors, and this must be taken into account during monitoring program design. For example, selenium and nitrate are both chemical stressors, but behave differently in the aquatic environment; selenium effects are most likely to occur through dietary accumulation and reproduction, so it is relevant to monitor tissue in representative food-web organisms; whereas nitrate is more likely to affect receptors through direct contact in water, and so tissue monitoring is irrelevant. Table 10-3 shows how consideration of specific stressors, pathways, and receptor effects are used to guide the general design of the RAEMP.

Table 10-3. Relationships between conceptual site model and proposed monitoring.

Stressor category	Mine-related stressor	Dominant pathway	Assessment endpoint	Measurement endpoint	Elk River	Lake Koocanusa	Evaluation criteria
Chemical	Selenium	Dietary accumulation	Toxicity[1]	Water chemistry	✓	✓	Water-tissue relationships described in site-specific bioaccumulation models
				Tissue Se concentrations	✓	✓	Tissue guidelines and benchmarks
	Selenium, nitrate, sulphate, cadmium (and potentially others)	Water contact/ uptake	Toxicity[1]	Water chemistry	✓	✓	Short-, medium and long-term targets at Order stations. Mainstem and tributary concentrations and trends at additional monitoring stations closer to source areas. Water quality concentrations and compliance limits specified in EMA permits.
				Surface water toxicity tests	✓	✓	Toxicity response
		Sediment contact and/or uptake	Toxicity[1]	Sediment chemistry	✓		Sediment quality guidelines, benchmarks, reference concentrations
				Sediment toxicity tests			Toxicity response
		Multiple	Community structure	Benthic invertebrate EPT and E proportions	✓	✓	Reduction relative to reference conditions and in mine-influenced monitoring areas over time.
			Fish population	Westslope cutthroat trout and longose sucker population characteristics and health	✓		Changes in populations over time
	Nutrients (phosphorus and nitrogen	Water contact and/or uptake	Eutrophication	Water nutrient concentrations	✓	✓	Guidelines, benchmarks, targets, reference conditions, changes over time
				Periphyton chlorophyll-a and biomass	✓		
				Water column chlorophyll-a	✓	✓	
Physical	Calcite	Substrate characteristics	Community structure	Calcite index (presence or concretion)	✓		Initial trigger levels based on concentration scores. Combined calcite and benthic invertebrate monitoring will be undertaken as a supporting study in 2015 to update target and adaptive management trigger levels to account for calcite effects to EPT and E proportions and periphyton biomass (Chapter 7).
	Erosion, sediment transport and deposition	Changes in substrate particle size distribution	Population or community structure	Sedimentation and substrate size distribution	✓		To be determined
				Benthic invertebrate EPT and E proportions	✓		Reduction relative to reference conditions and in mine-influenced monitoring areas over time.
	Barriers, connectivity	Access to habitat	Fish population	Habitat quantity	✓		Changes in available habitat over time
	Altered flow patterns	Habitat quantity and quality		Westslope cutthroat trout and longose sucker population characteristics and health	✓		Changes in populations over time

Note [1]: Assessing survival, growth and/or reproduction

10.2.1 Surface Water Quality and Quantity

Water quality data will continue to be collected throughout the Designated Area in the mainstem receiving environments, mine-influenced tributaries, and reference areas. This is required under existing EMA operating permits, and includes routine monitoring of more than 100 stations throughout that Designated Area. These data will prove helpful in multiple respects: evaluating progress toward meeting the long-term water quality targets (Order stations highlighted in bold in Table 10.4), identification of source loading contributors, informing aquatic biota monitoring programs, and/or providing the necessary data to improve planning tools in support of management and mitigation decisions.

Of the routine monitoring stations, data from a sub-set of stations will be used to evaluate performance relative to environmental objectives and outcomes. A summary of the proposed surface water quality monitoring locations (per MU) is presented in Table 10.4. Monitoring locations are listed upstream to downstream within respective MUs, with Order stations in bold. A map of the network is provided in Figure 10-2.

Table 10-4. Regional surface water quality and primary productivity monitoring locations.

MU-1	MU-2	MU-3	MU-4	MU-5	MU-6
FR_UFR1	**LC_LC5**	GH_ER2	**EV_ER4**	**RG_ELKORES**	RG_WARDB
GH_FR1		**GH_ER1**	CM_MC1		RG_USELK
			EV_ER1		**RG_DSELK**
					RG_GRASMERE
					RG_BIGSPRINGS
					RG_BORDER

Note: "**GH_FR1**" corresponds to Order Station "Fording River downstream of Greenhills Creek (FR4).
"**LC_LC5**" corresponds to Order Station "Fording River at the mouth (FR5).
"**GH_ER1**" corresponds to Order Station "Elk River downstream of Greenhills Creek (ER1).
"**EV_ER4**" corresponds to Order Station "Elk River downstream of the Fording River (ER2).
"**EV_ER1**" corresponds to Order Station "Elk River downstream of Michel Creek (ER3).
"**RG_ELKORES**" corresponds to Order Station "Elk River at Elko Reservoir (ER4).
"(**RG_DSELK, RG_GRASMER**E, and **RG_BIGSPRINGS, RG_BORDER**)" corresponds to Order Station "Lake Koocanusa south of the mouth of the Elk River (LK2) in British Columbia.
Note: Monitoring in MUs 1-5 will be for chlorophyll-a in periphyton and MU6 will focus on total phosphorus concentrations in water.

At each location listed in Table 10-4 above, samples are collected on a monthly basis (if safely accessible) and weekly during peak transitional times (ie freshet), and submitted to a CALA[11]-accredited laboratory for analysis. Samples will be analyzed for:

- conventional parameters (pH, dissolved oxygen, specific conductance, total dissolved solids, total suspended solids, hardness, alkalinity, dissolved organic carbon, total organic carbon, colour, turbidity)
- major ions (bromide, fluoride, calcium, chloride, magnesium, potassium, sodium, sulphate, sulphide);
- nutrients (ammonia, nitrate, nitrite, TKN, orthophosphate, total phosphorus, biochemical oxygen demand)
- dissolved and total metals (aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, tin, titanium, uranium, vanadium, and zinc)
- field parameters (temperature, specific conductance, dissolved oxygen, pH).

Note[1]: The Canadian Association for Laboratory Accreditation Inc. (CALA) is a not-for-profit Canadian laboratory accreditation body. Its members participate in rigorous programs of inter-lab comparisons and on-site assessments, based on international standards.

Water quality sampling in the Lake Koocanusa will include the same parameters with the addition of Secchi depth and chlorophyll-a. Due to differences in reservoir and river conditions, sampling methods are adjusted to maintain consistency with the Montana Department of Environmental Quality "Lake Koocanusa Sampling Project – 2013: Water Quality Sampling Plan". Water samples within the reservoir are being collected at various depths, depending upon stratification at a given location and time. A depth integrated sample will also be collected at the RG_BIGSPRINGS station.

Future data will be used to evaluate ambient water quality relative to current baseline conditions, ecological benchmarks, target concentrations, spatial patterns and temporal trends in the Designated Area.

Regional flow data will be accessed and monitored using Environment Canada's regional hydrometric data stations. These include Line Creek at the mouth (08NK022), Fording River at the mouth (08NK018), Elk River near Natal (08NK016), Elk River at Fernie (08NK002), and Elk River below Elko Dam (08NK030). These data, in conjunction with the above-mentioned water-quality data, will be used to refine the Model (see Annex D.3: Water Quality Models – Hydrology Inputs Report).

Consistent with current baseline evaluations, spatial variability of surface water quality along the Elk River and its major tributaries (Fording River and Michel Creek) and Lake Koocanusa will be evaluated, and presented in tables and figures that illustrate the results. Water-quality trends will be evaluated at the Order stations and compared to modelled concentrations and targets.

In addition to the requirements stipulated by the Order, data from the other stations routinely monitored in accordance with EMA permits will be considered, as appropriate, in evaluating environmental performance objectives and outcomes.

10.2.2 Substrate Quality (Sediment Quality, Calcite)

Evaluation of substrate quality includes assessment of sediment chemistry and toxicity, as well as monitoring of calcite deposition. Details regarding the goals and approach for future monitoring associated with substrate quality are described below.

10.2.2.1 Sediment Quality

Aquatic habitats of the Elk River watershed are predominantly lotic, with coarse bottom substrates (e.g., cobbles and gravels). Lentic areas such as oxbows, wetlands, ponds and small lakes, where fine sediments can accumulate overtime, are sparsely distributed and represent a relatively small proportion of the aquatic habitat within the watershed (Golder 2014 and Interior Reforestation 2008).

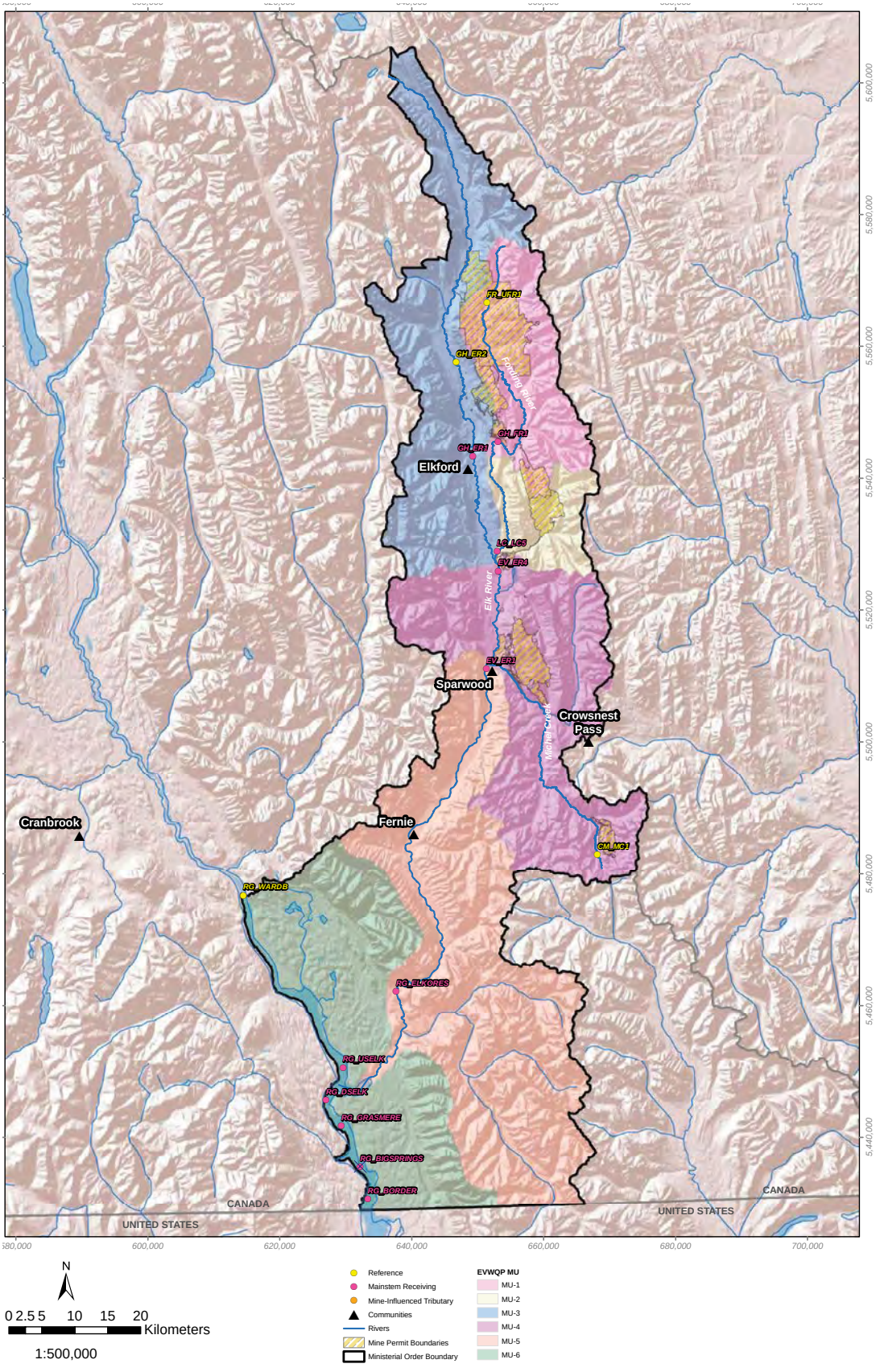


Figure 10-2. Surface water and primary productivity monitoring network.

Sediment quality will be monitored for chemistry and toxicity in the mainstem receiving environment, mine-influenced tributaries and reference areas. This monitoring will focus on samples collected in areas of fine sediment deposition, which have the greatest potential for elevated concentrations of mine-related constituents, to provide an additional line of evidence for evaluating the protection of aquatic life. Data will be evaluated against reference concentrations and sediment quality guidelines, and assessed in terms of spatial patterns and changes over time within the Designated Area.

10.2.2.2 Calcite

The Calcite Index (see Chapter 7) will be used to quantify and monitor calcite deposition within the Elk Valley watershed. These data, in association with information on the types and characteristics of calcite deposits, will be collected in coordination with periphyton and benthic invertebrate monitoring during a supporting study starting in 2014. Monitoring locations will be selected to reflect the full range of calcite index values observed throughout the watershed, so that potential effects on periphyton productivity and benthic invertebrate community structure can be related to the different degrees of calcite deposition. The monitoring will extend into the next cycle of RAEMP sampling (2015), and the results will be used to refine future environmental sampling programs.

10.2.3 Periphyton and Nutrient Monitoring

Waters within the Designated Area are considered oligotrophic and phosphorus-limited. Given that the initial implementation plan involves at least two active water treatment facilities (AWTFs) using biological processes, the addition of phosphorus is an unavoidable consequence of remediating selenium and nitrate-enriched waters. To prevent potential incremental increases in phosphorus from adversely affecting the Designated Area, LAEMPs have been and, if necessary, will be developed to monitor primary productivity in mine-influenced tributaries and downstream receiving environments associated with each AWTF. Upon approval of the Plan and in addition to LAEMPs, primary productivity will also be assessed at representative locations of the Elk River watershed and in Lake Koocanusa, to thoroughly characterize baseline conditions.

The B.C. water quality guideline (WQG) for nutrients and algae within streams are based on chlorophyll-a measurements in periphyton (MOE 2001), which reflect the productivity of chlorophyll-a-producing algae. This WQG is not applicable to lake or reservoir environments; as an alternative, total phosphorus concentrations in water will be sampled to monitor the trophic status of the reservoir. As noted in Chapter 4, existing primary productivity data are spatially limited; therefore, a regional sampling program is proposed to characterize baseline conditions (see Figure 10-2 and Table 10-4). These data will assist in evaluating the potential for eutrophication within the Designated Area, will help inform management decisions (e.g. potential modifications to the active water treatment facilities), and may be used to evaluate bioaccumulation of constituents in the receiving environment.

As illustrated in Figure 10-2, periphyton sampling locations have been positioned to monitor and evaluate spatial patterns along the entire length of the Elk River and its major tributaries (the Fording River and Michel Creek). Based on work within the Designated Area (Minnow, in preparation), collection of periphyton samples for productivity analysis (chlorophyll-a) will be standardized to mid-September (i.e., close to the end of the growing season, and before potential die-off). This will allow for spatial and temporal comparability of data. To the extent possible, periphyton sampling will be conducted synoptically with water sampling in September. Periphyton tissue concentrations for selenium will also be analyzed as part of the RAEMP and to support updates to the bioaccumulation model.

Nutrients, including total phosphorus, will be analyzed as part of the water quality sampling program for Lake Koocanusa (see Section 10.2.1). These data will be compared to current baseline conditions in the reservoir, to evaluate changes over time and confirm the maintenance of trophic status in the lake.

The approach proposed above will directly assess potential eutrophication, and thereby contribute to the understanding of overall ecosystem health. For surface water quality, sufficient baseline data exist to characterize the baseline envelope, and thus can be incorporated into the adaptive management plan (Chapter 11); however, baseline data for primary productivity are limited, and further data collection will be an important component of aquatic ecosystem monitoring.

10.2.4 Benthic Invertebrate Monitoring

Benthic invertebrates represent an important component of aquatic food webs in the Elk River watershed, and therefore play a role in selenium transfer. They also serve as an indicator of overall aquatic ecosystem health, since they integrate the effects of chemical and physical stressors. Benthic invertebrates also have small home ranges (i.e., limited movement compared to vertebrates) making them reliable indicators of localized conditions.

Tissue selenium concentrations and the community structure of benthic invertebrates will be monitored at numerous locations throughout the watershed, including reference, mine-influenced tributaries and receiving environments associated with each of the mining operations. The 2015 sampling design is expected to generally follow the 2012 biological monitoring program (Minnow 2014), which included a comprehensive evaluation of benthic invertebrate communities and tissue chemistry throughout the Designated Area (Figure 10-3). Consistent with monitoring to date, samples will be collected according to Canadian Aquatic Biomonitoring Network (CABIN) protocols (Environment Canada 2010). Community data will be evaluated using the reference condition approach (RCA) as previously discussed in Chapter 4.

Community and/or tissue chemistry data collected as part of site-specific LAEMPs will be used to guide the design and interpretative reporting of the RAEMP, as applicable. Teck is also considering the need for a supporting study specific to evaluation of benthic invertebrate community structure using the Before After Control Impact (BACI) approach as per advice received from the TAC.

Tissue samples will also be collected annually for analysis of selenium concentrations at a few key locations throughout the watershed in coordination with periphyton tissue monitoring. This data will be presented and evaluated for spatial and temporal patterns, as well as potential effects on invertebrates or their predators. These concentrations will also be used to validate and refine the selenium bioaccumulation model. This approach is consistent with data handling steps performed for the current baseline evaluation (see Annex K.1).

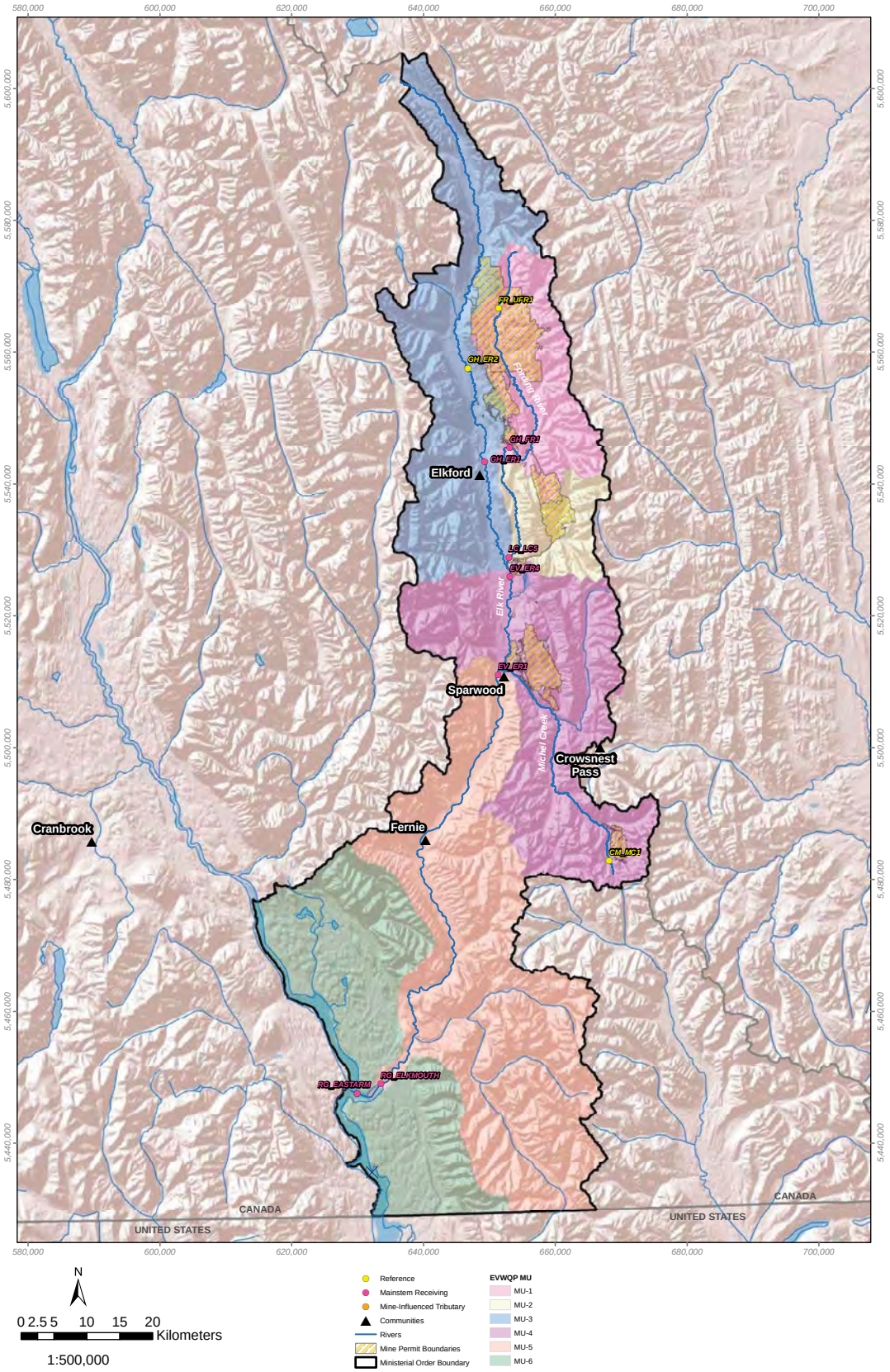


Figure 10-3. Benthic invertebrate community structure monitoring network.

10.2.5 Fish and Fish Population Health

The health and sustainability of fish populations in the receiving environment are important to maintaining ecosystem functions within the watershed, as well as supporting an active fishery. Monitoring of fish populations/health and tissue selenium concentrations will be included in the RAEMP.

Two species, westslope cutthroat trout (WCT) and longnose sucker, will serve as sentinel species in the assessment of fish populations and health. WCT are widely distributed throughout the watershed, and are the only species present in the Fording River upstream of Josephine Falls. Although longnose sucker populations are typically more localized at lower elevations, they represent an important component of lentic habitat in those areas.

The fish health monitoring program will aim to assess differences in endpoints such as population size/demographics, body condition, and growth in mine-exposed areas compared to reference areas and also compared within the same areas over time.

Multiple years are required to understand and quantify fish population characteristics, potential changes, and relationships to multiple stressors (e.g., mining, angling, extreme weather events, water chemistry, habitat fragmentation). Teck will continue the multi-year (2012-2015, inclusive) WCT study in the Fording River upstream of Josephine Falls. The objectives of this study are to assess whether the WCT population in the upper Fording watershed is healthy, robust and sustainable, and to assess movement and critical habitat to help guide fish habitat management decisions. Data collected in this study will also help identify future monitoring endpoints associated with the RAEMP, to assist in evaluating fish population health and potential effects of multiple stressors over time.

Longnose sucker monitoring will include assessment of fish health and population endpoints in a variety of off-channel habitats where populations are of sufficient size that they can be reliably quantified and tracked. Details related to collection methods, sampling areas, sample sizes and data analysis will be provided in the RAEMP study design.

Collection of fish tissues for selenium analysis may also be incorporated into the RAEMP as required. The two sentinel species (WCT and longnose sucker) will be targeted along with mountain whitefish. Tissue data will be compared to established benchmarks and historical data, and will be evaluated outside of the RAEMP with respect to fish consumption guidelines in support of updates to the Human Health Risk Assessment (Chapter 5). Details related to collection methods, sampling areas, sample sizes and data analysis will be provided in the RAEMP study design, as guided by EMA authorization requirements.

10.2.6 Ecotoxicology Assessment

Sublethal toxicity tests using ambient site-waters have confirmed that current baseline surface water concentrations do not adversely affect sensitive aquatic receptors. The most sensitive species is cladoceran (*Ceriodaphnia dubia*), and early-life stages (embryo test) of rainbow trout (*Oncorhynchus mykiss*).

Toxicity tests to date did not necessarily capture the full range of concentrations within the Elk and Fording Rivers (e.g., low-flow and high-flow). As a result and upon Plan approval, a supporting study will be initiated to evaluate sublethal toxicity. Locations for the sublethal ecotoxicology assessment program will be confirmed as part of the study design which will be finalized in early 2015. The study design will include methodology for specific toxicity tests (e.g., Environment Canada's biological methods, longer-term methods as recommended through TAC advice).

The primary purposes of the sublethal toxicity tests will be to:

- monitor ambient conditions to confirm that targets are protective of the aquatic biota
- monitor to address uncertainties associated with dissolved cadmium during Plan development
- provide inputs for further evaluation.

Unlike the other water quality constituents of interest (selenium, sulphate and nitrate), cadmium has its highest concentrations during spring freshet (high-flow), when toxicity-modifying factors (e.g., hardness and dissolved organic carbon) are at their lowest. As a result, to confirm that cadmium concentrations are consistent with the environmental performance objectives and outcomes of the Plan, sublethal toxicity tests will be performed twice per year for two years. Supporting study results will inform the need for continued testing and will be evaluated in consultation with MOE and in consideration of RAEMP data needs. The primary purpose of the ecotoxicology supporting study is to validate ambient environmental conditions.

Additional surface water samples may be collected synoptically with other biological data as part of the RAEMP to measure aquatic toxicity to biota representing different trophic levels and thereby provide an additional line of evidence for evaluating conditions at representative locations of the watershed. Sediment toxicity testing will be done as noted Section 10.2.2.1.

10.2.7 Lake Koocanusa

Water quality monitoring within the reservoir will continue as detailed in section 10.2.1. In 2014, a comprehensive monitoring program was initiated to characterize chemical and biological conditions within the reservoir.[2] This monitoring program includes:

- water (quality synoptically captured with biological monitoring endpoints)
- sediment (quality)
- plankton (community composition, tissue metal concentrations and productivity)
- benthic invertebrates (tissue metal concentrations and community survey)
- fish (tissue metal concentrations and health endpoints).

Biological monitoring will continue in the reservoir in 2015 and 2016, after which results will be assessed to develop the scope of future monitoring as part of the RAEMP.

10.2.8 RAEMP Reporting

At the conclusion of each cycle of the RAEMP, an interpretive evaluation report will be prepared to:

- explain the methods used for sampling and analyses
- present the results of all components of the program intended to assess the aquatic ecosystem health, and water chemistry changes for constituents of concern
- evaluate all lines of evidence to contribute to the understanding of whether management and mitigation actions are working as expected.

The evaluation will consider all lines of evidence and available data within the Designated Area. The evaluation of data will determine if additional supporting studies are required to address any identified data gaps and critical uncertainties.

In advance of each cycle of RAEMP implementation, a detailed study design will be submitted to MOE and Ktunaxa Nation Council. It will outline study objectives, locations, methods, sample sizes, and schedule for sample collections, along with the technical rationale for any changes proposed from the previous cycle.

Reporting requirements associated with existing EMA permits, EA current baseline data and supporting studies will be independently maintained. The relevant data, results, and conclusions of these reports will be incorporated into the RAEMP interpretive report as appropriate, and will also guide the design of future monitoring programs.

10.3 Groundwater

The approach to groundwater monitoring is three-pronged and includes: a groundwater synthesis report, implementation of a groundwater monitoring program informed by the outcomes of the synthesis report, and development of supplemental management strategies if required (see Annex L.3).

Groundwater Synthesis Report

The ground water synthesis report will evaluate regional groundwater conditions and protection objectives in the context of existing mitigation and management strategies. The report will also assess anticipated future groundwater conditions based on changes to mining activities and water quality improvements resulting from mitigation actions. This assessment will lead to identification of areas and/or aquifers that may require protection or consideration of adaptive management steps to achieve related water quality objectives. Where areas are identified as potentially requiring additional consideration, an evaluation of the appropriate management strategies will be performed. The report will incorporate information from groundwater programs implemented or in development at each Teck Elk Valley operation as well as baseline data captured as a component of Environmental Assessments and results from the well sampling program detailed in Chapter 5. For example, existing EMA and Mines Act permits include requirements to establish groundwater monitoring programs for the purpose of better understanding the fate and transport of groundwater on a localized level. The objectives of these monitoring programs are to:

- characterize the groundwater resource (including water quality, quantity, flow, hydraulic connectivity of the affected aquifer(s), and relationships to surface water)
- identify and if necessary, quantify, impacts to groundwater from mining-related activities
- provide information necessary to support the development and verification of water quality predictions for mine sites.

In addition to these programs, data from groundwater monitoring associated with Teck's Applied Research and Development (R&D) program will be considered in the development of the groundwater synthesis report.

Monitoring Program

The groundwater monitoring program will be developed based on results and gaps identified in the groundwater synthesis report. While the exact monitoring components are to be determined, the well sampling program will be one component that will continue in advance of completing the groundwater synthesis report and recommendations. Although results from the well sampling program showed that baseline groundwater concentrations do not present an unacceptable risk to consumers, 11 wells, or ~12% of those sampled, had elevated values of the Order constituents of interest (within 30% of the WQG). The groundwater monitoring program will include resampling these 11 wells that either exceeded guideline or were within 30% of the WQG. Ten additional wells will be added to provide additional data. These wells have been selected based on high usage (multiple users or uses for the well) or slightly elevated concentrations during the initial screening for one or more of the Order constituents.

Supplemental management strategies

The collective information gained from operational monitoring, applied R&D, well sampling program and Environmental Assessment baseline data evaluated through the groundwater synthesis report will provide the

necessary information to develop the regional groundwater monitoring program and serve to assess and inform the effectiveness of mitigation measures implemented as part of the Plan. As such, supplemental management strategies will be developed as part the adaptive management process to ensure protection of groundwater is achieved.

10.4 Human Health

Data collected as part of the aquatic ecosystem health and groundwater monitoring programs will be used in future updates to the Human Health Screening Level Risk Assessment, as detailed in Chapter 5. Data sources will include:

- surface water quality
- groundwater quality
- sediment quality
- tissue constituent concentrations (e.g. selenium).

Data on additional terrestrial pathways (e.g. meat and organ tissue concentrations for wild game, riparian plants), collected as part of Teck's baseline data programs for EAs, will also be used to update the human health risk assessment.

10.5 Other Monitoring

There are additional monitoring programs that Teck captures data from to fulfill other objectives related to permits, Applied R&D, performance measurement and for general information. Data from these programs may also be used to assist in evaluation of whether Plan objectives are being met, as appropriate. Table 10.5 highlights some of these programs and their potential data inputs.

Table 10.5. Other monitoring to assist in evaluating success of Plan objectives.

Other monitoring	Data collection types
Meteorological	Precipitation (snow, rain), wind speed, wind direction, humidity, temperature, pressure
Reclamation and closure	Vegetation mapping, soil placement techniques, elevation impacts on species distribution, vegetation mitigation planning, assessment of metals in soils and vegetation, and reclamation sources
Hydrology	Hydrometric monitoring
Applied R&D	Geochemical and isotopic waste analysis, spoil gas composition data, waste rock leaching data, waste rock microbial data, isotopic and geochemical water quality monitoring onsite and regionally, groundwater quality monitoring in disturbed and undisturbed ground, surface treatment water balance data (i.e., evapotranspiration, run off, net percolation and storage for different reclamation options), snow deposition, melt and abolition data, vegetation survey, disturbed and native ground geophysical surveys, hyporheic zone mapping

Note: This is a summary of potential data that will or has been collected in Teck's other monitoring programs. Data inputs will be assessed and regularly reviewed to determine ongoing monitoring endpoints.

10.6 Quality Assurance/Quality Control

QA/QC programs will involve collection of scientifically credible samples that permit evaluation of data quality objectives and statistical interpretation of the data collected. QA/QC programs will be developed, implemented and reported on for each monitoring program or supporting study, to confirm that the sampling processes standardized and consistent and that meaningful data with known sampling errors and/or variance are being captured.

10.7 Reporting

Results of the monitoring programs may be evaluated, to:

- assess environmental conditions
- confirm whether Plan objectives are being met
- identify and help define the need for adaptive management actions
- refine planning tools used in the development of the Plan (e.g., the Elk Valley Water Quality Planning Model and selenium bioaccumulation model).

This information will be summarized in two reporting formats: 1) an annual water quality report; and 2) a three-year Plan report that corresponds to the reporting cycle for the aquatic effects monitoring program (Chapter 11). The RAEMP report will form a part of the three-year Plan report as per details in Section 10.2.8. Summary reports and associated data collected under ecosystem monitoring programs will be provided to MOE and the Ktunaxa Nation Council, and made available to public on the Plan website (www.teckelkvalley.com).

Chapter 11
Adaptive Management

Chapter Overview

This chapter describes the adaptive management framework for the Elk Valley Water Quality Plan (the Plan) and outlines the tiered decision-making framework for adaptively managing the Plan during implementation.

Concordance with Ministerial Order and Terms of Reference

Chapter 11 is the primary chapter that satisfies Section 3.16 of the Elk Valley Water Quality Plan Terms of Reference, and combined with other chapters satisfies Sections B.15 and B.16 and Section D of Schedule C of Ministerial Order M113 and sections 3.9(a), 3.12, 3.13, 3.14, 3.15, 3.16 and 4.2.2 of the Elk Valley Water Quality Plan Terms of Reference.

Highlights

- **Teck will be responsive to monitoring data and supporting studies, applied R&D and changing circumstances, and will update the Plan as required to meet water-quality and calcite targets and environmental management objectives.** Adaptive management is a systematic process for reviewing the Plan to ensure that objectives are being met, to adjust management actions as required to achieve its targets, and/or to review and adjust targets when appropriate. Monitoring of water quality, ecosystem health, periphyton, and groundwater and other supporting studies will enable modifications to take new information and changing circumstances into account.
- **Teck will also update the initial implementation plan based on R&D advances, development of mine plans, and reviews of other relevant management plans.** R&D may lead to the incorporation of new technologies and management approaches. Mine reclamation and closure plans, and changes to mine plans, will be incorporated into the Plan. Development of new mines in the Elk Valley will require re-examination of the Plan.

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11.1 Introduction

The Order (Schedule C, Section A) specifies that to remediate water-quality effects of past activities, the Plan will describe the following operational actions to be taken by Teck:

- Immediately begin to stabilize concentrations of selenium, cadmium, nitrate, and sulphate, and the rate of formation of calcite in the waters of the Designated Area (see Chapter 8; initial implementation plan).
- In the medium-term, reduce the rate of formation of calcite, and set targets to demonstrate progressive reduction in water quality concentrations of selenium, cadmium, nitrate and sulphate in the Designated Area (see Chapter 7; calcite management plan).
- In the longer term:
  - Further reduce concentrations of selenium, cadmium, nitrate and sulphate in the Designated Area to acceptable contaminant levels, as defined by long-term concentration targets and timeframes (see Chapter 8; initial implementation plan).
  - Control the rate of calcite formation to acceptable levels as defined by long-term targets and timeframes (see Chapter 7; calcite management plan).

The environmental management objectives of the Plan specified in the Order (Schedule C, Section B, 7) include:

- protection of aquatic ecosystem health
- management of bioaccumulation of contaminants in the receiving environment
- protection of human health
- protection of groundwater.

The targets and timeframes for water quality and calcite management were developed taking the following Order requirements (Schedule C, Section B, 10) into consideration:

- current contaminant concentrations
- current and emerging economically achievable treatment technologies
- sustainable balancing of environmental, economic and social costs and benefits
- current and emerging science regarding the fate and effects of contaminants.

The approach in the Plan reflects Teck's current understanding of how best to manage water quality and calcite, and the targets established pursuant of the Order. Many factors will change over time, and will require adaptive management. The over-arching objective of adaptive management is to provide a structured but flexible process for evaluating and , when required, adjusting the Plan, in response to new information and changing circumstances, to allow the goals and environmental management objectives of the Plan to be achieved as circumstances change.

Adaptive management will address the following more specific objectives:

- Incorporate the results of monitoring the aquatic environment in the Designated Area, relative to meeting the environmental management objectives of the Plan.
- Use the results of supporting studies that are developed to validate and inform the Plan and to address specific uncertainties (e.g., selenium bioaccumulation model).
- Incorporate new mitigation measures developed by Teck's R&D program, to improve the long-term sustainability of the initial implementation plan and calcite management plan by enhancing cost-effectiveness, long-term operation and maintenance, and environmental performance.

- Take reclamation and closure issues into account in future updates of the initial implementation plan and calcite management plan, as reclamation research and monitoring address uncertainties and provide quantitative measures of how reclamation practices and plans at Teck operations influence water quality and calcite[1].
- Manage changes in resource evaluation and mine plans, and update the Plan accordingly.
- Update the planning tools used during implementation, including the Elk Valley Water Quality Planning Model (the Model), selenium bioaccumulation models, and site-specific hydrologic and water balance models that support detailed design of mitigation measures.
- Review and, if required, update water-quality and calcite targets and timeframes to reflect results of aquatic effects monitoring and advances in science (e.g., literature publications).
- Re-evaluate the sustainable balancing of environmental, economic and social costs and benefits to reflect any changes to future mine plans by Teck or proposed development of new mines by other proponents. Depending on the circumstances, adaptive management could lead to lower or higher long-term target levels, and shorter or longer implementation timeframes.

The overall adaptive management process is illustrated in Figure 11-1. Each adaptive management component incorporates periodic evaluation and reporting, and identifies trigger points that determine if additional root-cause analysis is required to determine whether the plan must be adapted. This process is described in Sections 11.2 through 11.7. As Teck gains experience and knowledge during implementation, the adaptive management components will themselves evolve. Teck will also coordinate Plan implementation with other relevant management plans, as discussed in Section 11.8. Plan evaluation and reporting is described in Section 11.9 and public reporting is described in Section 11.10. Adaptive management for calcite is presented in Chapter 7.

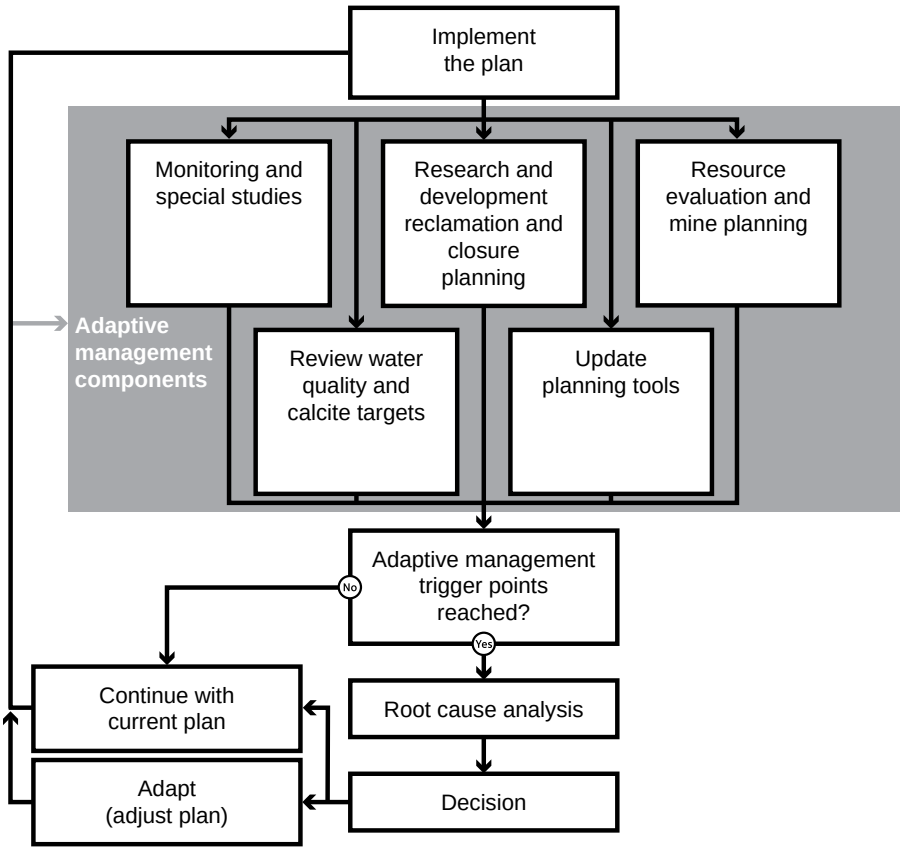


Figure 11-1. Adaptive management decision framework.

[1] The influence of reclamation activities and closure planning is not presently included in the water quality predictions for the initial implementation plan. This conservative measure was taken to account for the current uncertainty in the effectiveness of reclamation to reduce infiltration.

11.2 Monitoring and Supporting Studies

Environmental monitoring, as outlined in Chapter 10, will be used to evaluate whether Plan objectives are being met. The main components that will contribute to adaptive management are:

- water quality monitoring at Order stations
- regional aquatic effects monitoring
- groundwater monitoring
- human health assessment.

These monitoring components will provide a direct means of evaluating:

- aquatic ecosystem health
- bioaccumulation of constituents
- the potential for eutrophication
- the protectiveness of long-term targets (through sublethal toxicity testing)
- the protection of groundwater and human health.

Supporting studies were incorporated into monitoring programs to address uncertainties that require further evaluation. Additional supporting studies may be identified and completed during Plan implementation. Together, data from monitoring and supporting studies will facilitate assessment of whether the Plan is achieving its environmental management objectives.

11.2.1 Water-Quality Assessment

The primary effect pathway is associated with release of selenium, nitrate, sulphate and cadmium (Order constituents) from mine sources and advective transport in water. Water-quality monitoring data at Order stations will be collected monthly and assessed annually to determine if concentrations, loadings and trends of constituents are consistent with predictions and remain on track to meet water-quality targets and timeframes. Additional adaptive management triggers will be developed for monitoring locations located closer to source areas in mainstem river and tributary locations, including any monitoring locations specified in effluent permits issued under the B.C. Environmental Management Act.

The evaluation will include updated model predictions that incorporate any model refinements, changes to mine plans, and adjustments to the initial implementation plan. The primary triggers for annual water quality assessments will be:

- Did any measured constituent concentrations for the year fall outside of the envelope of predicted future concentrations?
- Is the temporal trend of Order constituent concentrations and loadings different from model predictions?

The full evaluation methodology will be provided in the first annual water-quality and calcite update report (see Section 11.9) . This will include evaluation of the quantitative thresholds for the difference between measured and predicted trends that would trigger the need for root-cause analysis. The methodology and triggers will be reviewed as part of each annual report, and updated as appropriate.

The evaluation will account for variability in flows, spatially and temporally, and how this may affect constituent concentration trends. One way to accomplish this is to compare measured concentrations, using actual flows, to modelled results. A 12-month rolling average can be used for selenium and nitrate, because their trajectories will change with implementation of mitigation measures. Seasonal variations, including high and low flow conditions will be considered as part of the data evaluation.

Statistical trend analysis will be used to assess sulphate and cadmium, because no mitigation is planned for these constituents. Trends will be evaluated to assess the potential for future concentrations to exceed their targets. Historical trends for cadmium are inconsistent, and future concentrations are expected to have a negligible potential to exceed long-term target levels at any Order stations. Work is continuing on developing a predictive model for cadmium, which will be incorporated into the annual evaluation if it can be modelled with sufficient resolution to be used as a planning tool.

Sulphate concentrations are projected to remain below long-term targets indefinitely at all Order stations, with the possible exception of FR4 in the upper Fording River (MU-1), where concentrations could reach long-term targets by 2030. However, the model predictions are conservatively high, and will be compared with a statistical trends analysis to evaluate this risk. A toxicity testing program will also be developed and implemented to validate and, if appropriate, revise the long-term target. If sulphate concentrations remain on a trend to reach the long-term target at FR4, this will require re-evaluation of the treatment technologies or other mitigation measures to control sulphate, and of the water-quality targets and timelines.

If one or more water quality triggers are reached, then a more detailed root-cause analysis will be undertaken. Specific investigations that could be considered in a root-cause analysis include:

- a review of mitigation measures to determine whether underperformance contributed to triggers being reached
- a mass-balance evaluation of constituent concentrations, flows and loadings to identify source areas that contributed to triggers being reached
- a review of the Model, including the hydrology inputs, geochemical source-terms and model assumptions, to determine if refinements to the Model are required.

The root-cause analysis will identify need for adaptive management actions that could include one or more of the following:

- further investigations or more frequent evaluation, if the cause is not sufficiently well- understood to make a management decision
- adjustment of triggers, targets or timeframes
- improving performance of existing mitigation projects
- increasing or decreasing the level of future mitigation
- revising the scope or frequency of monitoring programs
- continued monitoring, and re-evaluation after the next cycle.

Variations in expected concentrations may result in conditions better or worse than expected. Because of the high level of year-to-year and seasonal variability of the hydrology in high elevations areas like the Elk Valley, decisions to increase or decrease the level of future mitigation would typically require several years of data, to distinguish between natural variability and a variance from expected performance. If potential variances from expected performance are identified, additional analysis and follow-up work will be undertaken to identify the root cause and to implement the actions needed to meet short-, medium- and long-term water-quality targets and timeframes, or to assess appropriate adjustments to those targets and timeframes.

The general decision process for the assessment of water quality at Order stations is shown in Figure 11-2.

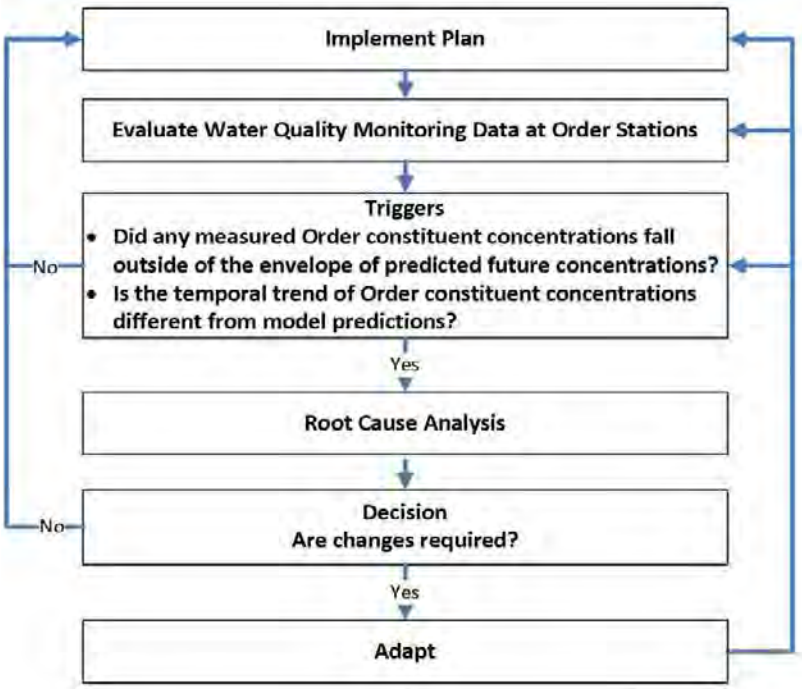


Figure 11-2. Order stations water quality decision framework.

11.2.2 Regional Aquatic Effects Monitoring

As described in Chapter 10, the regional aquatic effects monitoring program (RAEMP) will measure and integrate multiple types of data to assess the health of the aquatic ecosystem throughout the Designated Area. The RAEMP provides an integrated assessment of pathways for release, transport and fate of Order constituents in water, sediment and biota, as well as the combined effects of all stressors on sensitive biota. RAEMP components that will be used to adaptively manage the Plan for selenium, nitrate, sulphate, cadmium and calcite include:

- monitoring of the integrated effects of Order constituents on water, sediment and biota
- monitoring of nutrient levels in water and periphyton in the Elk Valley, and phosphorus and chlorophyll-a concentrations in Lake Koocanusa, to evaluate primary productivity
- an ecotoxicology supporting study to assess protection of the aquatic life, address uncertainties and, if required, update long-term water-quality targets.

11.2.2.1 Integrated Aquatic Effects Monitoring

The RAEMP will use a three-year integrated evaluation and reporting cycle for all components. The second cycle of regional aquatic effects monitoring is 2013 to 2016, with an interpretative report in 2017. Adaptive management triggers related to monitoring will be developed and evaluated in a three-year Plan report, which will be developed in parallel with the second cycle of the RAEMP interpretive report (see Section 11.9). The RAEMP assessment and measurement endpoints that will be used to develop and evaluate adaptive management triggers for the Plan are listed in Table 11-1.

Table 11-1. Monitoring endpoints and adaptive management triggers.

Stressor Category	Mine-Related Stressor	Dominant Pathway	Assessment Endpoint	Measurement Endpoint	Elk River Watershed	Lake Koocanusa	Basis for Adaptive Management Triggers
Chemical	Selenium	Dietary accumulation	Toxicity[1]	Water chemistry	✓	✓	Water-tissue relationships described in site-specific bioaccumulation models.
				Tissue selenium concentrations	✓	✓	Tissue guidelines and benchmarks.
	Selenium, nitrate, sulphate, cadmium (and potentially others)	Water contact and/or uptake	Toxicity[1]	Water chemistry	✓	✓	Short-, medium-, and long-term targets at Order stations. Mainstem and tributary concentrations and trends at additional monitoring stations closer to source areas. Water quality concentrations and compliance limits specified in EMA permits.
				Surface water toxicity tests	✓		Toxicity response.
		Sediment contact and/or uptake	Toxicity[1]	Sediment chemistry	✓	✓	Sediment quailty guidelines, benchmarks, reference concentrations.
				Sediment toxicity tests	✓		Toxicity response.
		Multiple	Community Structure	Benthic invertebrate EPT and E proportions	✓		Reduction relative to reference conditions and in mine-influenced monitoring areas over time.
			Population	Westslope cutthroat trout and longnose sucker population characteristics	✓		Changes in populations over time.
	Nutrients (Phosphorus and Nitrogen)	Water contact and/or uptake	Eutrophication	Water nutrient concentrations	✓	✓	Guidelines, benchmarks, targets, reference conditions, changes over time.
				Periphyton chlorophyll-a and biomass	✓		
				Water column chlorophyll-a		✓	
Physical	Calcite	Substrate characteristics	Community structure	Calcite index (presence and concretion)	✓		Initial trigger levels based on concretion scores. Combined calcite and benthic invertebrate monitoring will be undertaken as a supporting study in 2015 to update target and adaptive management trigger levels to account for calcite effects to EPT and E proportions and periphyton biomass (see Chapter 7).

Notes: [1] Assessing survival, growth and/or reproduction.

Adaptive management triggers will incorporate:

- water quality guidelines (WQGs), benchmarks and targets for selenium, nitrate, sulphate and cadmium
- effects to benthic invertebrate community structure
- B.C. WQGs for nutrients and algae, including periphyton chlorophyll-a guidelines for streams and total phosphorus concentrations in water for lakes
- selenium tissue guidelines and site-specific benchmarks for the protection of aquatic life
- sediment quality guidelines for selenium and cadmium
- calcite targets, based on an evaluation of effects of calcite on benthic invertebrates, periphyton and physical and chemical measures of stream-bed habitat
- status of juvenile and adult WCT in the upper Fording River.

Monitoring of selenium in water and tissue will also be used to validate and update the selenium bioaccumulation models discussed in Section 11.6. Adaptive management triggers, associated root-cause analyses and potential adaptive management actions will be fully developed as part the first cycle of the three-year Plan reporting (see Section 11.9).

If one or more triggers are reached, a more detailed root-cause analysis will be undertaken. For example, if monitoring identified a greater effect on benthic invertebrate community structure at locations where conditions were expected to be stable or improving, this could trigger a root-cause analysis. The analysis could include a supporting study to re-sample areas to check whether the differences detected from monitoring are anomalous or real.

11.2.2.2 Primary Productivity Monitoring

The trophic state describes the general biological status of surface waters. Surface waterbodies with an oligotrophic trophic state have low algal concentrations (i.e., low primary productivity), whereas eutrophic systems will have higher algal concentrations. The trophic state of surface waters is influenced by nutrient inputs and other factors (e.g., temperature, turbidity, shading) Phosphorus is the focus of adaptive management of primary productivity, because it is and will remain the limiting nutrient in Designated Area, and release of phosphorus from AWTFs is the primary mine-effect pathway.

As described in Chapter 10, periphyton and nutrients will be monitored within the Elk Valley (MUs 1-5), and nutrients and chlorophyll-a will be monitored in Lake Koocanusa (MU-6), to evaluate changes in primary productivity. As outlined in Chapter 6, the use of biological AWTFs to treat selenium and nitrate-enriched waters is expected to increase total phosphorus concentrations in surface waters. Monitoring will therefore assist in evaluating the potential for unacceptable increases in primary production, and guide adaptive management related to phosphorus to meet the environmental management objectives.

The B.C. WQGs for nutrients and algae (Nordin 2001) will be adopted as an interim adaptive management trigger for primary productivity of streams in the Elk Valley. The B.C. guideline for streams is based on algal chlorophyll-a rather than water nutrient concentrations, because the effects of nutrients cannot be reliably predicted relative to other conditions that affect primary productivity in streams (e.g., water velocity, light intensity, water temperature, and invertebrate grazing pressure. The periphyton guideline for recreational and aesthetic purposes is 50 mg/m^2 chlorophyll-a, and the guideline for the protection of aquatic life of 100 mg/m^2 chlorophyll-a.

Algal monitoring and recent analysis in Lake Koocanusa is relatively limited, and further monitoring is required to establish primary productivity triggers. Woods 1982 evaluated limnological data for Lake Koocanusa from 1972-1980, and concluded that although Lake Koocanusa was eutrophic based on nutrient loadings, its water quality and primary productivity data classify it as oligotrophic. A B.C. MOE study that examined primary

productivity in Lake Koocanusa from 1972 to 1990 reached a similar conclusion, noting that that factors regulating the trophic state likely include a combination of physical and nutrient conditions (Hamilton et al. 1990). Paragamian 2002 concluded that Lake Koocanusa acts as a nutrient sink. These studies illustrate the complexity of the factors controlling primary productivity in Lake Koocanusa.

Teck will monitor nutrients and chlorophyll-a in Lake Koocanusa, and nutrient inputs from the Elk River, to evaluate whether primary productivity triggers related to nutrient inputs from the Elk River can be established. The Canadian guidance document for management of phosphorus in freshwater water systems (CCME 2004) provides a framework that will be considered when evaluating primary productivity in Lake Koocanusa.

A root-cause analysis, described above,will be undertaken if periphyton chlorophyll-a concentrations at any Order station in MU-1 to 5 are expected to exceed the periphyton WQG for recreational and aesthetic purposes of 50 mg/m2. Nutrient and chlorophyll-a monitoring data in Lake Koocanusa will be evaluated as part of the RAEMP.

Teck is also updating the Model to provide improved resolution for predicting future increases in total phosphorus concentrations in the Elk and Fording rivers. The model will be used to assist with adaptive management of phosphorus.

11.2.2.3 Ecotoxicology Assessment

During development of the Plan, sublethal toxicity tests using ambient waters were completed and used to assess baseline water-quality conditions (Chapter 4), and to set long-term targets (Chapter 8). The tests did not capture the full range of Order constituent concentrations in the Elk and Fording rivers (e.g., under low- and high-flow conditions), nor specific long-term tests recommended by the TAC.

A sublethal toxicity testing supporting study will be undertaken during Plan implementation (see Chapter 10) to confirm that surface waters that meet water-quality benchmarks for Order constituents are not toxic to sensitive aquatic receptors. The adaptive management trigger would be an EC_{20} sublethal effect. Should ambient tests show no toxicity, this would indicate that conditions meet Plan objectives. If there is a sublethal effect, the tests will be repeated under similar conditions. If the second test(s) also show a sublethal effect, Teck will conduct a root-cause analysis (e.g., ongoing testing at the same location or toxicity identification evaluations) to guide the adaptive management decision-making process. Ambient sublethal toxicity tests will also be used to confirm and, if required, revise long-term targets (see Section 11.7). A study design for an ecotoxicology supporting study will be prepared by the end of the first quarter of 2015, for implementation beginning in the second half of 2015.

11.2.3 Protection of Groundwater

As described in Chapter 5, baseline groundwater concentrations are protective of human health. The initial groundwater evaluation identified two transport pathways for constituents of interest in groundwater: source release to upland groundwater (at the mine sites[2]), and surface water recharge from the Elk River to groundwater. As such, groundwater in the Elk River floodplain has a high degree of hydraulic connectivity to the Elk River, resulting in a greater potential for shallow groundwater to be influenced by the constituents. In particular, shallow groundwater in floodplain areas hydraulically down-gradient of a meander may receive a higher component of surface water recharge. Surface water recharge to groundwater also appears to be higher where river gradients are higher. These findings were validated by slightly elevated constituent concentrations in a limited number of groundwater wells within the Elk Valley.

To evaluate whether the implementation plan is protective of groundwater, well samples will continue to be

[2] Under existing EMA authorizations, individual mining operations are developing groundwater monitoring networks and programs to improve the understanding of groundwater at an operational (local) level. Results of these investigations will be used to help improve Teck's understanding of local groundwater in relation to potential mitigation scenarios.

collected. As described in Chapter 10, sampling will be conducted quarterly to account for seasonal variability. These data will be used to confirm that groundwater concentrations remain protective of human health. Well monitoring will continue until selenium concentrations stabilize in the Elk River watershed.

As part of existing EMA and Mines Act Permits, groundwater monitoring programs have been implemented or are in development for each of Teck's coal operations in the Elk Valley. The objective of programs is to better understand the influence of mine operations on groundwater and potential interactions with surface water. Results will be used to assess the potential influence of Teck operations on groundwater wells and support adaptive management of groundwater.

If concentrations in wells remain above drinking water guidelines for Order constituents, additional monitoring will be considered. The adaptive management trigger would be an increasing trend in groundwater well concentrations. Should the data indicate that concentrations are increasing, a root-cause analysis will be conducted to guide the adaptive management decision-making process. A root-cause analysis could, for example, include a supporting study to better understand groundwater-to-surface-water connections in a particular area.

11.2.4 Human Health Assessment

The human health assessment was completed for baseline conditions (see Chapter 5), and determined that present concentrations do not present unacceptable human health risks. . The assessment will be updated periodically. If a human-health risk related to Order constituents is identified, root-cause analyses could include further characterization and assessment of risks, or supporting studies to address uncertainties. Adaptive management actions could include:

- revising the human health assessment to reflect the results of root-cause analysis
- supporting studies to address uncertainties
- adapting the water quality implementation plan.

11.3 Research and Development

The focus of Teck's R&D is to investigate and implement more effective and efficient solutions for managing constituents of interest in mine-affected watersheds. Active water treatment technology R&D and source control R&D are the two components of this initiative, and guided the selection of the management options described in Chapter 6. As R&D continues, new technologies and management approaches may be used in adaptive management of the Plan implementation. As stated in Section 6.3.1, the steps for advancing technologies to a stage where they can be considered for full deployment are:

1. Identify basic knowledge and technology.
2. Identify sites for full-scale implementation.
3. Bound the risks.
4. Prioritize implementation technologies and sites.
5. Implement at full scale.
6. Monitor and improve first implementation.
7. Consider broader technology applications within mine plans.

The adaptive management trigger will be when new technologies reach step 7, and have been developed to the stage where they can be considered for broader application within existing mine development areas and for future mine plans. Instead of a root-cause analysis, the adaptive management trigger will result in a re-evaluation of the initial implementation plan or calcite management plan to include new technologies. Incorporation of new technologies will be evaluated in the context of sustainable balancing of environmental, economic and social costs and benefits, as contemplated in the Order.

11.4 Resource Evaluation and Future Mine Planning

Resource evaluation and mine planning is ongoing at all five of Teck's Elk Valley coal operations. The initial implementation plan incorporates the 2013 future mine plan. Mine plans will change in response to resource evaluations, economic conditions, and applied research and development.

Teck will undertake a periodic review and evaluation of changes in mine plans, and incorporate them into updates of the Plan and the Model. The Model will be used to compare future predictions for the water quality implementation plan against short-, medium- and long-term targets and timeframes. The initial implementation plan and calcite management plan will be updated periodically to reflect changes to mine plans when required to support future mine development permit applications.

11.5 Reclamation and Closure Plans

Reclamation and closure activities will change the topography, substrate characteristics and vegetation of the Elk Valley. Through reclamation research and monitoring, and applied R&D, Teck will acquire a better understanding of the hydrological and geochemical responses to reclamation and closure activities.

The influence of reclamation and closure is not addressed in the initial implementation plan or the calcite management plan, which is a conservative assumption that recognizes the uncertainty in the degree to which reclamation will reduce infiltration. This influence will be addressed in future updates of the initial implementation plan and calcite management plan, as reclamation research and monitoring address the uncertainties.

11.6 Updating Planning Tools

The planning tools used during implementation will be updated to incorporate monitoring data. These include the Model, selenium bioaccumulation models, and site-specific hydrological and water balance models that have been or will be developed to support design of mitigation measures.

The Model will be updated on a three-year cycle to incorporate new water-quality and flow information. These data will be used to validate the model calibration and update it if required. The Model will also incorporate improvements in geochemical source terms and hydrological inputs from Teck's applied R&D programs. As site-specific hydrological and water balance models are developed at Teck's operations, these will be incorporated into the Model.

As described in Chapter 10, the RAEMP will include monitoring of selenium concentrations in water, periphyton, benthic invertebrates and fish. The tissue monitoring program will include collection of data to validate, address uncertainties and update the selenium bioaccumulation models. The bioaccumulation models will be evaluated and updated on a three-year cycle as described in Section 11.9.

11.7 Review of Water Quality and Calcite Targets

Water-quality and calcite targets will be reviewed periodically in connection with the three-year Plan Report. These targets and timeframes will be reviewed periodically and updated, if required, to reflect results of monitoring and supporting studies, and advances in the scientific understanding of the effects of Order constituents or calcite on the environment.

Changes in mine development plans in the Elk Valley (including proposed new mines by proponents other than Teck), or changing economic conditions, could also necessitate reevaluation of the sustainable balancing of environmental, economic and social costs and benefits, and thereby result in revisions to targets and timeframes.

Results of the ambient sublethal toxicity testing supporting study will be evaluated to confirm and if necessary update the water-quality targets. The integrated water-quality effects assessment used to derive targets and assess effects at the MU scale will be updated and used as part of the ongoing assessment of effects to support of future mine development applications.

Results of the environmental monitoring program will be evaluated to validate, and if appropriate revise, long-term target concentrations. Environmental monitoring will also be used to validate and update the selenium bioaccumulation models and, if necessary, to revise long-term water-quality targets.

The calcite targets defined in Chapter 7 are interim values, and will be re-evaluated based on results of monitoring of effects of calcite on benthic invertebrates, periphyton and physical and chemical measures of stream-bed habitat.

11.8 Coordination with Other Management Plans

The Order requires that the Plan outline how it will be integrated or coordinated with other existing or proposed plans for the Designated Area.

11.8.1 Biodiversity Management Plan

Teck recognizes that its activities have the potential to affect biodiversity and alter ecosystems. It is therefore essential for it to operate in a manner that minimizes and mitigates impacts. Protecting and enhancing biodiversity is one of Teck's the six areas of sustainability focus, and it has set for itself the goal of achieving a net positive impact on biodiversity.

To achieve this goal, Teck is developing biodiversity management plans at each of its operations in the Elk Valley, following a 2013 pilot project at Line Creek Operations. Each plan starts with the collection, collation and analysis of information on operations, integrates the myriad of biodiversity information available, including baseline information. The plans will highlight and quantify biodiversity values that may experience residual risks or impacts from Teck operations after mitigation efforts on site. Biodiversity management plans will inform Teck's offsetting needs. Anticipating its offsetting needs, Teck has already undertaken additional off-site conservation efforts by purchasing approximately 7,500 ha of land in the Elk Valley and the Flathead River Valley preserving key wildlife and fish habitat for generations to come.

Biodiversity management plans will support the continuation of sustainable mining in the Elk Valley. Teck will manage coordination of biodiversity management plans with the Plan internally.

11.8.2 Regional Fish Habitat Management Plan

Teck is developing a regional fish habitat management plan in the Elk Valley to provide a regional framework for assessing effects on fish habitat and developing habitat offsetting options. These measures are required under the federal Fisheries Act. Teck intends to use the regional fish habitat management plan to develop a bank of habitat offset projects to support requirements for future project applications.

Teck will manage coordination of the regional fish habitat management plan and the Plan internally.

11.8.3 Cumulative Effects Management Framework

Teck and the Ktunaxa Nation Council are collaborating on a pilot program to develop a cumulative effects management framework for the Elk Valley. Responsibility for this project is being transferred to the B.C government, and is in the early stages of development. As a result, it is uncertain how it will be considered during Plan implementation.

11.8.4 East Kootenay-Koocanusa Fish and Wildlife Program

The East Kootenay-Koocanusa Fish and Wildlife Program is a joint initiative of the Columbia Basin Trust and the Fish and Wildlife Compensation Program. The program was launched in 2013 with a $3 million commitment from the Columbia Basin Trust to help conserve, restore, enhance, and support sustainable use of fish, wildlife and their critical habitats in and around the Koocanusa Reservoir and tributaries in the Upper Kootenay River watershed.

Teck participated in the working group to develop the program's action plan, and will continue to participate in working groups, providing updates on the Plan and receiving updates from the East Kootenay-Koocanusa Fish and Wildlife Program.

11.8.5 Other Management Plans

Other proponents of proposed mining projects in the Elk Valley may put forward separate plans to manage potential future impacts of their activities. The Plan will be examined in light of these other plans, to confirm that its targets and timeframes for implementation remain appropriate.

11.9 Elk Valley Water Quality Plan Evaluation and Reporting

There will be two adaptive management evaluation and Plan reporting cycles: 1) an annual water quality and calcite update; and 2) a three-year Plan report that corresponds to the reporting cycle for aquatic effects monitoring (see Chapter 10). The reports will include evaluation against relevant management triggers and any associated root-cause analyses and adaptive management outcomes. Adaptive management triggers, associated root-cause analyses and potential adaptive management actions described in earlier sections of the chapter will be fully developed as part the first cycle of Plan reporting.

The annual water quality and calcite report will provide an update of monitoring and management activities for the previous year and progress towards meeting water quality and calcite targets and timelines. The first annual adaptive management update report will be prepared in 2016 for monitoring and management activities completed to the end of 2015. The anticipated scope of the annual water quality and calcite update includes:

- an update of water quality and calcite mitigation measures for the previous year
- water quality monitoring and modelling results for Order stations, any compliance locations that may be specified in effluent permits and other monitoring locations for which adaptive management triggers are defined

- water quality monitoring associated with implementation of AWTFs and other water quality mitigation measures implemented as part of the Plan
- annual primary productivity monitoring
- results of any annual updates to the assessment of human health and groundwater
- results of any supporting studies completed.

A three-year Plan report will be completed on cycle that corresponds to the aquatic effects monitoring. The first reporting cycle will be 2017. The anticipated scope of the three-year adaptive management report includes:

- evaluation of all environmental effects monitoring data, including water quality, calcite formation, primary productivity and biological monitoring
- an update on the results of the applied R&D program, and reclamation and closure planning activities related to water quality or calcite management
- an update of the initial implementation plan for water quality, including any revisions to future mine plans, and adaptive management adjustments to the implementation plan, and water quality targets or timeframes
- an update on implementation of the calcite management plan, including any adaptive management adjustments to the plan and calcite targets or timeframes
- evaluation of progress towards meeting water quality and calcite targets and timeframes
- evaluations of human health and groundwater
- updates to the water quality planning model and selenium bioaccumulation models
- results of any supporting studies
- an update on coordination with other environmental management plans.

The Plan reports will support environmental assessments, and permit applications for mine development projects, as well as permit applications for water quality and calcite mitigation projects included in the Plan. It is also anticipated that the Plan reports can be structured to meet permit reporting requirements related to water quality and calcite management that fall within the scope of the Plan.

Teck anticipates that Plan approval will include formation an advisory group to continue to provide science-based advice to Teck during Plan implementation. The timing of advisory group meetings could include annual meetings for the first five years of Plan implementation, and every three-years thereafter following the three-year Plan reporting cycle. Teck will continue to coordinate with the Montana Department of Environmental Quality on the collection and assessment of monitoring data in Lake Koocanusa during Plan implementation.

11.10 Public Reporting Requirements

During implementation of the Plan, Teck will report on progress through a public website, bilateral meetings with key groups, and community meetings.

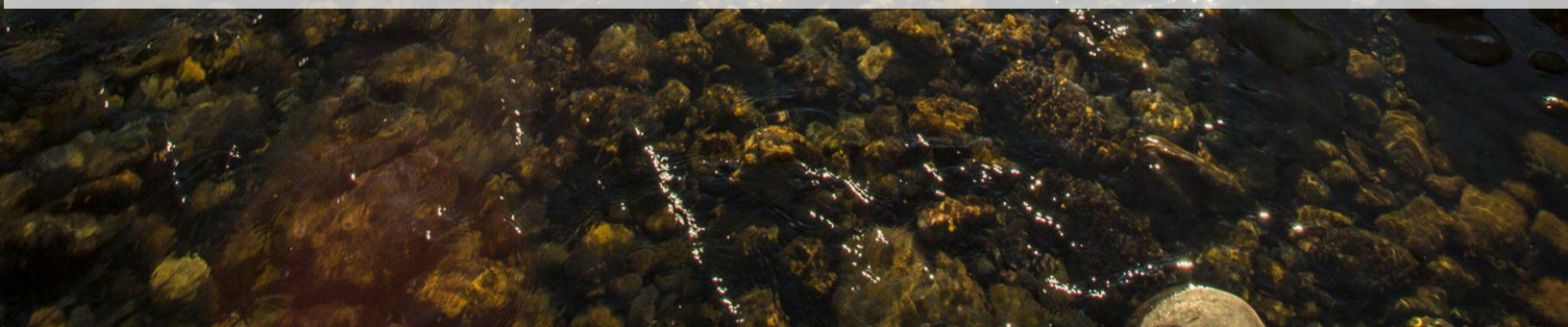
- The website will provide information on the Plan, including annual updates, and will include an online feedback form and contact information for submissions through mail, email or fax.
- Teck will hold bilateral meetings with key groups, and meetings in Elkford, Sparwood and Fernie to provide information. Initially, these meetings will be held annually. At the initial meetings Teck will solicit feedback on the frequency of consultation requested by the public, and adjust the meetings' frequency accordingly.
- It is anticipated that bilateral meetings with key groups and in the communities will be held at least every three years, in the year following each cycle of biological monitoring.

Inputs received from consultation will be considered as part of adaptive management of the Plan.



Elk Valley Water Quality Plan
2019 Implementation Plan Adjustment - Summary

February 2019



In April 2013, the British Columbia (B.C.) Minister of Environment issued Ministerial Order No. M113 (Order), which required Teck to prepare an area-based management plan for the Elk River watershed and the Canadian portion of the Koocanusa Reservoir. In this plan, Teck was required to identify the water quality mitigation, for existing plus planned (to end of 2037) waste rock, that is required to stabilize and reduce concentrations of nitrate, selenium, sulphate, and cadmium and the formation of calcite downstream, its five mines.

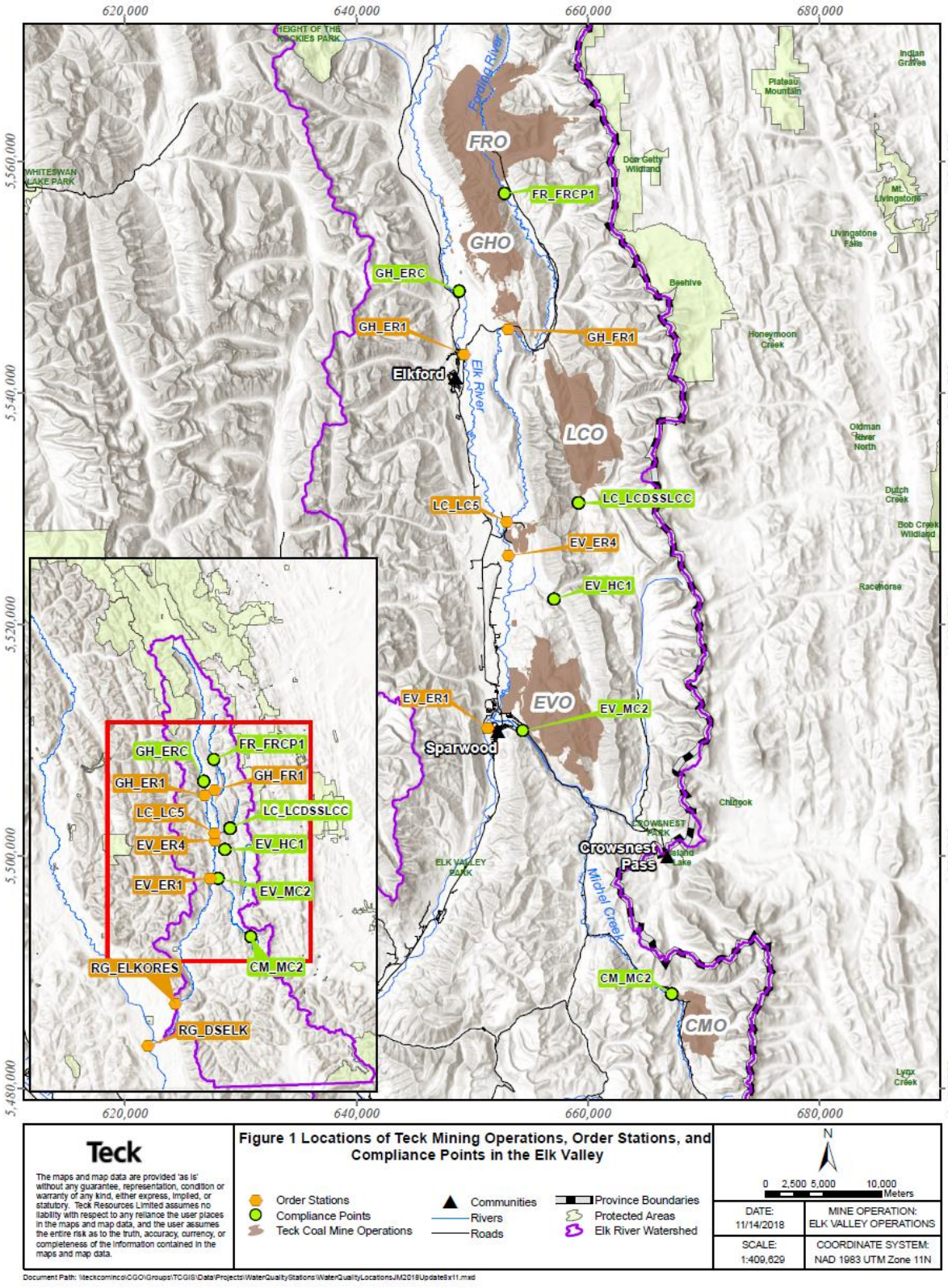
From 2013 to 2014, Teck developed an area-based management plan, called the Elk Valley Water Quality Plan. Teck had input from the public, First Nations, provincial and federal governments, technical experts, and other Communities of Interest. Teck submitted the Elk Valley Water Quality Plan to the Minister in July 2014 and it was approved in November that same year. The Elk Valley Water Quality Plan, or EVWQP, includes an Initial Implementation Plan (IIP) that outlines the mitigation planned to achieve targets for the concentration of selenium, sulphate, nitrate, and cadmium in surface water at specific locations throughout the Elk Valley and in the Koocanusa Reservoir. These targets, both short-term and long-term, are meant to stabilize and reverse increasing concentrations of the four constituents named in the Order. Active Water Treatment Facilities (AWTFs) and clean water diversions were identified in the EVWQP as mitigation tools to achieve this.

In November 2014, the B.C. Ministry of Environment issued Permit 107517 to Teck under the *Environmental Management Act*. Many of the actions and commitments that Teck made in the EVWQP IIP were incorporated into the permit requirements. To maintain compliance, Teck must meet the requirements in the Permit, including the construction and operation of AWTFs on the timelines specified and achievement of water quality targets.

Compliance Limits and Site Performance Objectives under Permit 107517 are collectively referred to as water quality targets in this document. Compliance Limits are set for compliance points. Compliance points are water monitoring stations that are downstream from each of Teck's mine operations in the Elk Valley. These points are intended to be at the point where all or most of the point and non-point discharges from a mine site or portions of a mine site are expected to report. There are eight compliance points that have limits for selenium, sulphate, nitrate, and cadmium (Figure 1; the compliance point shown as LC_WTF_OUT is for the West Line Creek AWTF effluent discharge point).

Site Performance Objectives, or SPOs are set for Order Stations. These stations are also water monitoring stations, but these are further downstream from Teck's mining operations. They are intended to reflect fully mixed conditions, taking into account water from all upstream sources. There are seven Order Stations which have SPOs for selenium, sulphate, nitrate, and cadmium. SPOs are based on the targets from the integrated effects assessment completed for the EVWQP, whereas the Compliance Limits listed in Permit 107517 were based on the 2014 Regional Water Quality Model (RWQM) projected water quality conditions under the IIP. The locations of the Order Stations and compliance points are illustrated on Figure 1.

Mines Act C-Permits require adjustments to the IIP, based on an adaptive management approach, by July 31, 2019 and every three years thereafter. Permit 107517 and Mines Act C-Permits required the RWQM be updated by October 31, 2017.The October 2017 RWQM update showed that the projected concentrations were above limits and SPOs, resulting in the need to update the mitigation plan (IIP).


620,000
640,000
660,000
680,000
5,560,000
5,540,000
5,520,000
5,500,000
5,480,000
HEIGHT OF THE ROCKIES PARK
WHITESWAN LAKE PARK
Elk River
Fording River
FRO
FR_FRCP1
GHO
GH_ERC
GH_ER1
GH_FR1
Elkford
LCO
LC_LC5
LC_LCDSSLCC
EV_ER4
EV_HC1
EV_ER1
EVO
EV_MC2
Sparwood
CM_MC2
CMO
RG_ELKORES
RG_DSELK
Crowsnest Pass
Michel Creek
ELK VALLEY PARK
CROWSNEST PARK
Indian Graves
Plateau Mountain
Don Getty Wildland
Mt. Livingstone
Livingstone Falls
Beehive
Honeymoon Creek
Oldman River North
Dutch Creek
Bob Creek Wildland
Racehorse
Chinook
Lynx Creek
Teck
The maps and map data are provided 'as is' without any guarantee, representation, condition or warranty of any kind, either express, implied, or statutory. Teck Resources Limited assumes no liability with respect to any reliance the user places in the maps and map data, and the user assumes the entire risk as to the truth, accuracy, currency, or completeness of the information contained in the maps and map data.
Figure 1 Locations of Teck Mining Operations, Order Stations, and Compliance Points in the Elk Valley
Order Stations
Compliance Points
Teck Coal Mine Operations
Communities
Rivers
Roads
Province Boundaries
Protected Areas
Elk River Watershed
N
0 2,500 5,000 10,000
Meters
DATE: 11/14/2018
MINE OPERATION: ELK VALLEY OPERATIONS
SCALE: 1:409,629
COORDINATE SYSTEM: NAD 1983 UTM Zone 11N
Document Path: \\teckcominco\CGO\Groups\TCGIS\Data\Projects\WaterQualityStations\WaterQualityLocationsJM2018Update8x11.mxd

Key Adjustments to the IIP Reflected in the 2019 IPA

The 2019 Implementation Plan Adjustment (2019 IPA) is a revised implementation plan developed to achieve the SPOs and Compliance Limits included in the EVWQP and Permit 107517.

Teck completed the 2019 IPA and provided opportunity for the B.C. Ministry of Energy, Mines and Petroleum Resources (EMPR), B.C. Ministry of Environment and Climate Change Strategy (ENV), and representatives of the Ktunaxa Nation Council (KNC) to provide input. Seven review meetings were held with EMPR, ENV and the KNC to review information and gather feedback for integration into the plan. Outreach to other Communities of Interest also occurred.

On August 31, 2018, Teck submitted the 2019 IPA to the provincial government and the KNC for their technical review. Teck will revise the 2019 IPA to incorporate feedback received through the technical review as well as through further outreach with other Communities of Interest. Once final, the 2019 IPA will be posted at www.teck.com/elkvalley.

The primary differences between the IIP and the 2019 IPA are summarized as follows:

- the timing of treatment
- total treatment capacity, and
- the period over which treatment was assessed (extended from a 20-year planning window to mitigate the estimated water quality effects of Teck's permitted development).

Timing of Water Treatment in the Valley and Locations

The IIP included the construction and operation of six AWTFs by 2032, with a total treatment capacity of 130,000 cubic metres per day (m^3/d). The 2019 IPA, informed by the 2017 RWQM[1], includes the construction of the original six AWTFs included in the IIP plus seven additional facilities and associated water management with a total treatment capacity of 204,600 m^3/d over the extended timeframe (see Table 1). Clean water diversions included in the 2019 IPA are shown in Table 2. Mitigation in the 2019 IPA is intended to stabilize and reduce concentrations of nitrate, selenium, and sulphate for Teck's permitted development as well as for planned development over the next 20 years. Removal of cadmium is not currently required to meet long-term water quality limits. The sequence of water treatment is also shown on Figure 2 for the Koocanusa Reservoir at the Order Station (RG_DSELK). In parallel to executing active water treatment, Teck continues to advance alternative water treatment technologies (including Saturated Rock Fills) which could replace AWTFs in future adjustments to the implementation plan.

[1] Following submission of the 2017 RWQM, changes were made to the model based on regulatory feedback, to improve model performance, and to some mining related inputs. These changes are documented in the IPA.

Table 1 Treatment Capacity and Timing Comparison between the 2019 Implementation Plan Adjustment and the Initial Implementation Plan

Modelled Active Water Treatment Facility (1)	2019 Implementation Plan Adjustment		Initial Implementation Plan	
	Date Fully Effective (2)	Hydraulic Capacity (m^3/d)	Date Fully Effective	Hydraulic Capacity (m^3/d)
West Line Creek (WLC) Phase I	December 31, 2018	6,000	June 30, 2014	7,500
WLC Phase II	December 31, 2019	1,100	-	-
Fording River Operation (FRO) AWTF-S Phase I	December 31, 2021	20,000	December 31, 2019	20,000
Elkview Operation (EVO) Phase I	September 30, 2022	20,000	December 31, 2021	30,000
FRO-N Phase I	December 31, 2023	30,000	December 31, 2023	15,000
WLC Phase III	December 31, 2025	12,500	-	-
EVO Phase II	December 31, 2027	20,000	December 31, 2025	20,000
FRO-S Phase II	December 31, 2029	5,000	-	-
Greenhills Operation (GHO) Phase I	December 31, 2031	2,500	December 31, 2027	7,500
WLC Phase IV	December 31, 2033	32,500	January 1, 2032	7,500
FRO-S Phase III	December 31, 2035	20,000	-	-
Line Creek Operation (LCO) Dry Creek Phase I	December 31, 2037	2,500	January 1, 2028	7,500
FRO-N Phase II	December 31, 2039	20,000	December 31, 2031	15,000
EVO Phase III	December 31, 2043	5,000	-	-
LCO Dry Creek Phase II	December 31, 2049	2,500	-	-
GHO Phase II	2100+	5,000	-	-
Total Hydraulic Capacity (m^3/d)		**204,600**		**130,000**

(1) Clean water diversions associated with the 2019 IPA include the diversion of Upper Kilmarnock watershed at FRO and diversion of Upper Line Creek, Horseshoe Creek and No Name Creek at LCO.

(2) The fully effective date is the date when the treatment facility has been built, seeded, commissioned and is effective at the hydraulic capacity listed above

Table 2 Clean Water Diversion Capacity and Timing Comparison between the 2019 Implementation Plan Adjustment and the Initial Implementation Plan

Clean-Water Diversion	Associated Active Water Treatment Facility	Initial Implementation Plan		2019 IPA	
		Streams and Volume Diverted	Date Operational	Streams and Volume Diverted	Date Operational
Kilmarnock Creek	FRO AWTF-S	Upper Brownie and Kilmarnock watersheds, estimated at 45,000 m^3/d	December 31, 2018	Upper Kilmarnock Watershed, estimated up to 45,000 m^3/d[a]	December 31, 2020[a]
Erickson Creek	EVO AWTF 1	Upper Erickson Watershed, estimated at 14,000 m^3/d	December 31, 2020	Not included	
South Gate Creek	EVO AWTF 1	South Gate Creek, estimated at 3,500 m^3/d	December 31, 2020	South Gate Creek, estimated at 3,500 m^3/d	In place and operating.
Upper Line Creek, Horseshoe and No Name Creeks	WLC AWTF 2	Upper Line Creek and Horseshoe Creek, estimated at 35,000 m^3/d and No Name Creek, estimated at 7,000 m^3/d	2032	Upper Line Creek and Horseshoe Creek estimated at 35,000 m^3/d.No Name Creek estimated at 7,000 m^3/d. Total of 42,000 m^3/d	December 31, 2025

Notes:

a) Scoping stage of project is underway which includes a more detailed assessment of the sizing and timing of the diversion, and of constructability and operability considerations. This more detailed assessment may result in changes to the sizing, timing or operational approach of the diversion.

Site Performance Objectives and 2019 IPA

The 2019 IPA works towards stabilization and reduction of selenium and nitrate concentrations in the Elk Valley at Order Stations. The Plan projects that selenium and nitrate concentrations will be at or below SPOs at all seven Order Stations following the commissioning of the Fording River Operations South AWTF and the Elkview Operations AWTF (i.e., from 2023 onward). Prior to the commissioning of these AWTFs, selenium and nitrate concentrations are predicted to be seasonally (under winter low flow conditions) above SPOs at the following Order Stations: Fording River downstream of Greenhills Creek (GH_FR1; 0200378), Fording River downstream of Line Creek (LC_LC5; 020028), Elk River upstream of Grave Creek (EV_ER4; 0200027), and the Koocanusa Reservoir (RG_DSELK; E300230). Studies are underway to evaluate the effects of these short-term projected seasonal exceedances of the SPOs on the aquatic ecosystem.

Projected selenium concentrations for the Koocanusa Reservoir with the 2019 IPA are shown on Figure 2. The information on the plot represents monthly average selenium concentrations over time. The solid orange, blue and gray lines correspond to the projected monthly average concentrations under 1-in-10-year low, average and 1-in-10-year high flows, respectively. The green dots represent the monthly average historical concentrations from the monitoring dataset for the RG_DSELK Order Station. The vertical blue lines represent the fully effective dates for the AWTFs in the 2019 IPA (Table 1).

Teck's current selenium and nitrate treatment technology (biological active water treatment) does not treat sulphate. Based on water quality modelling, sulphate treatment may be required as early as 2026 at Line Creek Operations. Teck continues to advance and evaluate different sulphate treatment technologies to support the implementation of sulphate treatment by 2026. This includes planning, which is underway, for a sulphate treatment technology pilot program which will be conducted in 2019 and 2020.

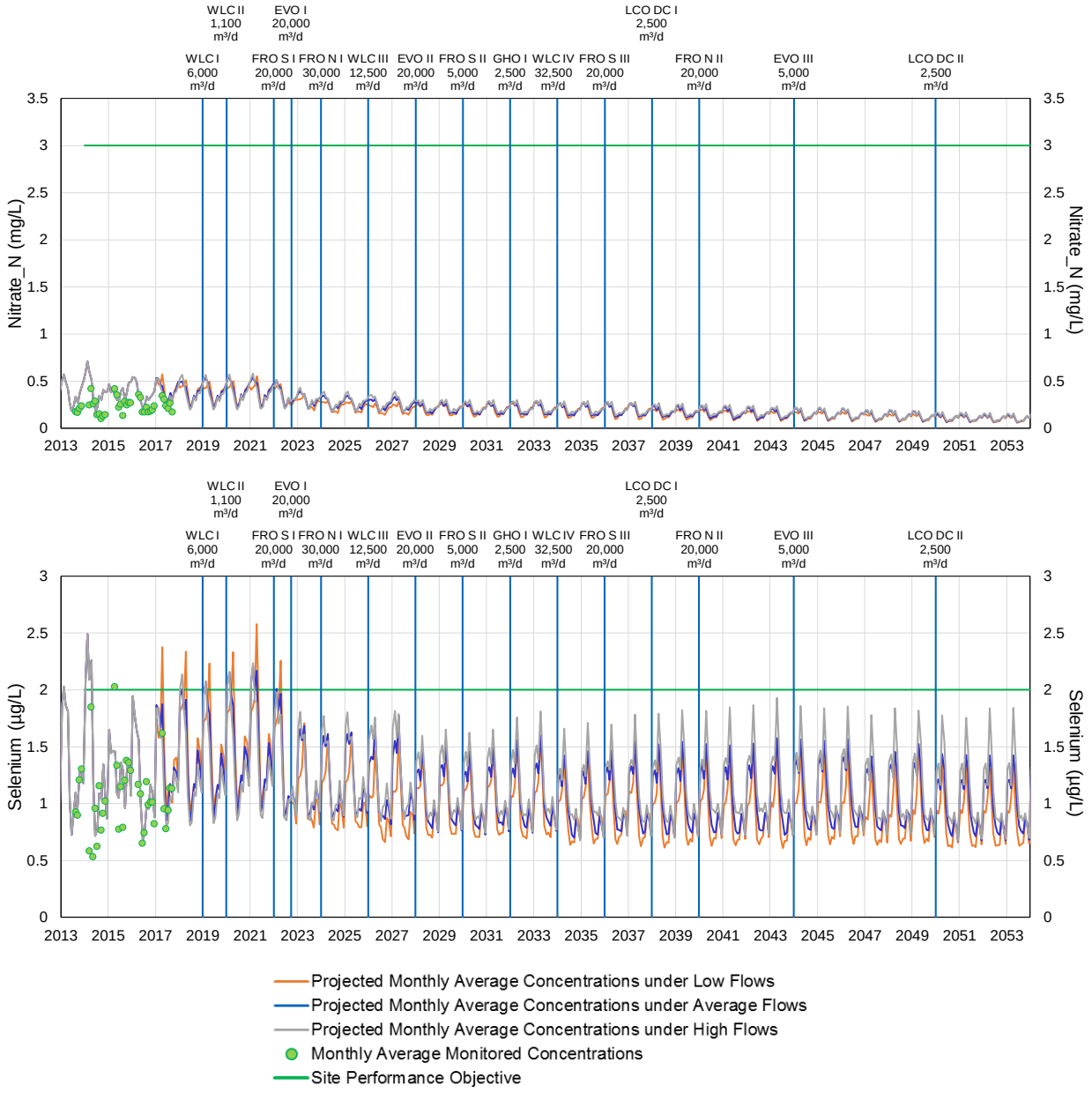


Figure 2 Projected Monthly Average Nitrate and Selenium Concentrations in the Koocanusa Reservoir Order Station RG_DSELK

Research and Development

Teck currently has more than 20 research and development projects underway related to water quality in the Elk Valley, including projects to better control the release of water quality constituents at the source and to develop new water treatment methods. This includes the application and advancement of alternative treatment technologies, nitrate source control, sulphate treatment and calcite management.

Teck will continue to undertake studies to evaluate the effects on the aquatic ecosystem, including studying the ecological relevance of short-term and seasonal nitrate, selenium and sulphate concentrations above SPOs. This will inform future adjustments to the implementation plan.

Closing

If you have any comments or questions on this 2019 IPA Summary, please contact Teck c/o:

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nic.milligan@teck.com

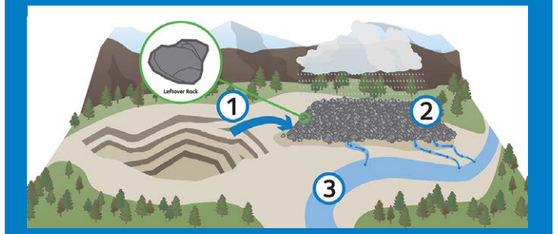


Elk Valley Water Quality Plan

Summer 2017 Update

Teck

Water Quality and Mining



The Challenge

1. The mining process generates large quantities of leftover rock that contains naturally-occurring substances such as selenium, an element that is essential for human and animal health in small amounts.

2. Water from both precipitation and runoff flows through these rock piles and carries selenium and other substances, such as nitrate, into the local watershed.

3. If present in high enough concentrations in the watershed, these substances can adversely affect aquatic health.

Our goal is to stabilize and reverse the increasing trend of selenium and other substances to ensure the ongoing health of the watershed, while at the same time allowing for continued sustainable mining in the region.

Our Commitment to Water Quality

We recognize addressing the water quality effects of mining is a legacy issue connected to decades of mining. It is complex, and ready-made solutions do not exist; however, we are making progress.

Teck is fully committed to finding solutions and this work is at the global forefront of managing water quality in mining. Success requires a long-term approach, driven by continued innovation and collaboration.

We Want to Hear From You

As we move forward with achieving the goals of the Elk Valley Water Quality Plan, we will continue to seek input and advice from experts, First Nations, residents and river users alike.

Phone toll-free to 1.855.806.6854 and leave a message. Send an email to feedbackteckcoal@teck.com. Fill out a feedback form here or at locations throughout the Elk Valley.

The Elk Valley Water Quality Plan

In 2014, B.C. Ministry of Environment approved an area based management plan — the Elk Valley Water Quality Plan (EVWQP)

The Plan was informed by scientific advice received from a Technical Advisory Committee chaired by B.C. Ministry of Environment with participation from government, First Nations, an independent scientist and community input received through three phases of public consultation in Elk Valley communities.

Elk Valley Water Quality Plan Implementation

1. Targets: Set short, medium, long-term water quality targets that are protective of aquatic and human health

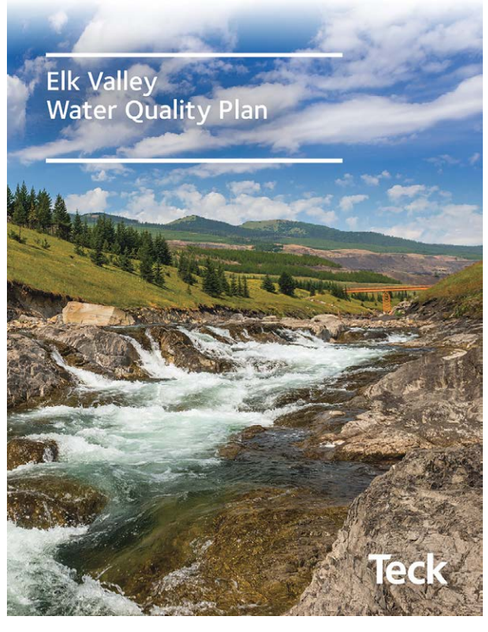
2. Water Management: Implement water treatment and mitigation actions to achieve targets

3. Monitoring: Define a monitoring program for water quality and aquatic health

4. Research and Development: Undertake an R&D program to advance ways to ensure water quality

5. Adaptive Management: Multi-decade plan, adapting implementation based on new information and learnings

An Environmental Monitoring Committee (EMC) was established to advise on the implementation of the plan. The EMC consists of experts from the Ministry of Environment, Ministry of Energy and Mines, the Interior Health Authority, the Ktunaxa Nation Council, an independent scientist and Teck. The EMC reviews and provides input and advice to all monitoring reports and study designs. The EMC publishes an annual public report at www.teck.com/elkvalley



Implementing Water Treatment



The West Line Creek Active Water Treatment Facility at Line Creek Operations.

1. West Line Creek Active Water Treatment Facility

- Commissioned in February 2016
- 7,500 m^3/day water treatment capacity
- Meeting design targets for selenium and nitrate reduction:
  - Selenium concentrations are reduced by about 96% in treated water
  - Nitrate concentrations are reduced by over 99%
- A challenge related to selenium compounds in discharge water has been identified. An option to address this issue has been developed and is undergoing piloting through summer 2017.

2. Planned Fording River Operations Active Water Treatment Facility

- Planned for operation in 2019
- Estimated 20,000 m^3/day capacity
- Tree harvesting and soil salvage of the project area is complete

3. Elkview Operations Active Water Treatment Facility

- Planned for operation in 2020
- Estimated 30,000 m^3/day capacity

Research and Development

Teck is undertaking an an extensive, multi-year R&D Program, focused on:

- Improving mine designs to better control release of water quality constituents at source
- Identifying and piloting improved methods for treating mine-affected water
- Approximately 15 projects are underway now

Pilot Study: Saturated Rock Fill Project

One major area of R&D work we are undertaking is a full-scale trial saturated rock fill at Elkview Operations to remove selenium within our existing operations.

This technology involves using naturally-occurring organic processes to treat mine-affected water. Saturated rock fills reduce nitrate and selenium through biologic reduction, similar to active water treatment.

So far, the pilot project has found that approximately 90% of selenium and nitrate is removed from the water through these natural processes.

There are many benefits to this approach including shorter schedule for design and construction and reduced complexity.

We continue to do more research to better understand this potential application, and how it can complement our water treatment approach.



Working at Fording River operations Active Water Treatment pilot project.

Local and Regional Monitoring



Water quality testing at Thompson Creek.

We are conducting extensive monitoring to improve our understanding of water quality and aquatic health. Existing studies show that selenium concentrations and other mine indicators of water quality within the watershed are at levels that have not affected populations of fish and other sensitive aquatic animals.

Water Quality Monitoring

- Teck is undertaking regular water quality monitoring (at least monthly) at more than 100 stations including main stem receiving environments; mine-influenced tributaries and reference areas.
- We also conduct quarterly regional groundwater monitoring at 37 wells and site-specific monitoring at more than 50 wells.

Aquatic Health Monitoring

- We monitor aquatic health through our Regional Aquatic Effects Monitoring Program and our Local Aquatic Effects Monitoring Programs.

Regional Aquatic Effects Monitoring Program

- The regional program is completed on a three-year cycle and monitoring includes water quality, sediment quality and calcite; periphyton (algae); benthic invertebrates (bugs) and fish. In some cases monitoring may also include birds and amphibians.

Local Aquatic Effects Monitoring Programs

- To date, local programs have been established for Line Creek, Fording River and Greenhills mining operations.
- The goal is to assess site-specific issues on a more frequent and localized basis.

Our Ongoing Commitment

Tributary Evaluation Program

Teck has conducted a Tributary Evaluation Program to evaluate the ecological value of tributaries in the Elk and Fording rivers to help identify tributaries that play a significant role in supporting the health of the ecosystem as a whole.

This program is informing a Tributary Management Plan which is intended to incorporate protection and rehabilitation goals for tributaries that will support achieving the area-based objectives of the Elk Valley Water Quality Plan.

Calcite Assessment

From 2013-2016, Teck assessed calcite on 370 km of the Elk and Fording rivers and their tributaries. The first calcite management program is planned to start on Greenhills Creek in 2017 and monitoring will continue throughout the watershed.

Human Health Risk Assessment

Teck is conducting additional monitoring to support an ongoing Human Health Risk Assessment (HHRA). The HHRA objective is to examine the potential effects of mine-related constituents and other parameters of interest.



Fishing the Elk River.

Fish and Fish Habitat Programs

A three year study was completed in 2015 on the Upper Fording River Westslope Cutthroat Trout population. It concluded that this genetically-pure population is viable and healthy but faces a number of potential challenges, including water quality; stream channel degradation; loss of tributary habitat and potential re-introduction of angling. The study recommended continued monitoring which will continue in 2017, 2019 and 2021.

In addition to our work in water quality, fish habitat rehabilitation projects are being implemented and planned in partnership with the Elk Valley Fish and Fish Habitat Committee which includes representatives from the Ktunaxa Nation Council, Fisheries and Oceans Canada and the Ministry of Forest Lands and Natural Resource Operations.

Approximately 33,000 m^2 of stream habitat was rehabilitated in 2016, including 133 large woody debris structures and 26 rock riffle structures.

Teck

APPENDIX 5.10-1: EVALUATION OF TOXICITY OF SULPHATE FOR THE GRASSY MOUNTAIN COAL PROJECT

Evaluation of toxicity of sulphate for the Grassy Mountain Coal Project

Final Report

February 28, 2019

Submitted to: **Hatfield Consultants Partnership**
North Vancouver, BC

#4, 6125 12 St SE, Calgary, Alberta T2H 2K1

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SIGNATURE PAGE

Report By:
Claudio Quinteros
Project Biologist

Reviewed By:
James Elphick, RPBio.
Environmental Toxicologist

This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

1.0 INTRODUCTION

Hatfield Consultants is developing site specific water quality objectives for the Grassy Mountain Coal Project and have identified sulphate as a constituent that requires additional information in order to establish protective limits.

Alberta Environment and Sustainable Resource Development established a hardness-dependent water quality guideline for sulphate for hardness of up to 250 mg/L (as $CaCO_3$). In water with hardness that is greater than 250 mg/L, the guideline indicates that the benchmark needs to be determined based on site water characteristics.

At Grassy Mountain, it is anticipated that water hardness will exceed 250 mg/L under conditions where sulphate is elevated, since the sources of sulphate and hardness (i.e., calcium and magnesium ions) are the same and, therefore, concentrations of these constituents are expected to be auto-correlated. Consequently, a toxicity testing program was proposed in which elevated concentrations of sulphate was tested in conjunction with elevated water hardness by addition of calcium and magnesium sulphate into receiving environment water collected from the site.

The following toxicity tests were performed:

- ~30 day *Oncorhynchus mykiss* embryo-alevin test
- 72-h *Pseudokirchneriella subcapitata* growth inhibition
- 6-8 day *Ceriodaphnia dubia* survival and reproduction

This report describes the results of these toxicity tests. Copies of raw laboratory data sheets and statistical analyses for each test species are provided in Appendices A to C. Analytical data are provided in Appendix D. The chain-of-custody forms are provided in Appendix E.

2.0 METHODS

A 1500 L volume of water was collected by Millennium EMS Solutions from Blairmore Creek on November 5, 2018, and delivered the same day to the Nautilus Environmental laboratory in Calgary, AB. Sulphate was increased in the water using $CaSO_4.2H_2O$ and $MgSO_4.7H_2O$ using a 5:1 ratio of calcium to magnesium to achieve the highest nominal test concentration of 1500 mg/L SO_4. This ratio was consistent with that observed at the site. The remaining test concentrations were prepared by diluting the sulphate amended sample with the site water.

Concentrations of sulphate, Ca, and Mg were measured at the test initiation and termination in the *C. dubia* and rainbow trout tests, and at test initiation only in the *P. subcapitata* test by ALS Environmental in Calgary, AB.

Testing was conducted according to procedures described by Environment Canada (1998, 2007a, and 2007b). Methods for the toxicity tests are summarized in Tables 1 to 3. Statistical analyses were performed using CETIS (Tidepool Scientific Software, version 1.9.4), and using the performance in the unamended site water as the control.

Rainbow trout eggs and milt were obtained from Allison Creek Brood Trout Station in Coleman, AB on November 7, 2018. Eggs and milt were obtained from four adults each and transported to the laboratory. Upon receipt, the eggs were inspected for quality and the milt for motility following mixing with water. The gametes were considered to be of good quality and the milt was pooled. The eggs were kept separate, and the eggs from an individual female was used to initiate all of the replicate A containers, a second female for replicate B, and so on. This blocked design was used in the event that one of the batches of eggs was not viable, in which case, the entire replicate could be excluded.

Table 1. Summary of test conditions: *Pseudokirchneriella subcapitata* growth inhibition test.

Test species	*Pseudokirchneriella subcapitata*, strain UTCC# 37
Organism source	In-house axenic culture, obtained from Canadian Phycological Culture Center
Organism age	3-to 7-day old culture in logarithmic growth phase
Test type	Static
Test duration	72 hours
Test vessel	Microplate
Test volume	220 µL
Test concentrations	7 concentrations, at least 6 enumerated, plus laboratory and site water control
Test replicates	5 per treatment, at least 3 enumerated; 8 for laboratory control
Number of organisms	10,000 +/- 1000 cells/mL
Control and dilution water	85% deionized water; 15% City of Calgary dechlorinated tap water supplemented with nutrients; site water used for site control and for dilution of sulphate spiked solution
Test solution renewal	None
Test temperature	24 ± 2°C
Feeding	None
Light intensity	3600 to 4400 lux
Photoperiod	24 hours light
Aeration	None
Test measurements	pH at test initiation and test completion; light intensity and temperature measured daily
Test protocol	Environment Canada (2007), EPS 1/RM/25
Statistical software	CETIS version 1.9.4
Test endpoints	Algal cell growth inhibition
Test acceptability criteria for controls	>16-fold increase in number of algal cells; CV ≤ 20%; no trend when analyzed using Mann-Kendall test
Reference toxicant	Zinc (added as $ZnSO_4$)

Table 2. Summary of test conditions: *Ceriodaphnia dubia* survival and reproduction test.

Test species	*Ceriodaphnia dubia*
Organism source	In-house culture
Organism age	<24 hour old neonates, produced within a 12-hour window
Test type	Static-renewal
Test duration	6 – 8 days
Test vessel	16 x 135 mm glass test tube
Test volume	15 mL
Test concentrations	Seven concentrations, plus laboratory and site water control
Test replicates	10 per treatment
Number of organisms	1 per replicate
Control and dilution water	20% Perrier water and 80% deionized water supplemented with vitamin B12 (2µg/L) and Na_2SeO_4 (5µg Se/L) for laboratory control only; site water used for site control and dilution of sulphate spiked site water
Test solution renewal	Daily (100% renewal)
Test temperature	25 ± 1°C
Feeding	Daily with *Pseudokirchneriella subcapitata* and YCT (3:1 ratio)
Light intensity	100 to 600 lux at water surface
Photoperiod	16 hours light/8 hours dark
Aeration	None
Test measurements	pH, conductivity, dissolved oxygen and temperature measured daily; evaluated for survival and reproduction daily
Test protocol	Environment Canada (2007), EPS 1/RM/21
Statistical software	CETIS version 1.9.4
Test endpoints	Survival and reproduction
Test acceptability criteria for controls	≥80% survival; ≥15 young per surviving control producing three broods; ≥60% of controls producing three or more broods, no ephippia present
Reference toxicant	Sodium chloride (NaCl)

Table 3. Summary of test conditions: ~30-d rainbow trout (*Oncorhynchus mykiss*) embryo-alevin test.

Test species	*Oncorhynchus mykiss*
Organism source	Allison Creek Brood Trout Station
Organism age	Within 30 minutes of fertilization
Test type	Static-renewal
Test duration	~30 days
Test vessel	2 L glass jars
Test volume	1.8 L
Test concentrations	Five concentrations, plus site and lab control
Test replicates	4 per treatment
Number of organisms	30 per replicate
Control and dilution water	De-chlorinated City of Calgary tap water for the laboratory control only; site water used for site control and dilution of sulphate spiked site water
Test solution renewal	Daily
Test temperature	14 ± 1°C
Feeding	None
Light intensity	Dark
Photoperiod	None
Aeration	Continuous
Test Measurements	pH, conductivity, dissolved oxygen and temperature were measured daily
Test protocol	Environment Canada (1998), EPS 1/RM/28 second edition
Statistical software	CETIS version 1.9.4
Test endpoints	Survival and viability
Test acceptability criterion for controls	Survival ≥ 65%
Reference toxicant	Zinc (7 day embryo exposure)

3.0 RESULTS

Results of the toxicity tests are summarized in Tables 4 through 6. Endpoints were calculated using the site control performance as the basis for comparison.

There were no adverse effects observed in the algal growth test using *P. subcapitata*. Stimulation of growth was observed in higher concentrations of sulphate, which is not uncommon in higher ionic strength waters.

For *C. dubia*, survival was generally high in the test concentrations; however, reduced reproduction was observed in the highest sulphate concentration, resulting in an IC20 of 744 mg/L SO_4.

In the rainbow trout embryo alevin test, there were relatively few deformities observed and, consequently, the survival and viability endpoints were generally similar. The most sensitive endpoint was an EC20 of 701 mg/L SO_4 for viability.

Table 4. Results: *Pseudokirchneriella subcapitata* growth inhibition test.

Concentration (mg/L SO_4)	Cell Yield (x 10^3 cells/mL) (Mean ± SD)	Stimulation %
Laboratory Control	487 ± 29	-
Site Control[1]	353 ± 15.1	-
162	277 ± 12	-21.5
212	409 ± 26.2	15.9
299	752 ± 38.6	113
438	453 ± 19.3	28.3
659	528.3 ± 35.5	49.7
980.5	732 ± 31.8	107.4
1475	746 ± 12.5	111.3
Test endpoint (mg/L SO_4)		
IC20 (95% CL)	>1475	-
IC50 (95% CL)	>1475	-

SD = Standard Deviation, IC = Inhibition Concentration

[1] = Site control contained 8.8 mg/L SO_4

Table 5. Results: *Ceriodaphnia dubia* survival and reproduction test.

Concentration (mg/L SO4)	Survival (%)	Reproduction (Mean ± SD)
Laboratory Control	100	20.4 ± 2.0
Site Control[1]	100	25.9 ± 2.0
162	100	24.9 ± 4.0
212	100	22.3 ± 2.9
299	90	20.4 ± 7.6
438	100	22.6 ± 3.5
659	100	21.8 ± 3.9
980.5	100	18.7 ± 5.3
1475	80	14.1 ± 8.4
Test endpoint (mg/L SO4)		
LC20 (95% CL)	1475 (1140 – NC)	--
LC50 (95% CL)	>1475	--
IC20 (95% CL)	--	744 (242 – 1038)
IC50 (95% CL)	--	>1475

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration, CL=Confidence Limit
NC = Not Calculable
[1] = Site control contained 8.8 mg/L of SO4

Table 6. Results: rainbow trout (*Oncorhynchus mykiss*) embryo-alevin test

Concentration (mg/L SO4)	Survival (%) (Mean ± SD)	Proportion viable (%)
Laboratory Control	73.3 ± 3.3	73.3 ± 3.3
Site Control[1]	62.2 ± 1.9	62.2 ± 1.9
311	56.7 ± 3.3	55.6 ±1.9
460	60.0 ± 13.3	57.8 ±11.7
689	50.0 ± 14.5	48.9 ± 13.9
913	35.6 ± 7.7	30.0 ± 6.7
1357	10.0 ± 17.3	7.8 ± 13.5
Test endpoint (mg/L SO4)		
LC20 (95% CL)	738 (346 – 907)	--
LC50 (95% CL)	982 (708 – 1163)	--
EC20 (95% CL)	--	701 (406 – 848)
EC50 (95% CL)	--	929 (717 – 1076)

SD = Standard Deviation, LC = Lethal Concentration, EC = Effect Concentration, CL=Confidence Limit
[1] = Site control measured 9.1 mg/L of SO4

4.0 QA/QC

The health histories of the test organisms used in the exposures were acceptable and met the requirements of the Environment Canada protocols. The tests met all control acceptability criteria and water quality parameters remained within ranges specified in the protocols throughout the tests. There were no deviations from the test methodologies, other than the planned modification of the rainbow trout method to block the replicates by adult female. One of the batches of eggs performed poorly, and the data for this replicate (i.e., data for all of the eggs from one female) were excluded from the analysis. Uncertainty associated with these tests is best described by the standard deviations around the means.

Results of the reference toxicant tests conducted during the testing program are summarized in Table 7. Results for these tests fell within the acceptable range for organism performance of mean and two standard deviations, based on historical results obtained by the laboratory with these tests. Thus, the sensitivity of the organisms used in these tests was considered to be appropriate.

Table 7. Reference toxicant test results.

Test Species	Endpoint	Historical Mean (2 SD Range)	CV (%)	Test Date
P. subcapitata	Growth (IC50): 29.4 µg/L Zn	23.9 (13.6–42.2)	18.9	December 4, 2018
C. dubia	Survival (LC50): 1.4 g/L NaCl	1.5 (1.1–2.1)	10.9	November 14, 2018
	Reproduction (IC50): 1.4 g/L NaCl	1.3 (0.9–1.7)	10.1	
O. mykiss embryo	Viability (EC50): 0.16 g/L Zn	0.3 (0.03–2.9)	53.5	November 7, 2018

SD = Standard Deviation, CV = Coefficient of Variation, LC = Lethal Concentration, IC = Inhibition Concentration, EC = Effect Concentration, NA=Not Applicable

5.0 REFERENCES

Environment Canada. 2007a. Biological test method: growth inhibition test using the freshwater alga. EPS 1/RM/25, Second Edition, March 2007.

Environment Canada. 2007b. Biological test method: test of reproduction and survival using the cladoceran *Ceriodaphnia dubia*. EPS 1/RM/21, Second Edition, February 2007.

Environment Canada. 1998. Biological test method: toxicity tests using early life stages of salmonid fish (rainbow trout). EPS 1/RM/28, Second Edition, July 1998.

Tidepool Scientific Software. 2018. CETIS comprehensive environmental toxicity information system, version 1.9.4.11 Tidepool Scientific Software, McKinleyville, CA. 275 pp.

APPENDIX A – *Pseudokirchneriella subcapitata* Toxicity Test Data

NAUTILUS ENVIRONMENTAL

Algae Project Bench Sheet

Method: AGD Client: AATIO2 Reference: 189-0392

Test log

Day	Date	Init	Time	Rotate Y/N	Rotate Time*	Threshold Size (µm)	Daily Data Review
0	2018/12/17	SS	1440	Y/N	Time*	3.75	FD
1	2018/12/18	KK	0800	Y	0800	NA	AP
2	2018/12/19	MW	1400	Y	1400	NA	AP
3	2018/12/20	KW ML	1430	Y	0800	3.75	

*recommended rotation times

Sample Information

Initial pH: 7.9
Initial EC (µS/cm): 289
Initial DO (mg/L): 7.8
Initial Temp (°C): 14.1

Inoculum - Physical Counts (must read between 981 and 1198 cells per 0.5 mL)		
	1	1070
	2	1177
	3	1075

Inoculum - Cell Yield	10014

(must be 10,000 +/- 1000 cells/mL)

Nutrients used:	(normal)	mine

pH Measurements:

Concentration	Initial Value	Final Value
100%	7.0	-
control (well D6)	7.0	-
control (well D7)	-	7.4

***pH range: 6.5-8.5; must be <1.5 units difference between control initial and final**

Quality Assurance - Test Initiation

Algae Culture Name: TUES-NOV 20180213AG
Age of Algae (must be 3-7 days): 6d
Test organisms appeared healthy before use: **(yes)/no**
Turnover Date: 2018/12/11
Start time of inoculum prep (must be <3hrs to loading): 1340
Volume filtered through the 45 µm membrane: N/A
Appearance before filtration: N/A
Appearance after filtration: N/A
Light Levels (**must be 3600 - 4400 lux**)
Day 0: 4390 Day 2: 4240
Day 1: 4010 Day 3: 4270
Temperature (**must be 22-26°C**)
Day 0: 24 Day 2: 24
Day 1: 24 Day 3: 25
Average Temperature: 24

Quality Assurance - Test Termination

Control Fold Growth (must be >16): SOFTCO 67
CV of standard Control Wells (must be ≤20%):
Mann-Kendall p value (must be >0.05) if CV is >10%:

Reviewed By: CO Date Reviewed: 2019/01/24

NAUTILUS ENVIRONMENTAL

Algae Project Bench Sheet

Complete Plate Physical Counts

		1500	1000	667	444	267	184	131	Sample	—	—	
A	X	X	X	X	X	X	X	X	X	X	X	X
B	X	6400	6200	4500	3500	6000	3200	2400	3000			X
	X	6400	6000	4500	3100	6000	3200	2400	3100			X
	X	—	—	—	—	—	—	—	—			X
C	X	6400	6200	4200	3800	6500	3200	2300	3300			X
	X	6200	6000	4200	3800	6500	3200	2300	3300			X
	X	—	—	—	—	—	—	—	—			X
D / CTL	X	3700	4100	4000	4300	X	X	4200	4400	4300	4400	X
	X	3700	4000	3800	4200	X	X	4200	4400	4300	4400	X
	X	—	—	—	—	X	X	—	—	—	—	X
E	X	6200	6500	4800	4100	5400	3700	2500	3000			X
	X	6200	6500	4800	4100	5600	3600	2500	3000			X
	X	—	—	—	—	—	—	—	—			X
F	X											X
	X											X
	X											X
G	X											X
	X											X
	X											X
H	X	X	X	X	X	X	X	X	X	X	X	X

Only three replicates are enumerated if the CV is ≤20% within a concentration. If the CV is >20%, the additional two replicates will also be enumerated

267
6000
6000
6500
6500
6000
6600

* sample has detect (esp in 267) checked in thermo. and algae counts are similar

Reviewed By: Cm Date Reviewed: 2019/01/24

NAUTILUS ENVIRONMENTAL

Algae Bench Sheet

Cell Yield Results:

Concentration (%)	Cell Yield (x10^3 cells/ mL)							
	Row					**Mean**	SD	CV (%)
	B	C	E	F	G			
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
Site CTL	355	367	337	-	-	353	15	4
131	277	265	289	-	-	277	12	4
189	379	421	427	-	-	409	26	6
267	708	768	780	-	-	752	38	5
444	439	445	475	-	-	453	19	4
667	528	493	564	-	-	528	36	7
1000	720	708	768	-	-	732	32	4
1500	756	750	732	-	-	746	12	2

Standard Control Well Final Cell Densities (D Row):

Column	Final Cell Density (x10^3 cells/mL)	Cell Yield (x10^3 cells/mL)
2	443	433
3	485	475
4	473	463
5	509	498
8	503	493
9	526	516
10	514	504
11	526	516
Average	497	487
SD	29	29
CV (%)	6	6.0
	Fold Growth (x)	50

Test Well Final Cell Densities:

Concentration (%)	Calculated Final Cell Density (x10^3 cells/ mL)				
	Row				
	B	C	E	F	G
	-	-	-	-	-
	-	-	-	-	-
Site CTL	365	377	347	-	-
131.0	287	275	299	-	-
189.0	389	431	437	-	-
267.0	718	778	790	-	-
444	449	455	485	-	-
667	538	503	574	-	-
1000	730	718	778	-	-
1500	766	760	742	-	-

Reviewed By: CO Date Reviewed: 2019/01/24

Selenastrum Growth Test — **Nautilus Environmental Calgary**

Analysis ID:	01-1052-1100	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.9.4		
Analyzed:	24 Jan-19 12:11	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1		
Batch ID:	06-0685-3740	**Test Type:**	Cell Growth	**Analyst:**	Madison Lehti		
Start Date:	17 Dec-18	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Reconstituted Water		
Ending Date:	20 Dec-18	**Species:**	Selenastrum capricornutum	**Brine:**			
Test Length:	72h	**Taxon:**	Chlorophyta	**Source:**	In-House Culture	**Age:**	6d
Sample ID:	03-8676-0535	**Code:**	1819-0392	**Project:**			
Sample Date:	05 Nov-18 11:00	**Material:**	Sulphate	**Source:**	Hatfield Consultants		
Receipt Date:	05 Nov-18	**CAS (PC):**		**Station:**	Grassy Mountain		
Sample Age:	41d 13h	**Client:**	Hatfield Consultants				

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	56991	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.042	2.802	0.8083	No Outliers Detected

Point Estimates

Level	mg/L	95% LCL	95% UCL
IC5	>1475	n/a	n/a
IC10	>1475	n/a	n/a
IC15	>1475	n/a	n/a
IC20	>1475	n/a	n/a
IC25	>1475	n/a	n/a
IC40	>1475	n/a	n/a
IC50	>1475	n/a	n/a

Cell Yield Summary

			Calculated Variate						Isotonic Variate	
Conc-mg/L	Code	Count	Mean	Min	Max	Std Dev	CV%	%Effect	Mean	%Effect
8.8	N	3	353	337	367	15.1	4.28%	0.0%	531.3	0.0%
162		3	277	265	289	12	4.33%	21.53%	531.3	0.0%
212		3	409	379	427	26.15	6.39%	-15.86%	531.3	0.0%
299		3	752	708	780	38.57	5.13%	-113.0%	531.3	0.0%
438		3	453	439	475	19.29	4.26%	-28.33%	531.3	0.0%
659		3	528.3	493	564	35.5	6.72%	-49.67%	531.3	0.0%
980.5		3	732	708	768	31.75	4.34%	-107.4%	531.3	0.0%
1475		3	746	732	756	12.49	1.67%	-111.3%	531.3	0.0%

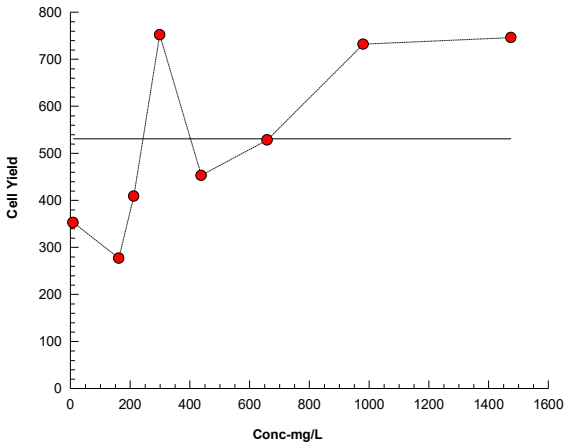
Cell Yield Detail

Conc-mg/L	Code	Rep 1	Rep 2	Rep 3
8.8	N	355	367	337
162		277	265	289
212		379	421	427
299		708	768	780
438		439	445	475
659		528	493	564
980.5		720	708	768
1475		756	750	732

Selenastrum Growth Test **Nautilus Environmental Calgary**

Analysis ID:	01-1052-1100	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.9.4
Analyzed:	24 Jan-19 12:11	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Graphics



Selenastrum Growth Test — **Nautilus Environmental Calgary**

Analysis ID:	02-6238-3514	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.9.4
Analyzed:	24 Jan-19 12:10	**Analysis:**	Parametric-Control vs Treatments	**Status Level:**	1
Batch ID:	06-0685-3740	**Test Type:**	Cell Growth	**Analyst:**	Madison Lehti
Start Date:	17 Dec-18	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Reconstituted Water
Ending Date:	20 Dec-18	**Species:**	Selenastrum capricornutum	**Brine:**	
Test Length:	72h	**Taxon:**	Chlorophyta	**Source:**	In-House Culture **Age:** 6d
Sample ID:	03-8676-0535	**Code:**	1819-0392	**Project:**	
Sample Date:	05 Nov-18 11:00	**Material:**	Sulphate	**Source:**	Hatfield Consultants
Receipt Date:	05 Nov-18	**CAS (PC):**		**Station:**	Grassy Mountain
Sample Age:	41d 13h	**Client:**	Hatfield Consultants		

Data Transform	Alt Hyp	NOEL	LOEL	TOEL	TU	PMSD
Untransformed	C > T	1475	>1475	n/a		15.29%

Dunnett Multiple Comparison Test

Control vs	Control II	Test Stat	Critical	MSD	DF	P-Type	P-Value	Decision(α:5%)
Negative Control	162*	3.603	2.558	53.96	4	CDF	0.0065	Significant Effect
	212	-2.655	2.558	53.96	4	CDF	0.9999	Non-Significant Effect
	299	-18.91	2.558	53.96	4	CDF	1.0000	Non-Significant Effect
	438	-4.74	2.558	53.96	4	CDF	1.0000	Non-Significant Effect
	659	-8.311	2.558	53.96	4	CDF	1.0000	Non-Significant Effect
	980.5	-17.97	2.558	53.96	4	CDF	1.0000	Non-Significant Effect
	1475	-18.63	2.558	53.96	4	CDF	1.0000	Non-Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.042	2.802	0.8083	No Outliers Detected

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	757924	108275	7	162.2	<1.0E-37	Significant Effect
Error	10680.7	667.542	16			
Total	768605		23			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Variances	Bartlett Equality of Variance Test	4.67	14.07	0.7001	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9778	0.9169	0.8516	Normal Distribution

Cell Yield Summary

Conc-mg/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
8.8	N	3	353	315.5	390.5	355	337	367	8.718	4.28%	0.00%
162		3	277	247.2	306.8	277	265	289	6.928	4.33%	21.53%
212		3	409	344	474	421	379	427	15.1	6.39%	-15.86%
299		3	752	656.2	847.8	768	708	780	22.27	5.13%	-113.03%
438		3	453	405.1	500.9	445	439	475	11.14	4.26%	-28.33%
659		3	528.3	440.1	616.5	528	493	564	20.5	6.72%	-49.67%
980.5		3	732	653.1	810.9	720	708	768	18.33	4.34%	-107.37%
1475		3	746	715	777	750	732	756	7.211	1.67%	-111.33%

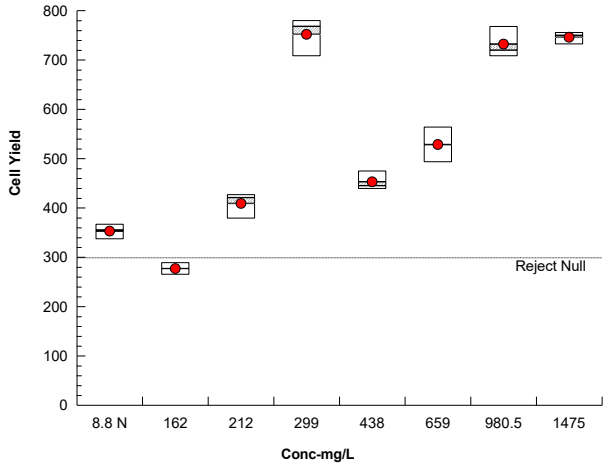
Selenastrum Growth Test **Nautilus Environmental Calgary**

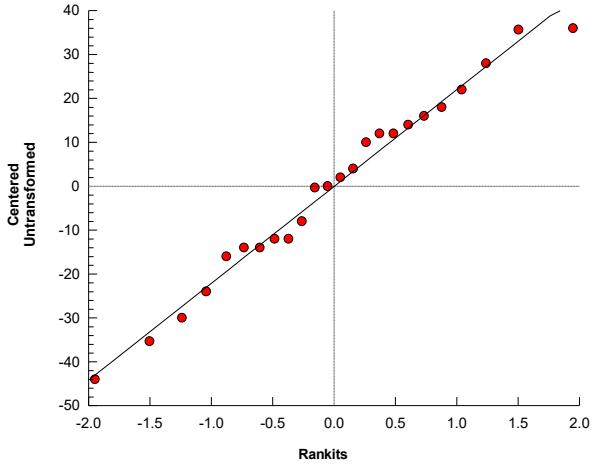
Analysis ID:	02-6238-3514	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.9.4
Analyzed:	24 Jan-19 12:10	**Analysis:**	Parametric-Control vs Treatments	**Status Level:**	1

Cell Yield Detail

Conc-mg/L	Code	Rep 1	Rep 2	Rep 3
8.8	N	355	367	337
162		277	265	289
212		379	421	427
299		708	768	780
438		439	445	475
659		528	493	564
980.5		720	708	768
1475		756	750	732

Graphics





APPENDIX B – *Ceriodaphnia dubia* Toxicity Test Data

NAUTILUS ENVIRONMENTAL

Ceriodaphnia Bench Sheet

Method CDD-Mod Client HATK02 Reference 1819-0392

Test Log

Date	Day	Time	Technician	Chem. Cart Used	Daily Data Review	Subsample Used	
2018/11/07	0	1610	CB	2	4F	Days 0 - 2	✓
2018/11/08	1	0945	CB	2	CB	Days 0 - 2	✓
2018/11/09	2	0815	CB	2	KD	Days 0 - 2	✓
2018/11/10	3	0930	CB	2	KC	Days 3 - 5	✓
2018/11/11	4	1015	KL	2	KL	Days 3 - 5	✓
2018/11/12	5	0915	KL	2	KL	Days 3 - 5	✓
2018/11/13	6	1540	CB	2	CB	Days 6 - 8	✓
2018/11/14	7	1350	CB	2	CB	Days 6 - 8	—
	8					-	

Sample Information

Initial pH: 7.7
Initial EC (µS/cm): 259
Initial DO (mg/L): 7.8
Initial Temp (°C): 11.1

Filtered with 60 µm nitex screen
Yes / No

Sample pre-aerated/hardness/pH adjust:
Yes / No

*if yes, describe procedure, rate and duration

Test Specifics

Food expiration: 11/25

Dilution water vessel and preparation date: #4 11/05, #1 11/05
#4 11/07, #4 11/07, #3 11/07

Cup	Control Validity Day 7 Number of Young	Number of Broods
1	20	3
2	20	
3	20	
4	21	
5	19	
6	25	
7	19	
8	20	
9	22	
10	18	

Average # of Young: 20

% with ≥ 3 Broods: 100

Control Mortality: 0
(must be ≤20%)

Reproduction Validity Criteria: the average number of young produced in first three broods is ≥ 15, when 60% of control organsims had 3 or more broods: **Yes** / **No**

Reviewed By: [signature] Date Reviewed: 2018/01/24.

NAUTILUS ENVIRONMENTAL

Ceriodaphnia Bench Sheet

Method CDD-Mod Client HAT 102 Reference 1819-8392

Chemistry

New Solutions (Lab) | Old Solutions

Conc. (%)	CtL	Site Ctl	132	198	296	444	667	1000
Day								

Old Solutions: 132 198 296 444 667 1000 (Lab CTL, Site CTL)

pH (units) (range: 6.5-8.5)

Day	New Solutions								Old Solutions							
0	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.8								
1	7.9	8.1	8.1	8.1	8.1	8.1	8.1	8.0	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.1
2	7.9	8.1	8.1	8.1	8.1	8.1	8.1	8.0	8.1	8.2	8.2	8.2	8.2	8.2	8.2	8.2
3	8.1	8.1	8.2	8.2	8.2	8.2	8.1	8.1	8.2	8.2	8.2	8.2	8.3	8.3	8.2	8.2
4	7.9	8.0	8.0	8.1	8.1	8.1	8.1	8.0	8.1	8.2	8.2	8.2	8.2	8.2	8.2	8.2
5	7.8	7.9	8.0	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.2	8.2	8.2	8.2	8.2	8.1
6	7.9	8.0	8.2	8.2	8.2	8.1	8.2	8.2	8.1	8.0	8.1	8.2	8.2	8.2	8.2	8.2
7									8.2	7.9	8.2	8.2	8.2	8.2	8.2	8.2
8																

Conductance (µS/cm)

Day	New Solutions								Old Solutions							
0	222	294	505	615	771	926	1252	1605								
1	205	287	518	623	781	973	1257	1638	228	310	508	616	768	957	1231	1612
2	198	308	526	631	772	971	1324	1621	239	318	517	620	767	971	1259	1637
3	205	312	500	618	776	967	1249	1621	224	309	522	618	768	968	1251	1591
4	196	288	519	639	781	978	1264	1647	224	319	502	608	761	950	1222	1604
5	214	290	515	617	777	972	1253	1638	234	307	508	620	759	958	1251	1610
6	209	295	513	611	772	971	1276	1645	239	296	512	620	758	955	1235	1604
7									193	274	490	586	728	912	1142	1510
8																

Dissolved Oxygen (mg/L) (40-100% saturation)

Day	New Solutions								Old Solutions							
0	7.2	7.8	8.0	8.0	8.2	8.2	8.2	8.2								
1	7.3	7.8	7.8	8.0	8.0	8.0	8.0	8.1	7.1	7.7	7.7	7.8	7.9	7.7	7.7	7.6
2	7.3	7.3	7.8	8.0	8.0	8.0	8.0	8.1	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
3	7.3	7.7	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.2	7.2	7.3	7.2	7.2	7.2
4	7.6	7.6	7.8	7.8	7.9	7.9	7.8	7.8	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.4
5	7.5	7.5	7.6	7.8	7.8	7.8	7.9	7.9	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.5
6	7.3	7.6	7.7	7.6	7.6	7.6	7.7	7.7	7.0	6.3	6.4	6.9	6.0	6.1	5.9	5.8
7									6.7	6.8	6.9	7.0	6.9	6.9	6.8	6.9
8																

Temperature 24 - 26 (°C)

Day	New Solutions								Old Solutions							
0	24	24	24	24	24	24	24	24								
1	24	24	24	24	24	24	24	24	25	25	25	25	25	26	26	26
2	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
3	24	24	24	24	24	24	24	24	24	24	24	25	25	25	25	25
4	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
5	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
6	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
7									24	24	24	24	24	24	25	25
8																

DO Levels (40-100% saturation)* -
2.9 to 7.3 mg/L at 24°C
2.9 to 7.2 mg/L at 25°C
2.8 to 7.1 mg/L at 26°C

*corrected for altitude

Reviewed By: ML Date Reviewed: 2019/01/24

NAUTILUS ENVIRONMENTAL

Ceriodaphnia Bench Sheet

Method CDD-Mod Client HAT 102 Reference 1819-0392

Chemistry

	New Solutions								Old Solutions							
Conc. (%)	1500								1500							
Day																
pH (units) (range: 6.5-8.5)																
0	7.8								0							
1	8.0								1	8.1						
2	8.1								2	8.1						
3	8.1								3	8.2						
8.0 (3)	8.2								4	8.1						
5	8.1								5	8.1						
6	8.1								6	8.1						
7									7	8.1						
8									8							
Conductance (µS/cm)																
0	2250								0							
1	2280								1	2240						
2	2290								2	2250						
3	2260								3	2240						
2250 (3)	2240								4	2240						
5	2260								5	2300						
6	2270								6	2240						
7									7	2100						
8									8							
Dissolved Oxygen (mg/L) (40-100% saturation)																
0	8.2								0							
1	8.1								1	7.8						
2	8.1								2	7.3						
3	7.3								3	7.3						
7.9 (3)	7.9								4	7.3						
5	7.9								5	7.5						
6	7.6								6	5.8						
7									7	6.9						
8									8							
Temperature 24 - 26 (°C)																
0	24								0							
1	24								1	25						
2	24								2	24						
3	24								3	24						
4	24								4	24						
5	24								5	24						
6	24								6	24						
7									7	25						
8									8							

DO Levels (40-100% saturation)* -
2.9 to 7.3 mg/L at 24°C
2.9 to 7.2 mg/L at 25°C
2.8 to 7.1 mg/L at 26°C

*corrected for altitude

Reviewed By: Date Reviewed: 20191011 24

NAUTILUS ENVIRONMENTAL

Ceriodaphnia Bench Sheet

Method CDD-Mod Client HAT 102 Reference 1819-0392

Biology

(#, young produced; 0, no young; X, dead; X#, young produced-dead; —,young produced after 3rd brood)

Brood organisms produced during an organism's 4th or subsequent brood are not included in brood counts

Day	1	2	3	4	5	6	7	8
Cup				Lab CTL				
1	0	0	0	3	4	6	10	—
2				3	0	7	10	—
3				3	4	8	8	—
4				4	0	6e	13	—
5				3	0	8	8	—
6				0	3	9	4	—
7				2	3	7	9	—
8				4	0	8	10	—
9				3	0	6	10	—
10				3	0	6	9	—
				Site CTL				
1	0	0	0	3	0	9	13	
2				3	0	10	14	
3				3	0	10	15	
4				0	3	8	9	
5				0	4	9	9	
6				0	4	10	12	
7				0	4	11	12	
8				0	4	10	13	
9				4	0	9	14	
10				0	3	11	12	
				132				
1	0	0	0	4	0	10	12	
2				3	0	10	13	
3				3	0	8	14	
4				3	0	10	13	
5				0	3	12	12	
6				0	4	10	10	
7				0	3	9	12	
8				0	3	10	14	
9				4	0	11	13	
10				3	0	11	13	
				198				
1	0	0	0	4	0	9	14	10
2				0	3	7	10	10
3				0	3	11	11	13
4				0	4	7	11	11
5				0	5	10	10	9
6				0	4	8	12	9
7				0	4	9	13	11
8				3	0	11	8	11
9				3	0	9	13	14
10				2	0	8	11	12

Day	1	2	3	4	5	6	7	8
Cup				296				
1	0	0	0	4	0	10	10	
2				0	4	8	8	
3				0	5	11	13	
4				3#	0	10	9	
5				3	0	X	X	
6				4	0	10	11	
7				0	0	0	3	
8				3	0	9	11	
9				3	0	10	14	
10				2	0	5	11	
				444				
1	0	0	0	0	3	9	12	
2				0	3	7	10	
3				0	4	10	11	
4				0	3	8	11	
5				0	3	9	10	
6				0	3	8	12	
7				4	0	9	13	
8				0	3	11	9	
9				3	0	9	13	
10				0	4	10	11	
				1067				
1	0	0	0	3	0	10	12	
2				0	3	10	13	
3				0	3	10	10	
4				0	3	10	10	
5				0	4	8	11	
6				0	2	7	10	
7				4	0	7	11	
8				0	3	10	9	
9				3	0	9	12	
10				3	0	9	12	
				1000				
1	0	0	0	0	3	7	8	
2				0	3	9	13	
3				3	0	7	9	
4				0	2	8	9	
5				0	3	8	12	
6				0	3	9	13	
7				0	3	7	13	
8				0	4	7	10	
9				0	2	5	9	
10				0	0	9	10	

Reviewed By: NL CB Date Reviewed: 20240102

NAUTILUS ENVIRONMENTAL

Ceriodaphnia Bench Sheet

Method CDD-Mod Client HAT 102 Reference 1819-0392

Biology

(#, young produced; 0, no young; X, dead; X#, young produced-dead; —,young produced after 3rd brood)

Brood organisms produced during an organism's 4th or subsequent brood are not included in brood counts

Day	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Cup				1500												
1	0	0	0	0	3	5	7									
2				4	0	8	12									
3				0	3	7	7									
4				0	X0	—	—	—								
5				3	0	4	8									
6		↓	↓	0	3	10	10									
7		X0	—	—	—	—	—	—								
8		0	0	0	3	6	12									
9		↓	↓	0	3	7	9									
10	↓	↓	↓	3	0	7	11									
1																
2																
3																
4																
5																
6																
7																
8																
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6																
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8																
9																
10																

Reviewed By: NE Date Reviewed: 2019/01/24

NAUTILUS ENVIRONMENTAL

Ceriodaphnia Bench Sheet

Test Organism Information

Client: HAT102

Culture history for adults used in the test for sample reference: 1819-0392

Day Used: 2018/11/07

Test organisms appeared healthy before use: (Yes)/No

Number of young produced per brood adult within first three broods:

Brood	row/replicate	A4	E3	B3	A5	E5	A1	F2	A2	B5		

Culture(s) Used for Testing: Tuesday A2

number of young	4	3	4	3	5	3	4	4	4			
number of young	9	8	7	8	7	6	7	9	10			
number of young	11	10	13	9	9	9	10	11	10			
number of young	11	12	13	11	10	10	11	15	12			

Number of Adults Alive in Culture	7 days prior: 25	day used: 25

Notes: all cups have 1 adult

Average No. of young in first 3 broods: 22
(must be ≥15)

Culture % mortality (7-days prior to testing): 0%
(must be ≤20%)

Number of young produced by each brood organism in last complete brood: 12
(must be ≥8)

Reviewed By: NL Date Reviewed: 2019/01/24

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental Calgary**

Analysis ID:	13-4811-1166	**Endpoint:**	7d Survival Rate	**CETIS Version:**	CETISv1.9.4
Analyzed:	01 Feb-19 10:15	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Batch ID:	20-2925-7067	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Madison Lehti
Start Date:	07 Nov-18	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	Mod-Hard Synthetic Water
Ending Date:	17 Nov-18	**Species:**	Ceriodaphnia dubia	**Brine:**	
Test Length:	10d 0h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture **Age:** <24
Sample ID:	03-8676-0535	**Code:**	1819-0392	**Project:**	
Sample Date:	05 Nov-18 11:00	**Material:**	Sulphate	**Source:**	Hatfield Consultants
Receipt Date:	05 Nov-18	**CAS (PC):**		**Station:**	Grassy Mountain
Sample Age:	37h	**Client:**	Hatfield Consultants		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	569643	200	Yes	Two-Point Interpolation

Point Estimates

Level	mg/L	95% LCL	95% UCL
LC5	1039	266.6	n/a
LC10	1168	1018	n/a
LC15	1313	1086	n/a
LC20	1475	1154	n/a
LC25	>1475	n/a	n/a
LC40	>1475	n/a	n/a
LC50	>1475	n/a	n/a

7d Survival Rate Summary

			Calculated Variate(A/B)							Isotonic Variate	
Conc-mg/L	Code	Count	Mean	Min	Max	Std Dev	CV%	%Effect	A/B	Mean	%Effect
8.8	N	10	1.0000	1.0000	1.0000	0.0000	0.00%	0.0%	10/10	1	0.0%
162		10	1.0000	1.0000	1.0000	0.0000	0.00%	0.0%	10/10	1	0.0%
212		10	1.0000	1.0000	1.0000	0.0000	0.00%	0.0%	10/10	1	0.0%
299		10	0.9000	0.0000	1.0000	0.3162	35.14%	10.0%	9/10	0.975	2.5%
438		10	1.0000	1.0000	1.0000	0.0000	0.00%	0.0%	10/10	0.975	2.5%
659		10	1.0000	1.0000	1.0000	0.0000	0.00%	0.0%	10/10	0.975	2.5%
980.5		10	1.0000	1.0000	1.0000	0.0000	0.00%	0.0%	10/10	0.975	2.5%
1475		10	0.8000	0.0000	1.0000	0.4216	52.70%	20.0%	8/10	0.8	20.0%

7d Survival Rate Detail

Conc-mg/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
8.8	N	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
162		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
212		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
299		1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
438		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
659		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
980.5		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1475		1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000

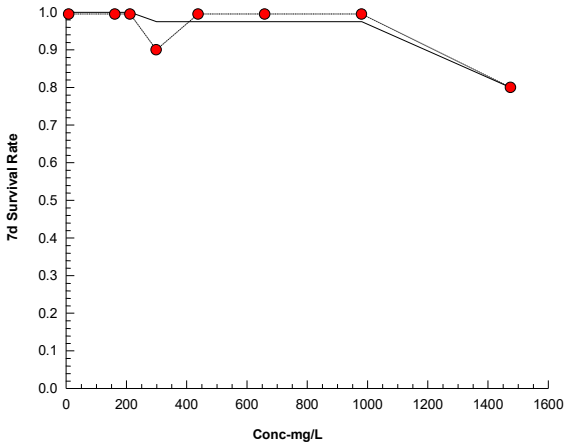
7d Survival Rate Binomials

Conc-mg/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
8.8	N	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
162		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
212		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
299		1/1	1/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1	1/1
438		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
659		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
980.5		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
1475		1/1	1/1	1/1	0/1	1/1	1/1	0/1	1/1	1/1	1/1

Ceriodaphnia 7-d Survival and Reproduction Test **Nautilus Environmental Calgary**

Analysis ID:	13-4811-1166	**Endpoint:**	7d Survival Rate	**CETIS Version:**	CETISv1.9.4
Analyzed:	01 Feb-19 10:15	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Graphics



CETIS Analytical Report

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental Calgary**

Analysis ID:	10-4220-9270	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.4
Analyzed:	01 Feb-19 10:15	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Batch ID:	20-2925-7067	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Madison Lehti
Start Date:	07 Nov-18	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	Mod-Hard Synthetic Water
Ending Date:	17 Nov-18	**Species:**	Ceriodaphnia dubia	**Brine:**	
Test Length:	10d 0h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture **Age:** <24
Sample ID:	03-8676-0535	**Code:**	1819-0392	**Project:**	
Sample Date:	05 Nov-18 11:00	**Material:**	Sulphate	**Source:**	Hatfield Consultants
Receipt Date:	05 Nov-18	**CAS (PC):**		**Station:**	Grassy Mountain
Sample Age:	37h	**Client:**	Hatfield Consultants		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1896283	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	3.53	3.306	0.0192	Outlier Detected

Point Estimates

Level	mg/L	95% LCL	95% UCL
IC5	167	26.6	193.4
IC10	191	76.72	444
IC15	243.9	192	776.7
IC20	743.5	242.5	1038
IC25	887.8	628	1162
IC40	1298	1076	n/a
IC50	>1475	n/a	n/a

Reproduction Summary

			Calculated Variate						Isotonic Variate	
Conc-mg/L	Code	Count	Mean	Min	Max	Std Dev	CV%	%Effect	Mean	%Effect
8.8	N	10	25.9	21	28	1.969	7.60%	0.0%	25.9	0.0%
162		10	24.9	14	27	3.957	15.89%	3.86%	24.9	3.86%
212		10	22.3	17	26	2.946	13.21%	13.9%	22.3	13.9%
299		10	20.4	3	29	7.633	37.42%	21.24%	21.6	16.6%
438		10	22.6	14	26	3.534	15.64%	12.74%	21.6	16.6%
659		10	21.8	13	26	3.91	17.94%	15.83%	21.6	16.6%
980.5		10	18.7	10	25	5.272	28.19%	27.8%	18.7	27.8%
1475		10	14.1	0	24	8.439	59.85%	45.56%	14.1	45.56%

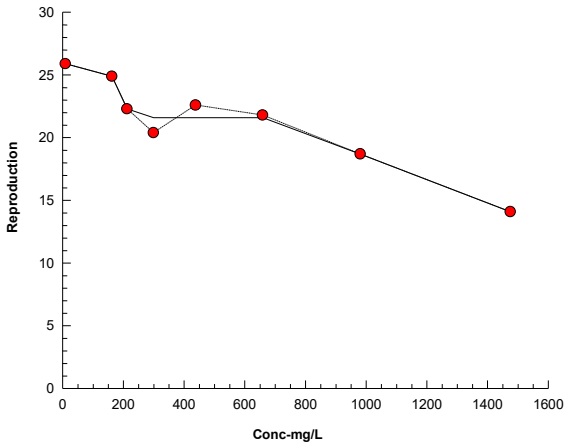
Reproduction Detail

Conc-mg/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
8.8	N	25	27	28	25	21	26	27	27	27	26
162		26	26	25	26	27	14	24	27	27	27
212		20	20	26	22	17	21	24	25	26	22
299		24	20	29	22	13	25	3	23	27	18
438		24	20	25	22	22	23	26	14	25	25
659		25	26	13	19	23	19	22	22	25	24
980.5		17	24	19	19	23	25	10	11	16	23
1475		14	24	17	0	15	19	0	21	10	21

Ceriodaphnia 7-d Survival and Reproduction Test **Nautilus Environmental Calgary**

Analysis ID:	10-4220-9270	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.4
Analyzed:	01 Feb-19 10:15	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Graphics



APPENDIX C – *Oncorhynchus mykiss* Toxicity Test Data

NAUTILUS ENVIRONMENTAL

Rainbow Trout E Test

Test ELS E Test Client HAT102 Reference 1819-0392 Rainbow Trout

Test Log

Date	Day	Time	Technician	Temperature Before Use (13-15 °C) Reading	Min	Max	Chem. Cart Used	Bench Sheet Review First	Second
2018/11/07	0	1700	CQ/MW/ST	15	14	15	1	CQ	
2018/11/08	1	1330	CQ/ST	14	14	15	1	KC	
2018/11/09	2	1130	MW/CQ	13	13	14	1	—	
2018/11/10	3	1450	MW	13	13	13	1	CB	
2018/11/11	4	1430	KC	13	13	13	1	KC	
2018/11/12	5	1430	KC	13	13	13	1	KC	
2018/11/13	6	1010	MW/CQ	13	13	13	1	CQ	
2018/11/14	7	0900	CQ	13	13	13	1	AP	
2018/11/15	8	~~0900~~	~~ST~~ 0800 CQ	13	13	14	1	CB	
2018/11/16	9	0900	~~ST~~ 0900 CQ	13	12	13	1	ST	
2018/11/17	10	0900	CQ	12	12	13	1	ST	
2018/11/18	11	1430	KC	14	12	14	1	AP	
2018/11/19	12	1330	CQ	14	12	14	1	AP	
2018/11/20	13	1130	MW	14	14	14	1	AP	
2018/11/21	14	MW ~~1010~~	MW	14	14	14	1	CQ	
2018/11/22	15	1430	CQ	13	12	13	1	KC	
2018/11/23	16	1030	CQ	13	13	13	1	LF	
2018/11/24	17	1340	ST	13	12	13	1	LF	
2018/11/25	18	1000	KC	13	13	13	1	KC	
2018/11/26	19	1135	MW	14	13	14	1	ED	
2018/11/27	20	0900	MW	14	13	14	1	LF	
2018/11/28	21	0920 ST	MW	14	13	14	1	LF	
2018/11/29	22	0835	ST	14	13	14	1	CQ	
2018/11/30	23	0840	MW	14	14	14	1	SS	
2018/12/01	24	1300	ST	13	13	14	1	KC	
2018/12/02	25	1400	KC	14	14	14	1	AP	
2018/12/03	26	1030	CQ	14	14	14	1	KC	
2018/12/04	27	1100	MW	14	14	14	1	ED	
2018/12/05	28	1030	MW	14	14	14	1	AP	
2018/12/06	29	1225	MW	14	13	14	1	CB	
2018/12/07	30	1430	CQ	14	13	14	1	CQ	
	31								
	32								
	33								
	34								
	35								

NAUTILUS ENVIRONMENTAL

Rainbow Trout E Test

Test ELS E Test Client HAT102 Reference 1819-0392 Rainbow Trout

Chemistry

New Solutions

Conc. (mg/L) / Day	CTL	Site CTL	297	444	667	1000	1500		
pH (units) (range: 6.5-8.5)									
0	7.9	7.9	8.0	8.0	8.0	8.0	8.0		
1	8.2	8.2	8.1	8.1	8.1	8.1	8.1		
2	8.2	8.2	8.2	8.1	8.2	8.2	8.2		
3	8.2	8.2	8.3	8.3	8.3	8.3	8.3		
4	8.3	8.3	8.2	8.2	8.1	8.2	8.2		
5	8.2	8.3	8.2	8.2	8.3	8.3	8.2		
6	8.2	8.2	8.2	8.2	8.2	8.2	8.2		
7	8.2	8.3	8.2	8.2	8.2	8.2	8.2		
8	8.3	8.2	8.2	8.2	8.3	8.1	8.2		
9	8.2	8.2	8.2	8.2	8.3	8.2	8.2		
Conductance (µS/cm)									
0	418	274	732	973	1283	1676	2230		
1	425	287	752	974	1780	1622	2310		
2	440	285	771	1005	1298	1699	2260		
3	439	291	778	1002	1300	1707	2370		
4	437	304	763	1031	1269	1685	2350		
5	433	302	755	989	1272	1641	2300		
6	440	283	779	992	1305	1703	2270		
7	440	290	786	1005	1289	1715	2311		
8	430	289	775	1002	1280	1710	2320		
9	440	290	780	1001	1299	1705	2260		
Dissolved Oxygen (mg/L) (60-100% saturation)									
0	8.9	9.8	9.6	9.7	9.7	9.7	9.5		
1	9.2	9.2	9.2	9.2	9.2	9.2	9.2		
2	9.2	9.1	9.3	9.3	9.3	9.2	9.3		
3	9.0	9.1	9.2	9.2	9.2	9.2	9.3		
4	9.0	9.3	9.3	9.3	9.3	9.3	9.4		
5	9.3	9.4	9.4	9.4	9.4	9.4	9.3		
6	9.3	9.3	9.3	9.3	9.4	9.4	9.3		
7	9.2	9.3	9.3	9.3	9.3	9.3	9.3		
8	9.2	9.3	9.3	9.3	9.3	9.3	9.3		
9	9.1	9.1	9.1	9.2	9.1	9.2	9.2		

Old Solutions

Conc. (mg/L) / Day	CTL	Site CTL	297	444	667	1000	1500		
pH (units) (range: 6.5-8.5)									
0									
1	8.2	8.2	8.0	8.0	8.0	8.0	7.9		
2	8.2	8.2	8.1	8.2	8.2	8.2	8.1		
3	8.3	8.2	8.2	8.2	8.2	8.2	8.2		
4	8.3	8.3	8.2	8.2	8.2	8.2	8.2		
5	8.3	8.3	8.2	8.2	8.2	8.2	8.2		
6	8.2	8.2	8.1	8.2	8.2	8.2	8.1		
7	8.2	8.2	8.2	8.2	8.1	8.1	8.2		
8	8.3	8.3	8.2	8.2	8.1	8.2	8.2		
9	8.3	8.3	8.2	8.2	8.2	8.1	8.1		
Conductance (µS/cm)									
0									
1	412	301	750	988	1274	1678	2220		
2	418	286	770	986	1286	1685	2250		
3	432	292	774	999	1296	1699	2350		
4	440	324	774	1002	1285	1688	2350		
5	459	319	788	988	1278	1650	2310		
6	435	288	779	999	1300	1654	2360		
7	445	297	780	984	1289	1655	2340		
8	445	299	760	999	1295	1650	2360		
9	435	318	756	990	1315	1650	2300		
Dissolved Oxygen (mg/L) (60-100% saturation)									
0									
1	9.1	9.5	9.5	9.5	9.5	9.5	9.4		
2	9.1	9.1	9.1	9.2	9.2	9.2	9.1		
3	9.1	9.1	9.1	9.2	9.1	9.1	9.1		
4	9.0	9.0	9.0	9.0	9.0	9.0	9.0		
5	9.4	9.3	9.3	9.2	9.2	9.1	9.1		
6	9.2	9.1	9.1	9.1	9.1	9.1	9.0		
7	9.2	9.1	9.1	9.2	9.1	9.1	9.1		
8	9.2	9.2	9.2	9.2	9.1	9.1	9.1		
9	9.1	9.0	9.0	9.0	8.9	8.9	8.9		

NAUTILUS ENVIRONMENTAL

Rainbow Trout E Test

Test ELS E Test Client HAT102 Reference 1819-0392 Rainbow Trout

Chemistry

New Solutions

Conc. (mg/L) / Day	CTL	Site CTL	297	444	667	1000	1500		
pH (units) (range: 6.5-8.5)									
10	8.1	8.2	8.2	8.2	8.2	8.2	8.1		
11	8.0	8.3	8.3	8.2	8.2	8.2	8.2		
12	8.1	8.2	8.2	8.2	8.2	8.2	8.2		
13	8.0	8.2	8.2	8.2	8.2	8.2	8.2		
14	8.2	8.2	8.2	8.2	8.2	8.2	8.2		
15	8.3	8.2	8.2	8.2	8.1	8.2	8.2		
16	8.3	8.2	8.2	8.2	8.2	8.1	8.1		
17	8.3	8.3	8.3	8.3	8.3	8.3	8.3		
18	8.1	8.1	8.1	8.1	8.1	8.1	8.1		
19	8.2	8.1	8.1	8.1	8.1	8.1	8.1		
20	8.1	8.2	8.2	8.2	8.2	8.2	8.2		
21	8.2	8.2	8.2	8.2	8.2	8.2	8.2		
22	7.9	8.0	8.0	8.1	8.1	8.1	8.1		
Conductance (µS/cm)									
10	430	290	760	1002	1298	1705	2310		
11	399	284	734	1116	1297	1576	2300		
12	395	295	754	956	1250	1618	2320		
13	405	262	721	933	1220	1590	2280		
14	450	280	820	1017	1370	1801	2370		
15	435	286	789	965	1280	1760	2310		
16	455	290	799	1011	1289	1810	2340		
17	448	278	774	1008	1317	1713	2450	2300	
18	450	320	781	1046	1325	1768	2440		
19	451	290	793	1013	1309	1707	2250		
20	450	296	789	1021	1326	1708	2450		
21	455	304	805	1038	1343	1743	2480		
22	451	298	794	1032	1333	1737	2470		
Dissolved Oxygen (mg/L) (60-100% saturation)									
10	9.1	9.1	9.1	9.1	9.1	9.1	9.1		
11	8.9	9.1	9.2	9.2	9.2	9.3	9.2		
12	8.9	8.9	9.0	9.1	9.1	9.2	9.2		
13	~~8.4~~	8.9	8.9	9.0	9.0	9.0	9.0		
14	8.9	8.9	8.9	9.0	9.1	9.1	9.0		
15	9.1	9.1	9.0	9.0	9.1	9.0	9.0		
16	9.2	9.1	9.0	9.0	9.0	9.0	9.0		
17	9.3	9.2	9.4	9.4	9.4	9.4	9.4		
18	9.3	9.2	9.2	9.2	9.0	9.2	9.3		
19	9.0	9.2	9.2	9.2	9.2	9.2	9.2		
20	9.0	9.0	9.1	9.2	9.2	9.2	9.1		
21	9.0	9.0	9.2	9.1	9.1	9.1	9.1		
22	8.9	9.1	9.1	9.1	9.1	9.1	9.1		

CTL day 13 MW 8.9

Old Solutions

Conc. (mg/L) / Day	CTL	Site CTL	297	444	667	1000	1500		
pH (units) (range: 6.5-8.5)									
10	8.2	8.2	8.1	8.1	8.1	8.1	8.1		
11	8.3	8.2	8.1	8.1	8.1	8.1	8.1		
12	8.2	8.2	8.1	8.1	8.1	8.1	8.1		
13	8.2	8.1	8.1	8.1	8.1	8.1	8.1		
14	8.2	8.2	8.1	8.2	8.2	8.1	8.1		
15	8.2	8.2	8.1	8.1	8.2	8.2	8.2		
16	8.2	8.2	8.2	8.1	8.1	8.1	8.1		
17	8.3	8.2	8.2	8.2	8.1	8.1	8.1		
18	8.1	8.1	8.0	8.0	8.0	8.0	8.0		
19	8.0	8.0	8.0	8.0	7.9	8.0	8.1		
20	8.0	8.0	8.0	8.0	8.0	8.0	8.0		
21	8.1	8.0	8.0	8.0	8.1	8.1	8.1		
22	8.1	8.0	7.9	8.0	8.0	7.8	8.1		
Conductance (µS/cm)									
10	430	289	760	996	1275	1680	2280		
11	464	288	738	946	1280	1649	2270		
12	460	305	750	955	1280	1650	2270		
13	405	273	723	934	1214	1585	3130		
14	450	300	815	1048	1373	1792	2380		
15	430	289	796	1001	1299	1689	2330		
16	449	311	794	1025	1338	1785	2360		
17	454	288	790	1023	1328	1746	2310		
18	429	279	791	1081	1343	1782	2460		
19	455	298	784	1009	1307	1691	2240		
20	445	297	788	1014	1312	1701	2440		
21	449	303	806	1036	1340	1747	2400		
22	461	309	789	1026	1337	1742	2490		
Dissolved Oxygen (mg/L) (60-100% saturation)									
10	8.9	9.0	9.0	8.8	8.7	8.7	8.7		
11	9.0	9.0	8.9	8.7	8.7	8.7	8.7		
12	9.0	9.0	8.9	8.9	8.9	8.7	8.7		
13	8.7	8.5	8.6	8.6	8.5	8.4	8.4		
14	8.5	8.6	8.5	8.5	8.7	8.5	8.5		
15	8.8	8.9	8.7	8.7	8.7	8.7	8.7		
16	8.9	8.9	8.7	8.7	8.6	8.7	8.7		
17	8.9	8.6	8.9	8.8	8.7	8.7	8.8		
18	~~8.7~~	~~8.7~~	~~8.7~~	~~8.7~~	~~8.8~~	~~8.8~~	~~8.8~~		
19	8.7	8.5	8.7	8.7	8.0	8.4	8.8		
20	8.7	8.6	8.4	8.6	8.6	8.5	8.6		
21	8.7	8.3	8.1	8.3	8.5	8.6	8.3		
22	8.6	8.5	8.6	8.6	8.5	8.6	8.5		

NAUTILUS ENVIRONMENTAL

Rainbow Trout E Test

Test: ELS E Test Client: HAT102 Reference: 1819-0392 Rainbow Trout

Chemistry

New Solutions

Day	CTL	Site CTL	297	444	667	1000	1500		
pH (units) (range: 6.5-8.5)									
23	8.1	8.2	8.2	8.2	8.2	8.2	8.2		
24	8.3	8.2	8.2	8.2	8.2	8.2	8.2		
25	8.1	8.1	8.1	8.1	8.1	8.1	8.1		
26	8.2	8.1	8.1	8.1	8.1	8.1	8.1		
27	8.1	8.1	8.1	8.1	8.1	8.1	8.1		
28	8.3	8.3	8.3	8.3	8.3	8.3	8.3		
29	8.2	8.2	8.2	8.2	8.2	8.2	8.2		
30									
31									
32									
33									
34									
35									
Conductance (µS/cm)									
23	458	296	803	1030	1338	1730	2470		
24	465	309	790	1031	1339	1718	2460		
25	469	314	796	1037	1373	1780	2470		
26	460	310	779	1040	1340	1729	2480		
27	463	298	814	1043	1353	1756	2320		
28	464	298	787	1036	1348	1737	2520		
29	467	297	708	1057	1372	1776	2540		
30									
31									
32									
33									
34									
35									
Dissolved Oxygen (mg/L) (60-100% saturation)									
23	8.8	9.0	9.1	9.0	9.0	9.0	9.0		
24	8.9	9.0	9.1	9.1	9.1	9.1	9.1		
25	9.1	9.1	9.1	9.1	9.1	9.1	9.1		
26	8.9	9.0	9.0	9.0	9.0	9.0	9.0		
27	9.1	9.1	9.1	9.1	9.1	9.1	9.1		
28	9.0	9.1	9.2	9.2	9.2	9.2	9.2		
29	9.0	9.0	9.1	9.1	9.1	9.1	9.1		
30									
31									
32									
33									
34									
35									

Old Solutions

Day	CTL	Site CTL	297	444	667	1000	1500		
pH (units) (range: 6.5-8.5)									
23	8.1	8.0	8.0	8.1	8.0	8.0	8.0		
24	8.0	8.0	7.9	8.0	8.0	7.9	8.0		
25	8.1	8.0	8.0	8.0	8.0	7.9	8.0		
26	8.1	8.1	8.0	8.1	8.1	8.1	8.1		
27	8.0	8.0	7.9	7.8	7.8	8.0	8.1		
28	8.1	8.1	7.9	8.0	8.1	8.2	8.1		
29	8.0	8.1	7.9	8.0	8.0	8.1	8.1		
30	8.1	8.1	8.0	8.1	8.1	8.1	8.1		
31									
32									
33									
34									
35									
Conductance (µS/cm)									
23	460	301	800	1031	1340	1683	2280		
24	452	307	780	1010	1330	1712	2460		
25	455	312	809	1037	1342	1750	2500		
26	456	310	800	1021	1331	1710	2480		
27	464	302	827	1091	1366	1753	2552		
28	467	302	814	1052	1359	1758	2530		
29	467	303	828	1047	1388	1785	2540		
30	456	304	820	1047	1389	1756	2580		
31									
32									
33									
34									
35									
Dissolved Oxygen (mg/L) (60-100% saturation)									
23	8.6	8.5	8.3	8.4	7.4	7.7	8.0		
24	8.6	8.4	8.4	8.4	7.9	7.2	8.2		
25	8.2	8.2	8.2	8.2	8.2	8.2	8.3		
26	8.2	8.3	8.3	8.3	8.3	8.2	8.3		
27	8.1	8.1	7.6	7.7	6.0*	7.7	7.8		
28	8.0	8.0	7.1	7.1	7.8	8.3	7.6		
29	7.3	7.8	7.2	7.6	7.6	8.0	7.7		
30	8.0	8.0	7.9	7.7	7.8	7.8	7.9		
31									
32									
33									
34									
35									

* Day 27, DO low due to microbial growth, jar replaced; organisms appear healthy

NAUTILUS ENVIRONMENTAL

Rainbow Trout E Test

Test ELS E Test Client HAT102 Reference PJ1819-004 1819-0392

Takedown Data

Concentration	Replicate	Survival	Incidents of Deformity	Observations/Comments
Lab Control	a	~~a~~ 21	0	
	b	23	1	bent fin
	c	15	1	bent spine
	d	23	0	
Site Control	a	19	0	
	b	19	0	
	c	5	0	
	d	18	0	
297	a	17	0	
	b	18	1	bent spine
	c	8	3	bent spine, craniofacial x2
	d	16	0	
444	a	18	1	bent fin
	b	22	1	bent spine
	c	9	2	Craniofacial / Fins
	d	14	0	
667	a	18	0	
	b	17	1	bent spine
	c	4	0	
	d	10	0	
1000	a	12	1	~~bent~~ craniofacial
	b	12	3	~~bent~~ spines / fins
	c	0	0	
	d	8	1	bent spine
1500	a	0	0	
	b	0	0	
	c	7	~~2~~ 2	bent spine / fins
	d	9	~~2~~ 2	↓ Craniofacial

Salmonid Embryo-Alevin Survival and Development Test — **Nautilus Environmental Calgary**

Analysis ID:	01-4246-4558	**Endpoint:**	Survival Rate	**CETIS Version:**	CETISv1.9.4
Analyzed:	28 Jan-19 15:24	**Analysis:**	Linear Regression (GLM)	**Status Level:**	1
Batch ID:	00-3448-5735	**Test Type:**	Survival-Development	**Analyst:**	Lab Tech
Start Date:	07 Nov-18	**Protocol:**	EC/EPS 1/RM/28	**Diluent:**	Site Water
Ending Date:	07 Dec-18	**Species:**	Oncorhynchus mykiss	**Brine:**	Not Applicable
Test Length:	30d 0h	**Taxon:**	Actinopterygii	**Source:**	Allison Creek Brood Station **Age:** 0
Sample ID:	03-8676-0535	**Code:**	1819-0392	**Project:**	
Sample Date:	05 Nov-18 11:00	**Material:**	Sulphate	**Source:**	Hatfield Consultants
Receipt Date:	05 Nov-18	**CAS (PC):**		**Station:**	Grassy Mountain
Sample Age:	37h	**Client:**	Hatfield Consultants		

Linear Regression Options

Model Name	Link Function	Threshold Option	Thresh	Optimized	Pooled	Het Corr	Weighted
Log-Normal (Probit)	η=inv Φ[π]	Control Threshold	0.377778	Yes	No	Yes	Yes

Regression Summary

Iters	LL	AICc	BIC	Mu	Sigma	Adj R2	F Stat	Critical	P-Value	Decision(α:5%)
6	-47.43	102.6	103.5	2.992	0.1473	0.5951	0.08517	3.49	0.9668	Non-Significant Lack of Fit

Point Estimates

Level	mg/L	95% LCL	95% UCL
LC5	561.8	166.5	753.3
LC10	635.5	232.4	817.6
LC15	690.6	290.6	865.5
LC20	737.8	346.5	907.2
LC25	780.8	402.3	946
LC40	900.7	578.8	1065
LC50	981.5	708	1163

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
Threshold	0.4025	0.04558	0.3053	0.4996	8.83	2.5E-07	Significant Parameter
Slope	6.79	2.033	2.457	11.12	3.34	0.0045	Significant Parameter
Intercept	-20.31	6.142	-33.4	-7.223	-3.307	0.0048	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	57.26	28.63	2	13.49	4.4E-04	Significant
Lack of Fit	0.6636	0.2212	3	0.08517	0.9668	Non-Significant
Pure Error	31.17	2.597	12			
Residual	31.83	2.122	15			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Goodness-of-Fit	Pearson Chi-Sq GOF Test	31.83	25	0.0068	Significant Heterogeneity
	Likelihood Ratio GOF Test	34.13	25	0.0033	Significant Heterogeneity
Extreme Value	Grubbs Extreme Value Test	2.633	2.652	0.0547	No Outliers Detected
Variances	Bartlett Equality of Variance Test	11.74	11.07	0.0385	Unequal Variances
	Mod Levene Equality of Variance	0.5667	4.387	0.7251	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9262	0.8965	0.1663	Normal Distribution
	Anderson-Darling A2 Normality Te	0.4955	2.492	0.2180	Normal Distribution

Salmonid Embryo-Alevin Survival and Development Test **Nautilus Environmental Calgary**

Analysis ID: 01-4246-4558 **Endpoint:** Survival Rate **CETIS Version:** CETISv1.9.4
Analyzed: 28 Jan-19 15:24 **Analysis:** Linear Regression (GLM) **Status Level:** 1

Survival Rate Summary

			Calculated Variate(A/B)								
Conc-mg/L	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
9.1	N	3	0.6222	0.6000	0.6333	0.0111	0.0192	3.09%	0.0%	56	90
311		3	0.5667	0.5333	0.6000	0.0193	0.0333	5.88%	8.93%	51	90
460		3	0.6000	0.4667	0.7333	0.0770	0.1333	22.22%	3.57%	54	90
689		3	0.5000	0.3333	0.6000	0.0839	0.1453	29.06%	19.64%	45	90
913		3	0.3556	0.2667	0.4000	0.0444	0.0770	21.65%	42.86%	32	90
1357		3	0.1000	0.0000	0.3000	0.1000	0.1732	173.20%	83.93%	9	90

Survival Rate Detail

Conc-mg/L	**Code**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**
9.1	N	0.6333	0.6333	0.6000	
311		0.5667	0.6000	0.5333	
460		0.6000	0.7333	0.4667	
689		0.6000	0.5667	0.3333	
913		0.4000	0.4000	0.2667	
1357		0.0000	0.0000	0.3000	

Survival Rate Binomials

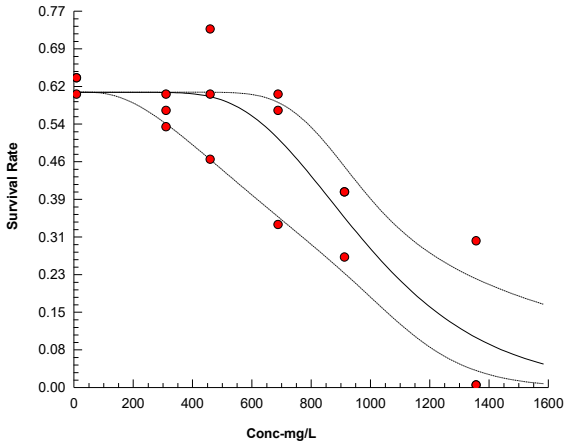
Conc-mg/L	**Code**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**
9.1	N	19/30	19/30	18/30	
311		17/30	18/30	16/30	
460		18/30	22/30	14/30	
689		18/30	17/30	10/30	
913		12/30	12/30	8/30	
1357		0/30	0/30	9/30	

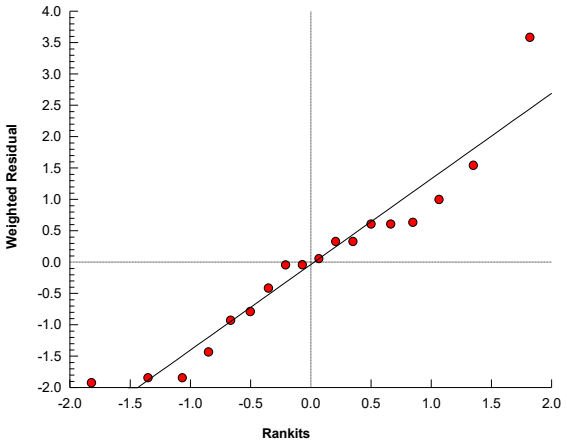
Salmonid Embryo-Alevin Survival and Development Test — **Nautilus Environmental Calgary**

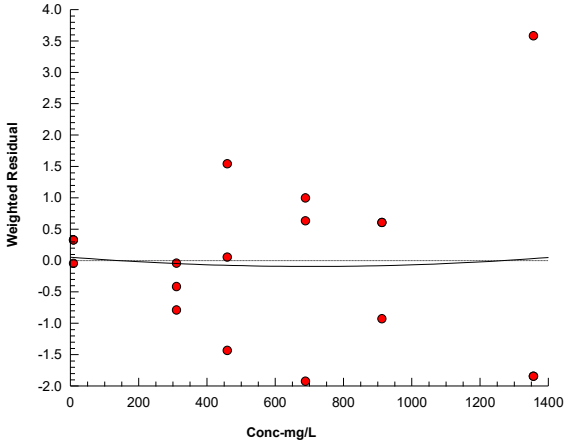
Analysis ID:	01-4246-4558	**Endpoint:**	Survival Rate	**CETIS Version:**	CETISv1.9.4
Analyzed:	28 Jan-19 15:24	**Analysis:**	Linear Regression (GLM)	**Status Level:**	1

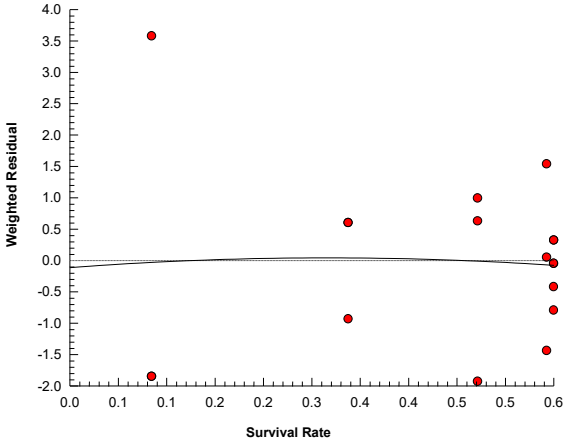
Graphics

Log-Normal: inv Φ[π]=α+β·log[x]









Salmonid Embryo-Alevin Survival and Development Test **Nautilus Environmental Calgary**

Analysis ID:	12-9628-9280	**Endpoint:**	Proportion Normal	**CETIS Version:**	CETISv1.9.4
Analyzed:	28 Jan-19 15:28	**Analysis:**	Linear Regression (GLM)	**Status Level:**	1
Batch ID:	00-3448-5735	**Test Type:**	Survival-Development	**Analyst:**	Lab Tech
Start Date:	07 Nov-18	**Protocol:**	EC/EPS 1/RM/28	**Diluent:**	Site Water
Ending Date:	07 Dec-18	**Species:**	Oncorhynchus mykiss	**Brine:**	Not Applicable
Test Length:	30d 0h	**Taxon:**	Actinopterygii	**Source:**	Allison Creek Brood Station **Age:** 0
Sample ID:	03-8676-0535	**Code:**	1819-0392	**Project:**	
Sample Date:	05 Nov-18 11:00	**Material:**	Sulphate	**Source:**	Hatfield Consultants
Receipt Date:	05 Nov-18	**CAS (PC):**		**Station:**	Grassy Mountain
Sample Age:	37h	**Client:**	Hatfield Consultants		

Linear Regression Options

Model Name	Link Function	Threshold Option	Thresh	Optimized	Pooled	Het Corr	Weighted
Log-Normal (Probit)	η=inv Φ[π]	Control Threshold	0.377778	Yes	No	Yes	Yes

Regression Summary

Iters	LL	AICc	BIC	Mu	Sigma	Adj R2	F Stat	Critical	P-Value	Decision(α:5%)
6	-43.75	95.21	96.16	2.968	0.1453	0.6653	0.14	3.49	0.9341	Non-Significant Lack of Fit

Point Estimates

Level	mg/L	95% LCL	95% UCL
EC5	536	227.8	701.7
EC10	605.3	296.5	763.2
EC15	657	353.7	809
EC20	701.3	406.4	848.3
EC25	741.6	457.2	884.7
EC40	853.8	609.9	992.3
EC50	929.3	717	1076

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
Threshold	0.4102	0.04177	0.3211	0.4992	9.82	<1.0E-37	Significant Parameter
Slope	6.883	1.771	3.109	10.66	3.888	0.0015	Significant Parameter
Intercept	-20.43	5.321	-31.77	-9.088	-3.84	0.0016	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	61.6	30.8	2	17.9	1.1E-04	Significant
Lack of Fit	0.8732	0.2911	3	0.14	0.9341	Non-Significant
Pure Error	24.94	2.078	12			
Residual	25.81	1.721	15			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Goodness-of-Fit	Pearson Chi-Sq GOF Test	25.81	25	0.0400	Significant Heterogeneity
	Likelihood Ratio GOF Test	27.05	25	0.0284	Significant Heterogeneity
Extreme Value	Grubbs Extreme Value Test	2.638	2.652	0.0534	No Outliers Detected
Variances	Bartlett Equality of Variance Test	12.74	11.07	0.0259	Unequal Variances
	Mod Levene Equality of Variance	0.6777	4.387	0.6569	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9298	0.8965	0.1926	Normal Distribution
	Anderson-Darling A2 Normality Te	0.3992	2.492	0.3687	Normal Distribution

Salmonid Embryo-Alevin Survival and Development Test **Nautilus Environmental Calgary**

Analysis ID: 12-9628-9280 **Endpoint:** Proportion Normal **CETIS Version:** CETISv1.9.4
Analyzed: 28 Jan-19 15:28 **Analysis:** Linear Regression (GLM) **Status Level:** 1

Proportion Normal Summary

			Calculated Variate(A/B)								
Conc-mg/L	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
9.1	N	3	0.6222	0.6000	0.6333	0.0111	0.0192	3.09%	0.0%	56	90
311		3	0.5556	0.5333	0.5667	0.0111	0.0193	3.46%	10.71%	50	90
460		3	0.5778	0.4667	0.7000	0.0676	0.1171	20.26%	7.14%	52	90
689		3	0.4889	0.3333	0.6000	0.0801	0.1388	28.39%	21.43%	44	90
913		3	0.3000	0.2333	0.3667	0.0385	0.0667	22.22%	51.79%	27	90
1357		3	0.0778	0.0000	0.2333	0.0778	0.1347	173.20%	87.5%	7	90

Proportion Normal Detail

Conc-mg/L	**Code**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**
9.1	N	0.6333	0.6333	0.6000	
311		0.5667	0.5667	0.5333	
460		0.5667	0.7000	0.4667	
689		0.6000	0.5333	0.3333	
913		0.3667	0.3000	0.2333	
1357		0.0000	0.0000	0.2333	

Proportion Normal Binomials

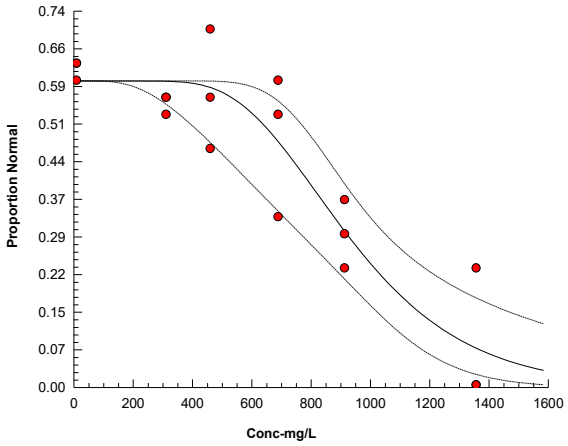
Conc-mg/L	**Code**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**
9.1	N	19/30	19/30	18/30	
311		17/30	17/30	16/30	
460		17/30	21/30	14/30	
689		18/30	16/30	10/30	
913		11/30	9/30	7/30	
1357		0/30	0/30	7/30	

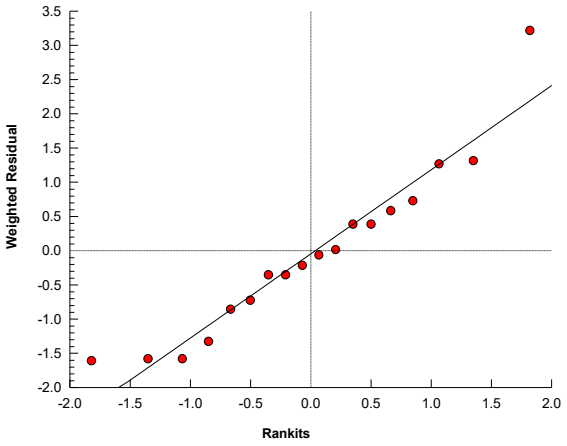
Salmonid Embryo-Alevin Survival and Development Test — **Nautilus Environmental Calgary**

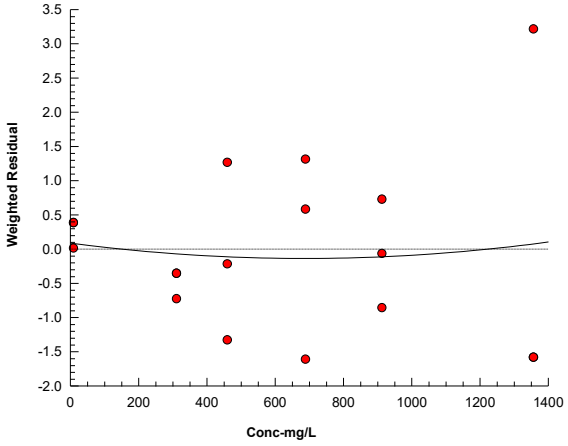
Analysis ID:	12-9628-9280	**Endpoint:**	Proportion Normal	**CETIS Version:**	CETISv1.9.4
Analyzed:	28 Jan-19 15:28	**Analysis:**	Linear Regression (GLM)	**Status Level:**	1

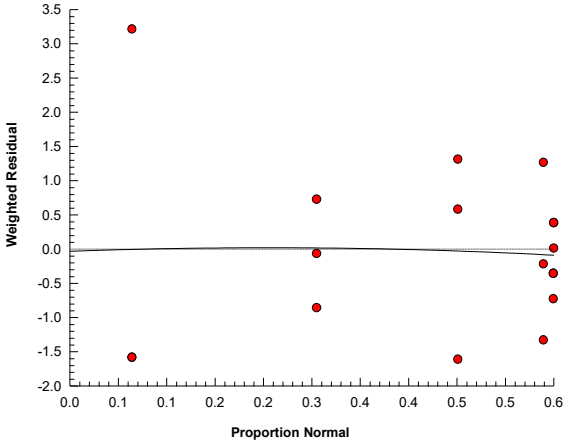
Graphics

Log-Normal: inv Φ[π]=α+β·log[x]









APPENDIX D – Analytical Chemistry Data

Nautilus Environmental
ATTN: Claudio Quinteros
4, 6125 12th Street SE
Calgary AB T2H 2K1

Date Received: 28-NOV-18
Report Date: 03-DEC-18 14:49 (MT)
Version: FINAL

Client Phone: 403-253-7121

Certificate of Analysis

Lab Work Order #: L2203118
Project P.O. #: PJ1819-004
Job Reference:
C of C Numbers:
Legal Site Desc:

Nelson Kwan, B.Sc.
Account Manager

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ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2203118-1 1819-0392 CD LAB CTL							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	57.2		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	17.4		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	73.0		0.30	mg/L		29-NOV-18	R4366842
L2203118-2 1819-0392 CD SITE CTL							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	41.0		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	8.35		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	8.80		0.30	mg/L		29-NOV-18	R4366842
L2203118-3 1819-0392 CD 132 MG/L							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	86.9		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	18.3		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	162		0.30	mg/L		29-NOV-18	R4366842
L2203118-4 1819-0392 CD 198 MG/L							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	104		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	20.8		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	212		0.30	mg/L		29-NOV-18	R4366842
L2203118-5 1819-0392 CD 297 MG/L							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	130		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	27.8		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	300		0.30	mg/L		29-NOV-18	R4366842
L2203118-6 1819-0392 CD 444 MG/L							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	181		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	37.7		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2203118-6 1819-0392 CD 444 MG/L							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Sulfate (SO4)	435	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-7 1819-0392 CD 667 MG/L							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	257		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	52.1		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	658	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-8 1819-0392 CD 1000 MG/L							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	333	DLDS	0.25	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	69.4	DLDS	0.025	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	985	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-9 1819-0392 CD 1500 MG/L							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	513	DLDS	0.50	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	104	DLDS	0.050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	1470	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-10 1819-0392 CD LAB CTL							
Sampled By: CLIENT on 14-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	59.3		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	17.5		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	73.7		0.30	mg/L		29-NOV-18	R4366842
L2203118-11 1819-0392 CD SITE CTL							
Sampled By: CLIENT on 14-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	41.1		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	8.47		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	8.78		0.30	mg/L		29-NOV-18	R4366842
L2203118-12 1819-0392 CD 132 MG/L							
Sampled By: CLIENT on 14-NOV-18							
Matrix: water							
Two Total Metals by CCMS							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2203118-12 1819-0392 CD 132 MG/L							
Sampled By: CLIENT on 14-NOV-18							
Matrix: water							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	88.1		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	18.5		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	162		0.30	mg/L		29-NOV-18	R4366842
L2203118-13 1819-0392 CD 198 MG/L							
Sampled By: CLIENT on 14-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	106		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	21.5		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	212		0.30	mg/L		29-NOV-18	R4366842
L2203118-14 1819-0392 CD 297 MG/L							
Sampled By: CLIENT on 14-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	136		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	27.4		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	298	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-15 1819-0392 CD 444 MG/L							
Sampled By: CLIENT on 14-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	179		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	38.1		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	441	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-16 1819-0392 CD 667 MG/L							
Sampled By: CLIENT on 14-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	239		0.050	mg/L		02-DEC-18	R4367280
Magnesium (Mg)-Total	52.1		0.0050	mg/L		02-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	660	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-17 1819-0392 CD 1000 MG/L							
Sampled By: CLIENT on 14-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	353	DLDS	0.25	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	71.3	DLDS	0.025	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	976	DLHC	1.5	mg/L		29-NOV-18	R4366842

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2203118-17 1819-0392 CD 1000 MG/L							
Sampled By: CLIENT on 14-NOV-18							
Matrix: water							
L2203118-18 1819-0392 CD 1500 MG/L							
Sampled By: CLIENT on 14-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	512	DLDS	0.50	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	102	DLDS	0.050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	1480	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-19 1819-0392 TR LAB CTL							
Sampled By: CLIENT on 22-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	58.7		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	18.1		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	72.4		0.30	mg/L		29-NOV-18	R4366842
L2203118-20 1819-0392 TR SITE CTL							
Sampled By: CLIENT on 22-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	42.5		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	8.49		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	8.75	DLHC	0.30	mg/L		29-NOV-18	R4366842
L2203118-21 1819-0392 TR 297 MG/L							
Sampled By: CLIENT on 22-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	135		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	27.5		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	303		0.30	mg/L		29-NOV-18	R4366842
L2203118-22 1819-0392 TR 444 MG/L							
Sampled By: CLIENT on 22-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	185		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	38.0		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	445	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-23 1819-0392 TR 667 MG/L							
Sampled By: CLIENT on 22-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2203118-23 1819-0392 TR 667 MG/L							
Sampled By: CLIENT on 22-NOV-18							
Matrix: water							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	270		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	52.9		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	661	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-24 1819-0392 TR 1000 MG/L							
Sampled By: CLIENT on 22-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	339	DLDS	0.25	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	69.0	DLDS	0.025	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	1010	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-25 1819-0392 TR 1500 MG/L							
Sampled By: CLIENT on 22-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	524	DLDS	0.50	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	103	DLDS	0.050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	1480	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-26 1819-0392 TR LAB CTL							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	57.9		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	18.2		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	73.1		0.30	mg/L		29-NOV-18	R4366842
L2203118-27 1819-0392 TR SITE CTL							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	43.8		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	8.70		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	8.76		0.30	mg/L		29-NOV-18	R4366842
L2203118-28 1819-0392 TR 297 MG/L							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	142		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	28.7		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	298		0.30	mg/L		29-NOV-18	R4366842

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2203118-28 1819-0392 TR 297 MG/L							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
L2203118-29 1819-0392 TR 444 MG/L							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	184		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	39.2		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	440	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-30 1819-0392 TR 667 MG/L							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	257		0.050	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	54.6		0.0050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	653	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-31 1819-0392 TR 1000 MG/L							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	336	DLDS	0.25	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	68.9	DLDS	0.025	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	980	DLHC	1.5	mg/L		29-NOV-18	R4366842
L2203118-32 1819-0392 TR 1500 MG/L							
Sampled By: CLIENT on 07-NOV-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	484	DLDS	0.50	mg/L		01-DEC-18	R4367280
Magnesium (Mg)-Total	98.6	DLDS	0.050	mg/L		01-DEC-18	R4367280
Miscellaneous Parameters							
Sulfate (SO4)	1480	DLHC	1.5	mg/L		29-NOV-18	R4366842

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier Key:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-CL	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)
Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.			
Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.			
SO4-IC-N-CL	Water	Sulfate in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
CL	ALS ENVIRONMENTAL - CALGARY, ALBERTA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: Nautilus Environmental
4, 6125 12th Street SE
Calgary AB T2H 2K1
Contact: Claudio Quinteros

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-CL	**Water**							
Batch R4366783								
WG2942857-2 LCS		**TMRM**						
Calcium (Ca)-Total			101.6		%		80-120	30-NOV-18
Magnesium (Mg)-Total			102.0		%		80-120	30-NOV-18
WG2942857-1 MB								
Calcium (Ca)-Total			<0.050		mg/L		0.05	30-NOV-18
Magnesium (Mg)-Total			<0.0050		mg/L		0.005	30-NOV-18
Batch R4367280								
WG2942857-3 DUP		**L2203118-1**						
Calcium (Ca)-Total		57.2	56.2		mg/L	1.6	20	01-DEC-18
Magnesium (Mg)-Total		17.4	17.7		mg/L	1.2	20	01-DEC-18
WG2942857-6 DUP		**L2203118-21**						
Calcium (Ca)-Total		135	141		mg/L	4.4	20	01-DEC-18
Magnesium (Mg)-Total		27.5	28.0		mg/L	2.0	20	01-DEC-18
WG2942857-5 LCS		**TMRM**						
Calcium (Ca)-Total			102.6		%		80-120	01-DEC-18
Magnesium (Mg)-Total			102.0		%		80-120	01-DEC-18
WG2942857-4 MB								
Calcium (Ca)-Total			<0.050		mg/L		0.05	01-DEC-18
Magnesium (Mg)-Total			<0.0050		mg/L		0.005	01-DEC-18
WG2942857-11 MS		**L2203118-2**						
Calcium (Ca)-Total			N/A	MS-B	%		-	01-DEC-18
Magnesium (Mg)-Total			115.9		%		70-130	01-DEC-18
SO4-IC-N-CL	**Water**							
Batch R4366842								
WG2943907-3 DUP		**L2203118-20**						
Sulfate (SO4)		8.75	8.72		mg/L	0.3	20	29-NOV-18
WG2943907-7 DUP		**L2203118-27**						
Sulfate (SO4)		8.76	8.91		mg/L	1.7	20	29-NOV-18
WG2943907-10 LCS								
Sulfate (SO4)			102.9		%		90-110	29-NOV-18
WG2943907-2 LCS								
Sulfate (SO4)			105.2		%		90-110	29-NOV-18
WG2943907-6 LCS								
Sulfate (SO4)			102.5		%		90-110	29-NOV-18
WG2943907-1 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	29-NOV-18
WG2943907-5 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	29-NOV-18

[redacted]

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SO4-IC-N-CL	**Water**							
Batch R4366842								
WG2943907-9 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	29-NOV-18
WG2943907-4 MS		**L2203118-20**						
Sulfate (SO4)			98.2		%		75-125	29-NOV-18
WG2943907-8 MS		**L2203118-27**						
Sulfate (SO4)			95.7		%		75-125	29-NOV-18

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental

www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L2203118-COFC

COC Number: 17 -

Page of

Report To	Contact and company name below will appear on the final report
Company:	Nautilus Environmental
Contact:	Claudio Quinteros
Phone:	403-253-7121
	Company address below will appear on the final report
Street:	4 6125 12th Street SE
City/Province:	Calgary, AB
Postal Code:	T2H 2K1
Invoice To	Same as Report To ☑ YES ☐ NO
	Copy of Invoice with Report ☐ YES ☐ NO
Company:	
Contact:	

Project Information

ALS Account # / Quote #:	
Job #:	
PO / AFE:	PJ1819-004
LSD:	

ALS Lab Work Order # (lab use only):

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☐ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax	claudio@nautilusenvironmental.ca
Email 2	
Email 3	

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax	abaccounts@nautilusenvironmental.ca
Email 2	abar@nautilusenvironmental.ca

Oil and Gas Required Fields (client use)

AFE/Cost Center:	PO#
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	

ALS Contact: **Sampler:**

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4-20%] ☐ | 3 day [P3-25%] ☐ | 2 day [P2-50%] ☐

EMERGENCY: 1 Business day [E - 100%] ☐ | Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply)] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	Total Sulphate	Total Mg	Total Ca	SAMPLES ON HOLD	SUSPECTED HAZARD (see Special Instructions)
1	1819-0392 CD Lab CTL	7-Nov-18		Water	2	R	R	R		
2	1819-0392 CD Site CTL	7-Nov-18		Water	2	R	R	R		
3	1819-0392 CD 132 mg/L	7-Nov-18		Water	2	R	R	R		
4	1819-0392 CD 198 mg/L	7-Nov-18		Water	2	R	R	R		
5	1819-0392 CD 297 mg/L	7-Nov-18		Water	2	R	R	R		
6	1819-0392 CD 444 mg/L	7-Nov-18		Water	2	R	R	R		
7	1819-0392 CD 667 mg/L	7-Nov-18		Water	2	R	R	R		
8	1819-0392 CD 1000 mg/L	7-Nov-18		Water	2	R	R	R		
9	1819-0392 CD 1500 mg/L	7-Nov-18		Water	2	R	R	R		

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☐ NO

Are samples for human consumption/ use? ☐ YES ☐ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
2					

SHIPMENT RELEASE (client use)		
Released by:	Date:	Time:

INITIAL SHIPMENT RECEPTION (lab use only)		
Received by:	Date: 1	Time: 705

FINAL SHIPMENT RECEPTION (lab use only)		
Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental

www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L2203118-COFC

COC Number: 17 -

Page of

Report To	Contact and company name below will appear on the final report
Company:	Nautilus Environmental
Contact:	Claudio Quinteros
Phone:	403-253-7121
	Company address below will appear on the final report
Street:	4 6125 12th Street SE
City/Province:	Calgary, AB
Postal Code:	T2H 2K1
Invoice To	Same as Report To ☑ YES ☐ NO
	Copy of Invoice with Report ☐ YES ☐ NO
Company:	
Contact:	

Project Information

ALS Account # / Quote #:	
Job #:	
PO / AFE:	PJ1819-004
LSD:	

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☐ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: claudio@nautilusenvironmental.ca

Email 2:

Email 3:

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: abaccounts@nautilusenvironmental.ca

Email 2: abar@nautilusenvironmental.ca

Oil and Gas Required Fields (client use)

AFE/Cost Center:	PO#
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	

ALS Lab Work Order # (lab use only):

ALS Contact:

Sampler:

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4-20%] ☐ | 3 day [P3-25%] ☐ | 2 day [P2-50%] ☐

EMERGENCY: 1 Business day [E - 100%] ☐ | Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply)] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	Total Sulphate	Total Mg	Total Ca	SAMPLES ON HOLD	SUSPECTED HAZARD (see Special Instructions)
10	1819-0392 CD Lab CTL	14-Nov-18		Water	2	R	R	R		
11	1819-0392 CD Site CTL	14-Nov-18		Water	2	R	R	R		
12	1819-0392 CD 132 mg/L	14-Nov-18		Water	2	R	R	R		
13	1819-0392 CD 198 mg/L	14-Nov-18		Water	2	R	R	R		
14	1819-0392 CD 297 mg/L	14-Nov-18		Water	2	R	R	R		
15	1819-0392 CD 444 mg/L	14-Nov-18		Water	2	R	R	R		
16	1819-0392 CD 667 mg/L	14-Nov-18		Water	2	R	R	R		
17	1819-0392 CD 1000 mg/L	14-Nov-18		Water	2	R	R	R		
18	1819-0392 CD 1500 mg/L	14-Nov-18		Water	2	R	R	R		

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☐ NO

Are samples for human consumption/ use? ☐ YES ☐ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C				FINAL COOLER TEMPERATURES °C			
2							

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date: 17/26	Time: 1:18	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L2203118-COFC

COC Number: 17 -

Page of

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Contact:	Claudio Quinteros
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	Company address below will appear on the final report
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City/Province:	Calgary, AB
Postal Code:	T2H 2K1
Invoice To	Same as Report To ☑ YES ☐ NO
	Copy of Invoice with Report ☐ YES ☐ NO
Company:	
Contact:	

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☐ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax claudio@nautilusenvironmental.ca
Email 2
Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax abaccounts@nautilusenvironmental.ca
Email 2 abar@nautilusenvironmental.ca

Project Information

ALS Account # / Quote #:
Job #:
PO / AFE: PJ1819-004
LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#
Major/Minor Code: Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only):

ALS Contact: **Sampler:**

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4-20%] ☐ | 3 day [P3-25%] ☐ | 2 day [P2-50%] ☐

EMERGENCY: 1 Business day [E - 100%] ☐ | Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply)] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	Total Sulphate	Total Mg	Total Ca	SAMPLES ON HOLD	SUSPECTED HAZARD (see Special Instructions)
						P				
19	1819-0392 TR Lab CTL	22-Nov-18		Water	2	R	R	R		
20	1819-0392 TR Site CTL	22-Nov-18		Water	2	R	R	R		
21	1819-0392 TR 297 mg/L	22-Nov-18		Water	2	R	R	R		
22	1819-0392 TR 444 mg/L	22-Nov-18		Water	2	R	R	R		
23	1819-0392 TR 667 mg/L	22-Nov-18		Water	2	R	R	R		
24	1819-0392 TR 1000 mg/L	22-Nov-18		Water	2	R	R	R		
25	1819-0392 TR 1500 mg/L	22-Nov-18		Water	2	R	R	R		

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☐ NO
Are samples for human consumption/ use? ☐ YES ☐ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☑ | SIF Observations Yes ☐ No ☐
Ice Packs ☑ Ice Cubes ☐ | Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C				FINAL COOLER TEMPERATURES °C			
2							

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date: 11/25	Time: 1205	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental

www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L2203118-COFC

COC Number: 17 -

Page of

Report To	Contact and company name below will appear on the final report
Company:	Nautilus Environmental
Contact:	Claudio Quinteros
Phone:	403-253-7121
	Company address below will appear on the final report
Street:	4 6125 12th Street SE
City/Province:	Calgary, AB
Postal Code:	T2H 2K1
Invoice To	Same as Report To ☑ YES ☐ NO
	Copy of Invoice with Report ☐ YES ☐ NO
Company:	
Contact:	

Project Information

ALS Account # / Quote #:	
Job #:	
PO / AFE:	PJ1819-004
LSD:	

ALS Lab Work Order # (lab use only):

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☐ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: claudio@nautilusenvironmental.ca

Email 2:

Email 3:

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: abaccounts@nautilusenvironmental.ca

Email 2: abar@nautilusenvironmental.ca

Oil and Gas Required Fields (client use)

AFE/Cost Center:	PO#
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	

ALS Contact: **Sampler:**

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)
- 4 day [P4-20%] ☐
- 3 day [P3-25%] ☐
- 2 day [P2-50%] ☐

EMERGENCY
- 1 Business day [E - 100%] ☐
- Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply)] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	Total Sulphate	Total Mg	Total Ca	SAMPLES ON HOLD	SUSPECTED HAZARD (see Special Instructions)
26	1819-0392 TR Lab CTL	7-Nov-18		Water	2	R	R	R		
27	1819-0392 TR Site CTL	7-Nov-18		Water	2	R	R	R		
28	1819-0392 TR 297 mg/L	7-Nov-18		Water	2	R	R	R		
29	1819-0392 TR 444 mg/L	7-Nov-18		Water	2	R	R	R		
30	1819-0392 TR 667 mg/L	7-Nov-18		Water	2	R	R	R		
31	1819-0392 TR 1000 mg/L	7-Nov-18		Water	2	R	R	R		
32	1819-0392 TR 1500 mg/L	7-Nov-18		Water	2	R	R	R		

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☐ NO

Are samples for human consumption/ use? ☐ YES ☐ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C				FINAL COOLER TEMPERATURES °C			
2							

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date: 11/25	Time: 10:3	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

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1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Nautilus Environmental
ATTN: Claudio Quinteros
4, 6125 12th Street SE
Calgary AB T2H 2K1

Date Received: 17-DEC-18
Report Date: 23-DEC-18 16:56 (MT)
Version: FINAL

Client Phone: 403-253-7121

Certificate of Analysis

Lab Work Order #: L2211474
Project P.O. #: PJ1819-004
Job Reference:
C of C Numbers:
Legal Site Desc:

Nelson Kwan, B.Sc.
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2211474-1 1819-0392 TR LAB CTL							
Sampled By: CLIENT on 07-DEC-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	61.4		0.050	mg/L		20-DEC-18	R4407187
Magnesium (Mg)-Total	18.2		0.0050	mg/L		20-DEC-18	R4407187
Miscellaneous Parameters							
Sulfate (SO4)	78.6		0.30	mg/L		19-DEC-18	R4412217
L2211474-2 1819-0392 TR SITE CTL							
Sampled By: CLIENT on 07-DEC-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	44.0		0.050	mg/L		20-DEC-18	R4407187
Magnesium (Mg)-Total	8.53		0.0050	mg/L		20-DEC-18	R4407187
Miscellaneous Parameters							
Sulfate (SO4)	9.56		0.30	mg/L		19-DEC-18	R4412217
L2211474-3 1819-0392 TR 297 MG/L							
Sampled By: CLIENT on 07-DEC-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	145		0.050	mg/L		20-DEC-18	R4407187
Magnesium (Mg)-Total	27.5		0.0050	mg/L		20-DEC-18	R4407187
Miscellaneous Parameters							
Sulfate (SO4)	331		0.30	mg/L		19-DEC-18	R4412217
L2211474-4 1819-0392 TR 444 MG/L							
Sampled By: CLIENT on 07-DEC-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	203		0.050	mg/L		20-DEC-18	R4407187
Magnesium (Mg)-Total	38.0		0.0050	mg/L		20-DEC-18	R4407187
Miscellaneous Parameters							
Sulfate (SO4)	494	DLHC	1.5	mg/L		19-DEC-18	R4412217
L2211474-5 1819-0392 TR 667 MG/L							
Sampled By: CLIENT on 07-DEC-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	281		0.050	mg/L		20-DEC-18	R4407187
Magnesium (Mg)-Total	53.7		0.0050	mg/L		20-DEC-18	R4407187
Miscellaneous Parameters							
Sulfate (SO4)	752	DLHC	1.5	mg/L		19-DEC-18	R4412217
L2211474-6 1819-0392 TR 1000 MG/L							
Sampled By: CLIENT on 07-DEC-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	296		0.050	mg/L		20-DEC-18	R4407187
Magnesium (Mg)-Total	54.7		0.0050	mg/L		20-DEC-18	R4407187
Miscellaneous Parameters							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2211474-6 1819-0392 TR 1000 MG/L							
Sampled By: CLIENT on 07-DEC-18							
Matrix: water							
Sulfate (SO4)	749	DLHC	1.5	mg/L		19-DEC-18	R4412217
L2211474-7 1819-0392 TR 1500 MG/L							
Sampled By: CLIENT on 07-DEC-18							
Matrix: water							
Two Total Metals by CCMS							
Total Metals in Water by CRC ICPMS							
Calcium (Ca)-Total	424		0.050	mg/L		20-DEC-18	R4407187
Magnesium (Mg)-Total	76.4		0.0050	mg/L		20-DEC-18	R4407187
Miscellaneous Parameters							
Sulfate (SO4)	1110	DLHC	1.5	mg/L		19-DEC-18	R4412217

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier Key:

Qualifier	Description
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-CL	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

SO4-IC-N-CL	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
CL	ALS ENVIRONMENTAL - CALGARY, ALBERTA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L2211474 Report Date: 23-DEC-18

Client: Nautilus Environmental
4, 6125 12th Street SE
Calgary AB T2H 2K1
Contact: Claudio Quinteros

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-CL	**Water**							
Batch R4407187								
WG2957387-4 DUP		**L2211474-1**						
Calcium (Ca)-Total		61.4	63.4		mg/L	3.2	20	20-DEC-18
Magnesium (Mg)-Total		18.2	17.8		mg/L	2.4	20	20-DEC-18
WG2957387-2 LCS		**TMRM**						
Calcium (Ca)-Total			94.0		%		80-120	20-DEC-18
Magnesium (Mg)-Total			89.8		%		80-120	20-DEC-18
WG2957387-1 MB								
Calcium (Ca)-Total			<0.050		mg/L		0.05	20-DEC-18
Magnesium (Mg)-Total			<0.0050		mg/L		0.005	20-DEC-18
WG2957387-9 MS		**L2211474-7**						
Calcium (Ca)-Total			N/A	MS-B	%		-	20-DEC-18
Magnesium (Mg)-Total			N/A	MS-B	%		-	20-DEC-18
SO4-IC-N-CL	**Water**							
Batch R4412217								
WG2960045-2 LCS								
Sulfate (SO4)			98.2		%		90-110	19-DEC-18
WG2960045-1 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	19-DEC-18

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

L2211474-COFC

COC Number: 17 -

Page of

Report To	Contact and company name below will appear on the final report
Company:	Nautilus Environmental
Contact:	Claudio Quinteros
Phone:	403-253-7121
	Company address below will appear on the final report
Street:	4 6125 12th Street SE
City/Province:	Calgary, AB
Postal Code:	T2H 2K1
Invoice To	Same as Report To ☑ YES ☐ NO
	Copy of Invoice with Report ☐ YES ☐ NO
Company:	
Contact:	

Report Format / Distribution	
Select Report Format:	☑ PDF ☐ EXCEL ☐ EDD (DIGITAL)
Quality Control (QC) Report with Report	☑ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked	
Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax	claudio@nautilusenvironmental.ca
Email 2	
Email 3	

Invoice Distribution	
Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax	abaccounts@nautilusenvironmental.ca
Email 2	abar@nautilusenvironmental.ca

Project Information		Oil and Gas Required Fields (client use)	
ALS Account # / Quote #:		AFE/Cost Center:	PO#
Job #:		Major/Minor Code:	Routing Code:
PO / AFE:	PJ1819-004	Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only):		ALS Contact:	Sampler:

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)
- 4 day [P4-20%] ☐
- 3 day [P3-25%] ☐
- 2 day [P2-50%] ☐

EMERGENCY
- 1 Business day [E - 100%] ☐
- Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply)] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	Total Sulphate	Total Mg	Total Ca	SAMPLES ON HOLD	SUSPECTED HAZARD (see Special Instructions)
	1819-0392 TR Lab CTL	7-Dec-18		Water	2	R	R	R		
	1819-0392 TR Site CTL	7-Dec-18		Water	2	R	R	R		
	1819-0392 TR 297 mg/L	7-Dec-18		Water	2	R	R	R		
	1819-0392 TR 444 mg/L	7-Dec-18		Water	2	R	R	R		
	1819-0392 TR 667 mg/L	7-Dec-18		Water	2	R	R	R		
	1819-0392 TR 1000 mg/L	7-Dec-18		Water	2	R	R	R		
	1819-0392 TR 1500 mg/L	7-Dec-18		Water	2	R	R	R		

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☐ NO

Are samples for human consumption/ use? ☐ YES ☐ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C				FINAL COOLER TEMPERATURES °C			
				1.6			

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by:	Date: 12/17	Time: 1:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

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1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

APPENDIX E – Chain-of-Custody Forms

TESTING LOCATION (Please Circle)

NAUTILUS ENVIRONMENTAL

Burnaby
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary
#4, 6125 12 Street SE
Calgary, Alberta, Canada
T2H 2K1
Phone 403.253.7121

Chain of Custody

Date_____Page__of__

Report to:

Company	Millennium EMS solutons ltd
Address	Suite 325, 1925-18th ave NE
City/Prov/PC	Calgary
Contact	Mike Bartlett
Phone	403-270-5008
Email	mbartlett@mems.ca

Invoice To:

Company	Same as report to
Address	
City/Prov/PC	
Contact	
Phone	
Email	
PO No.	

Sample Collection By: **Sample Type:** **Grab** ○ **OR** **Composite** ○

	SAMPLE ID	DATE (YYYY/MM/DD)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	ANALYSES REQUIRED: 30-d Oncorhynchus mykiss embryo and alevin	72-h Pseudokirchneriella subcapitata growth inhibition	5 – 8 day Ceriodaphnia dubia survival and reproduction	Receipt Temperature (°C)
1	Blairmore Creek Raw Water	2018/11/05	11:00	Water	75 X 20 L pails		X	X	X	3.6°C
2										
3										
4										
5										
6										
7										
8										
9										
10										

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers	75 x 20 L pails	4. Ice Present in Cooler?	Y / (N)
2. Courier	client off	5. Seal Present?	Y / (N)
3. Good Condition?	(Y) / N	6. Initials Present on Seal?	Y / (N)

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

DJ 2018/11/05 09L

(Printed Name) (Signature)

1515

(Company) (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

END OF REPORT

APPENDIX 5.15-1: RUNOFF COEFFICIENT = 0.51

Figure 5.15-1A: Estimated Change to Annual Discharge Volumes for Blairmore and Gold Creek (Combined Change) using Runoff Coefficient = 0.51

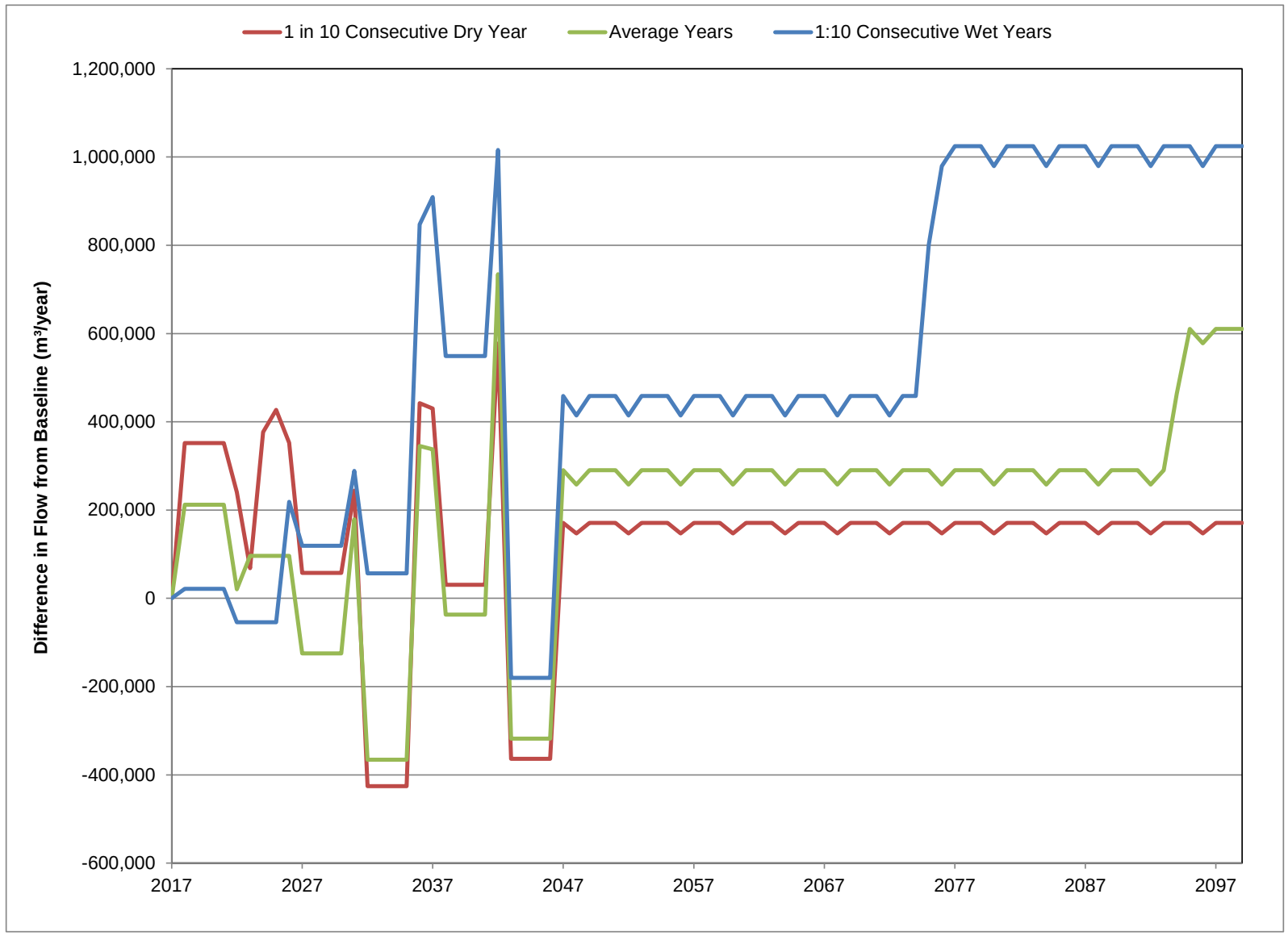


Figure 5.15-1B: Estimated Change to Annual Discharge Volumes for Blairmore and Gold Creek (Combined Change) using Runoff Coefficient = 0.41

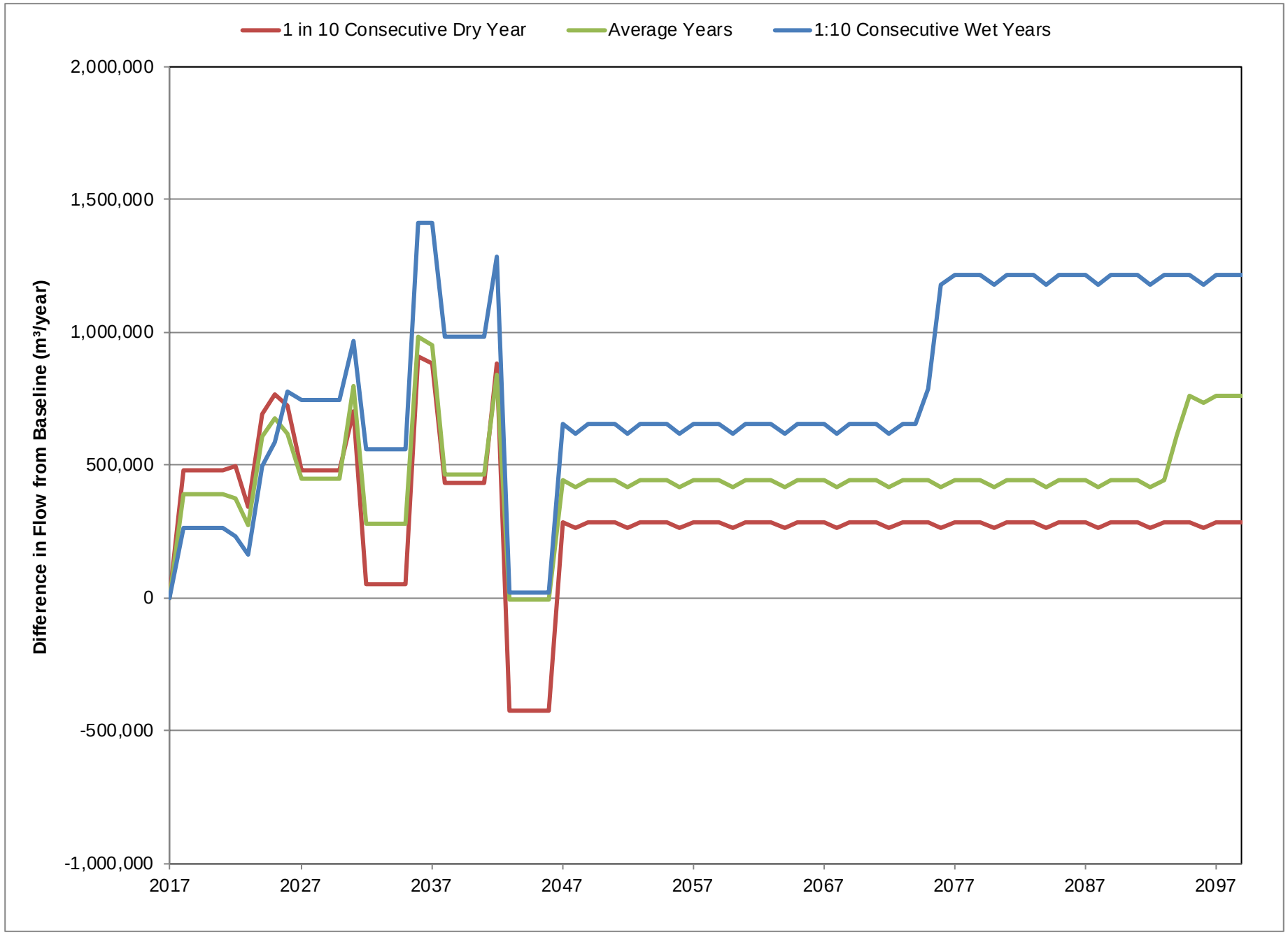


Figure 5.15-1C: Estimated Change to Annual Discharge Volumes for Blairmore and Gold Creek (Combined Change) using Runoff Coefficient = 0.61

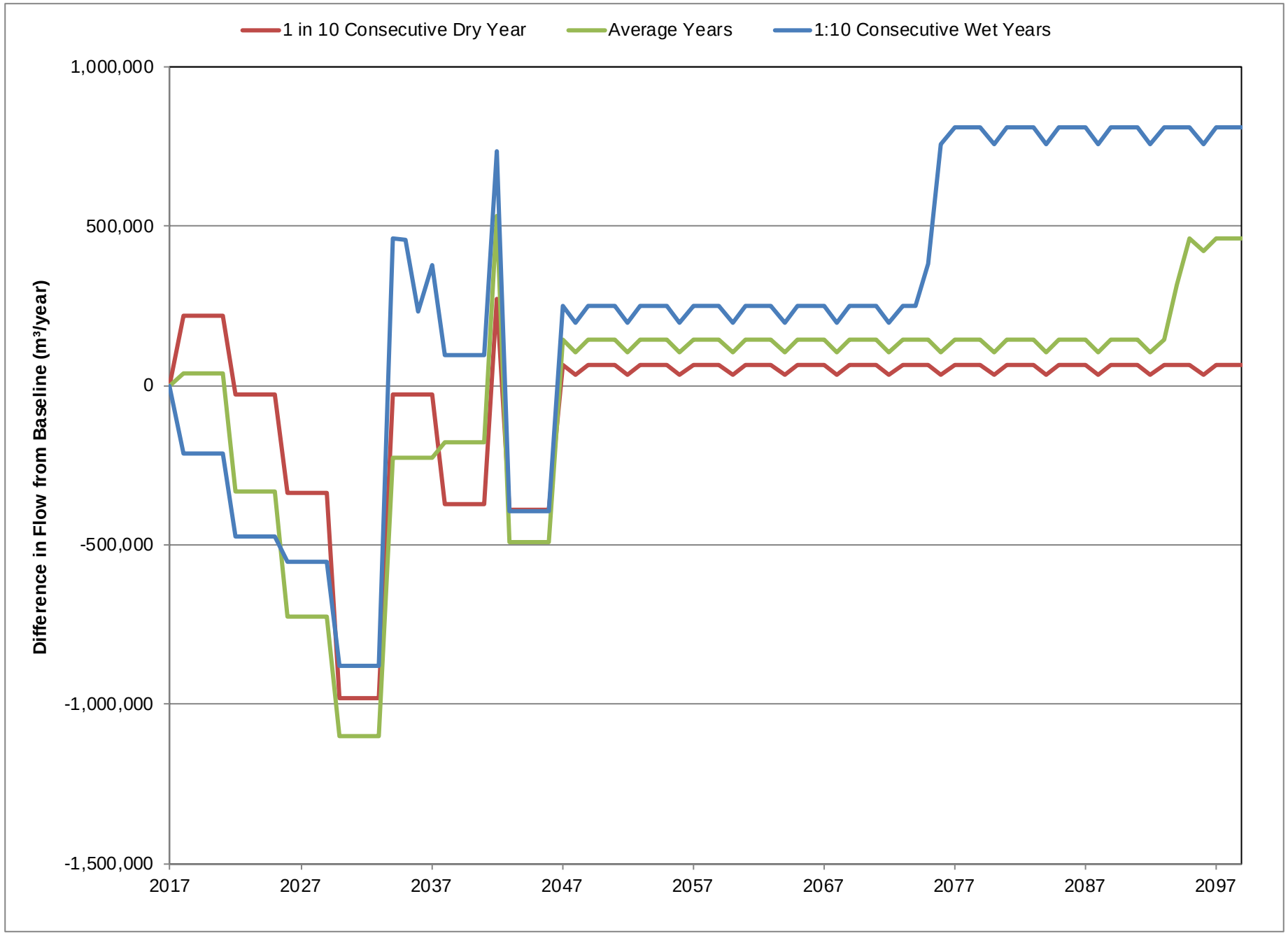


Figure 5.15-1D: Estimated Flow Changes in Gold Creek w.r.t. Baseline Flow using Runoff Coefficient of 0.51, Mean Average Precipitation

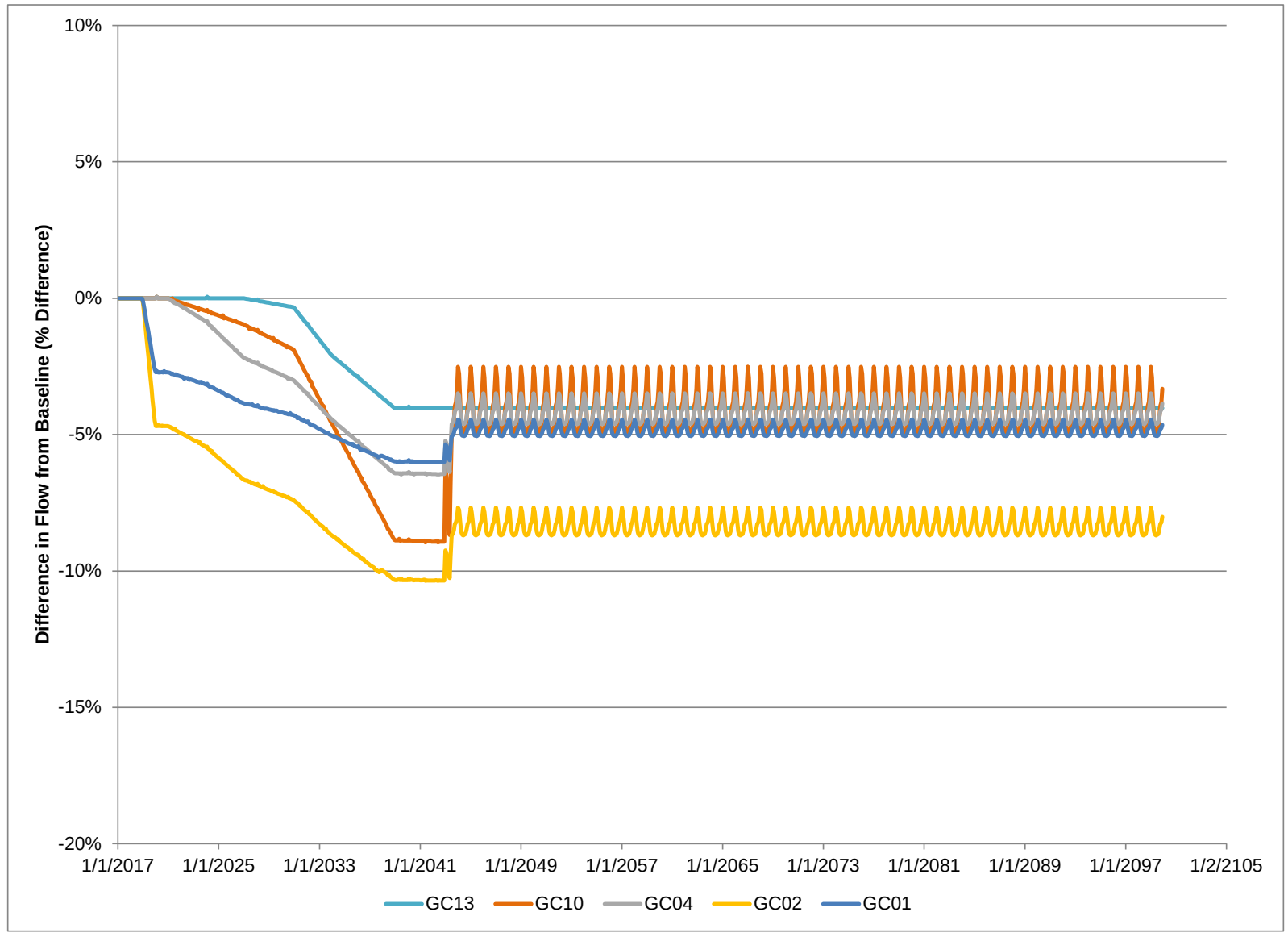


Figure 5.15-1E: Estimated Flow Changes in Gold Creek w.r.t. Baseline Flow using Runoff Coefficient of 0.41, Mean Average Precipitation

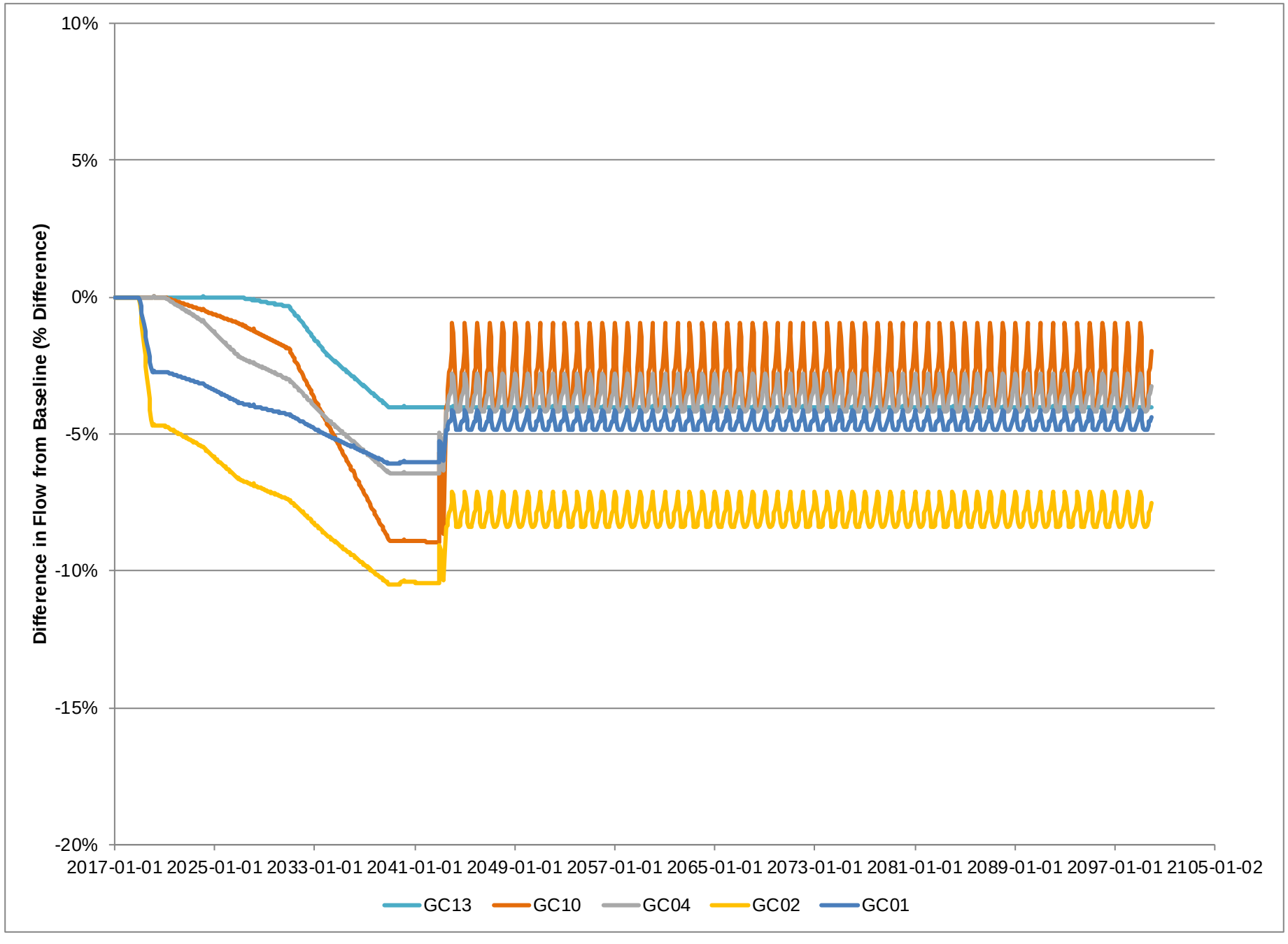


Figure 5.15-1F: Estimated Flow Changes in Gold Creek w.r.t. Baseline Flow using Runoff Coefficient of 0.61, Mean Average Precipitation

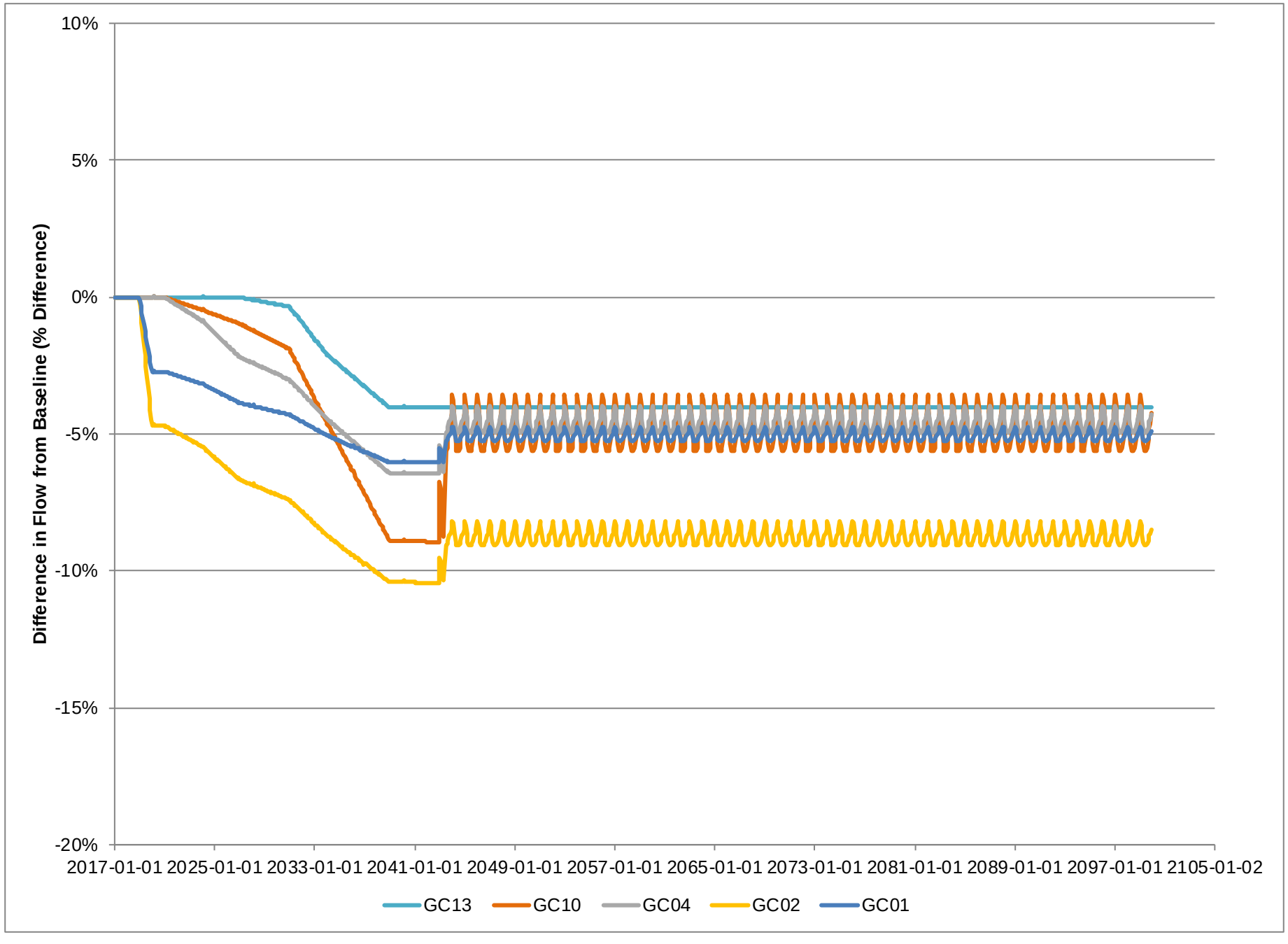


Figure 5.15-1G: Estimated Flow Changes in Gold Creek w.r.t. Baseline Flow using Runoff Coefficient of 0.51, 1 in 10 Wet Year Precipitation

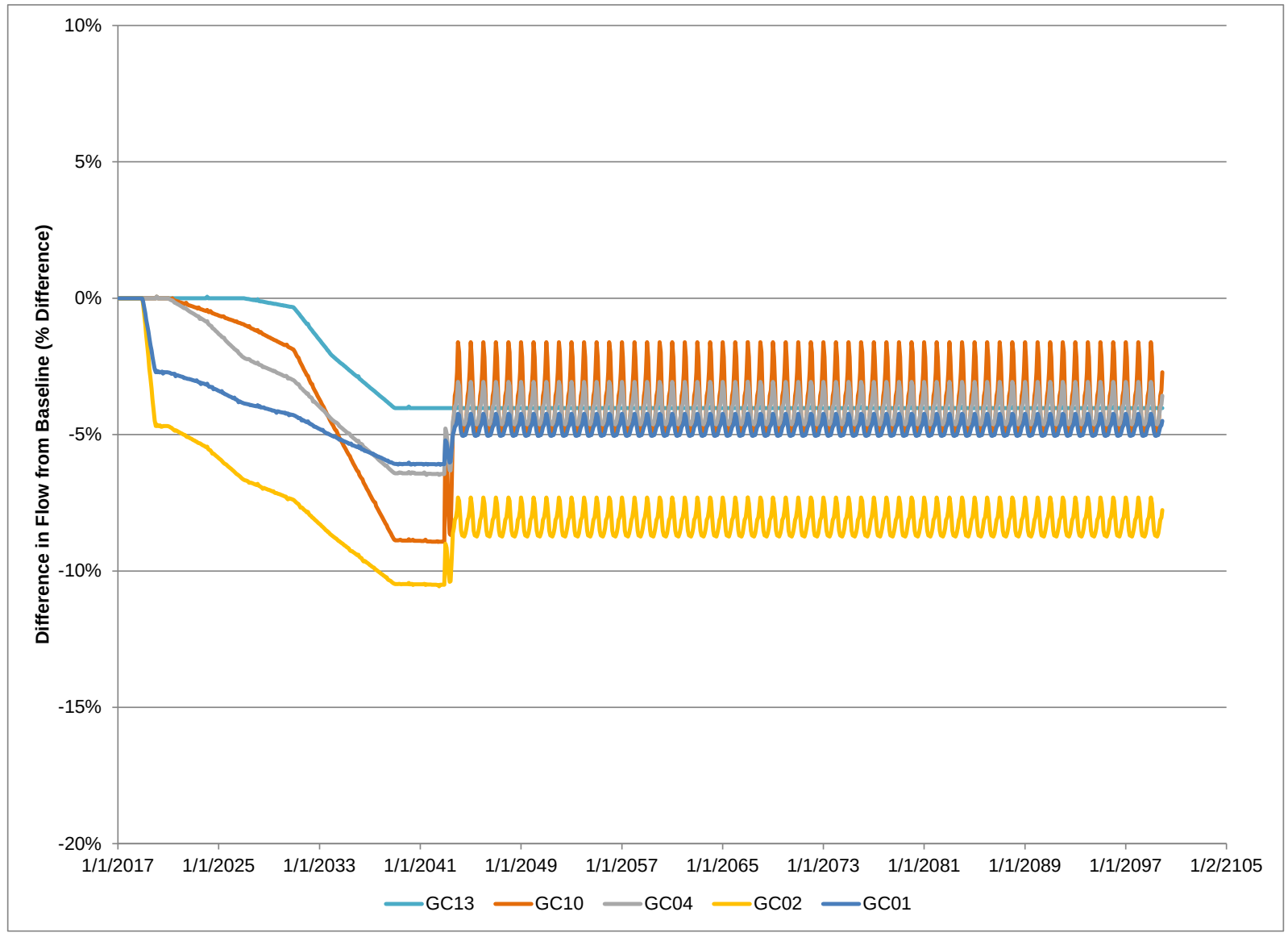


Figure 5.15-1H: Estimated Flow Changes in Gold Creek w.r.t. Baseline Flow using Runoff Coefficient of 0.41, 1 in 10 Wet Year Precipitation

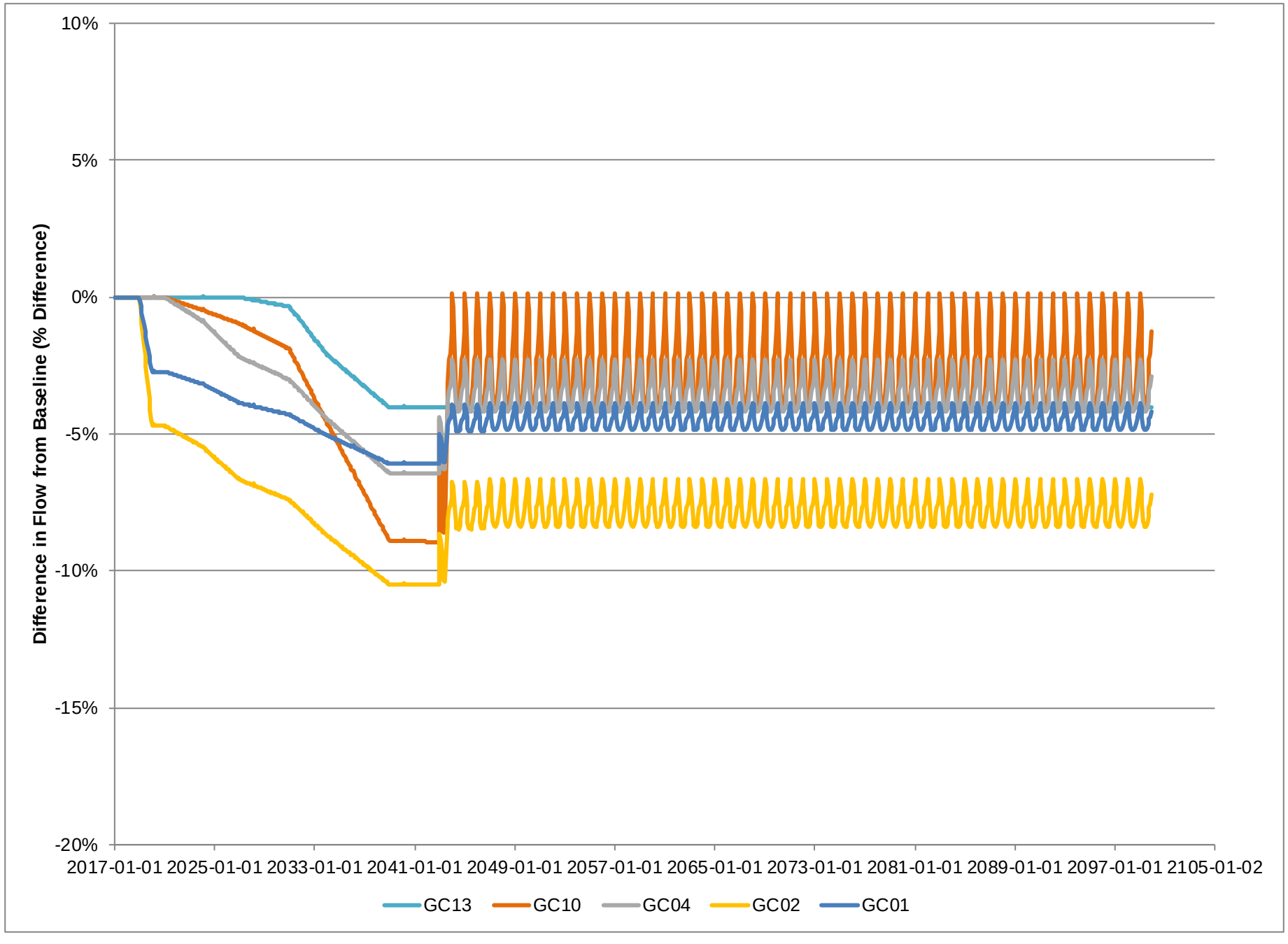


Figure 5.15-1l: Estimated Flow Changes in Gold Creek w.r.t. Baseline Flow using Runoff Coefficient of 0.61, 1 in 10 Wet Year Precipitation

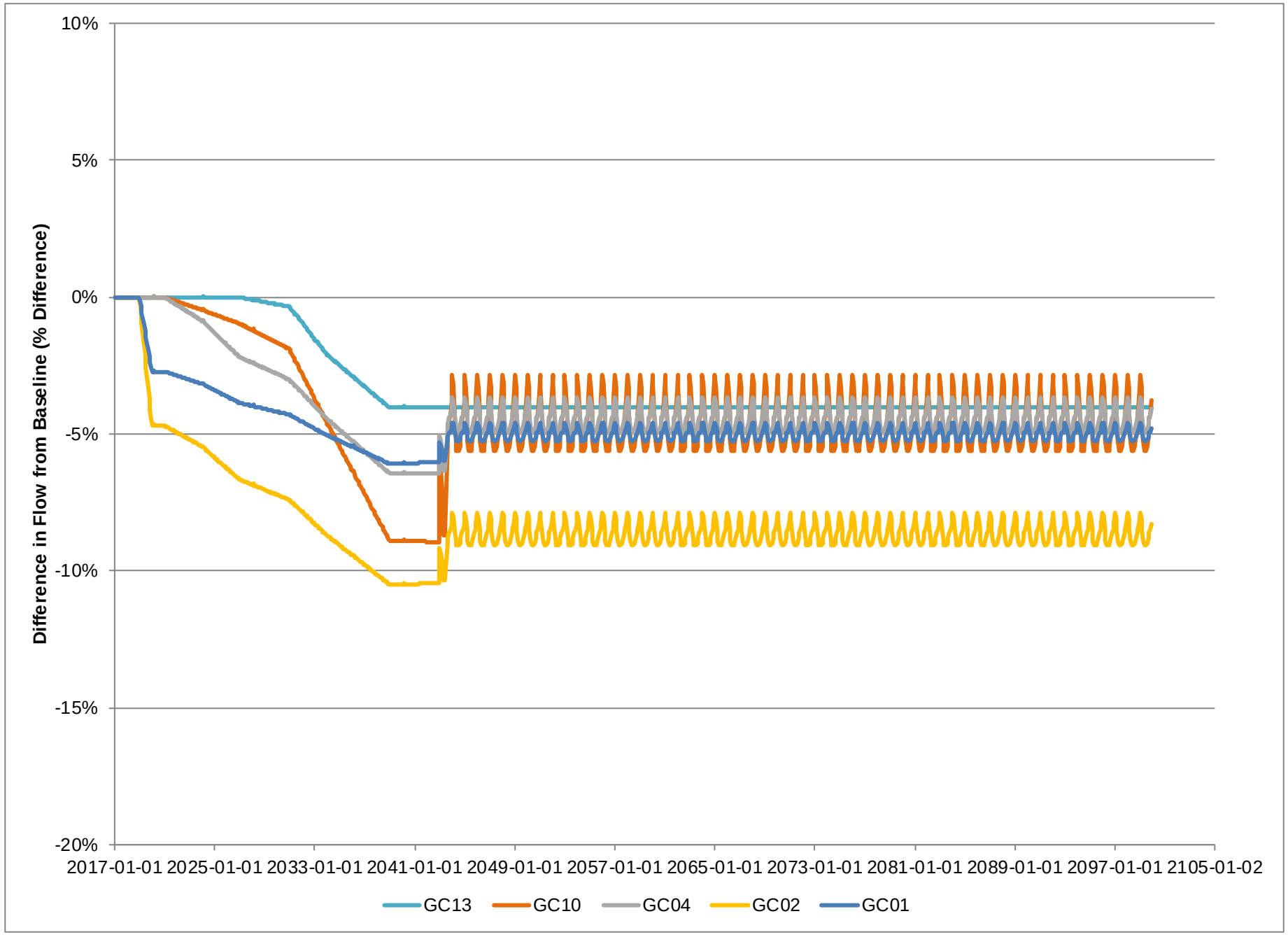


Figure 5.15-1J: Estimated Flow Changes in Gold Creek w.r.t. Baseline Flow using Runoff Coefficient of 0.51, 1 in 10 Dry Year Precipitation



Figure 5.15-1K: Estimated Flow Changes in Gold Creek w.r.t. Baseline Flow using Runoff Coefficient of 0.41, 1 in 10 Dry Year Precipitation

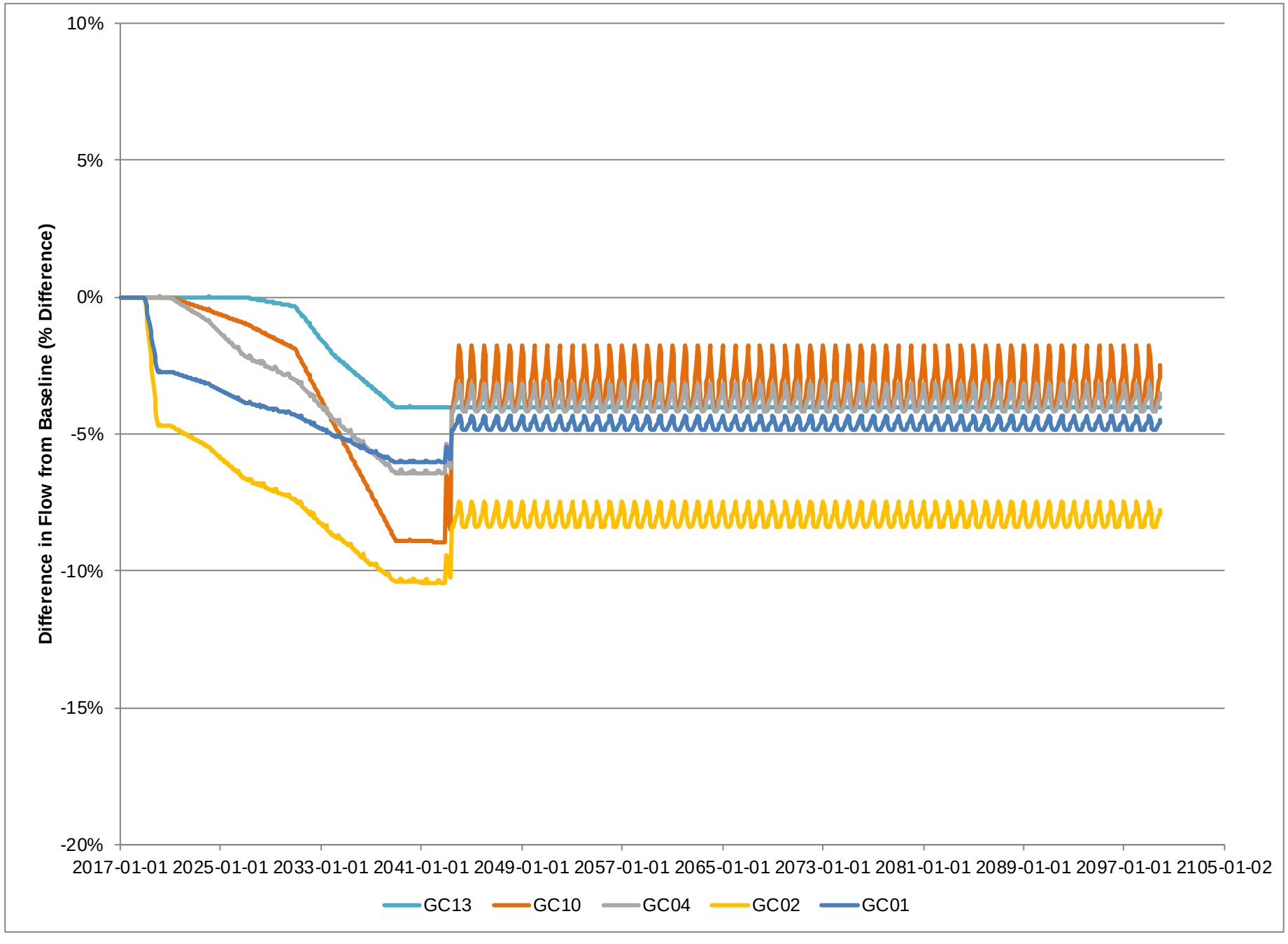


Figure 5.15-1L: Estimated Flow Changes in Gold Creek w.r.t. Baseline Flow using Runoff Coefficient of 0.61, 1 in 10 Dry Year Precipitation

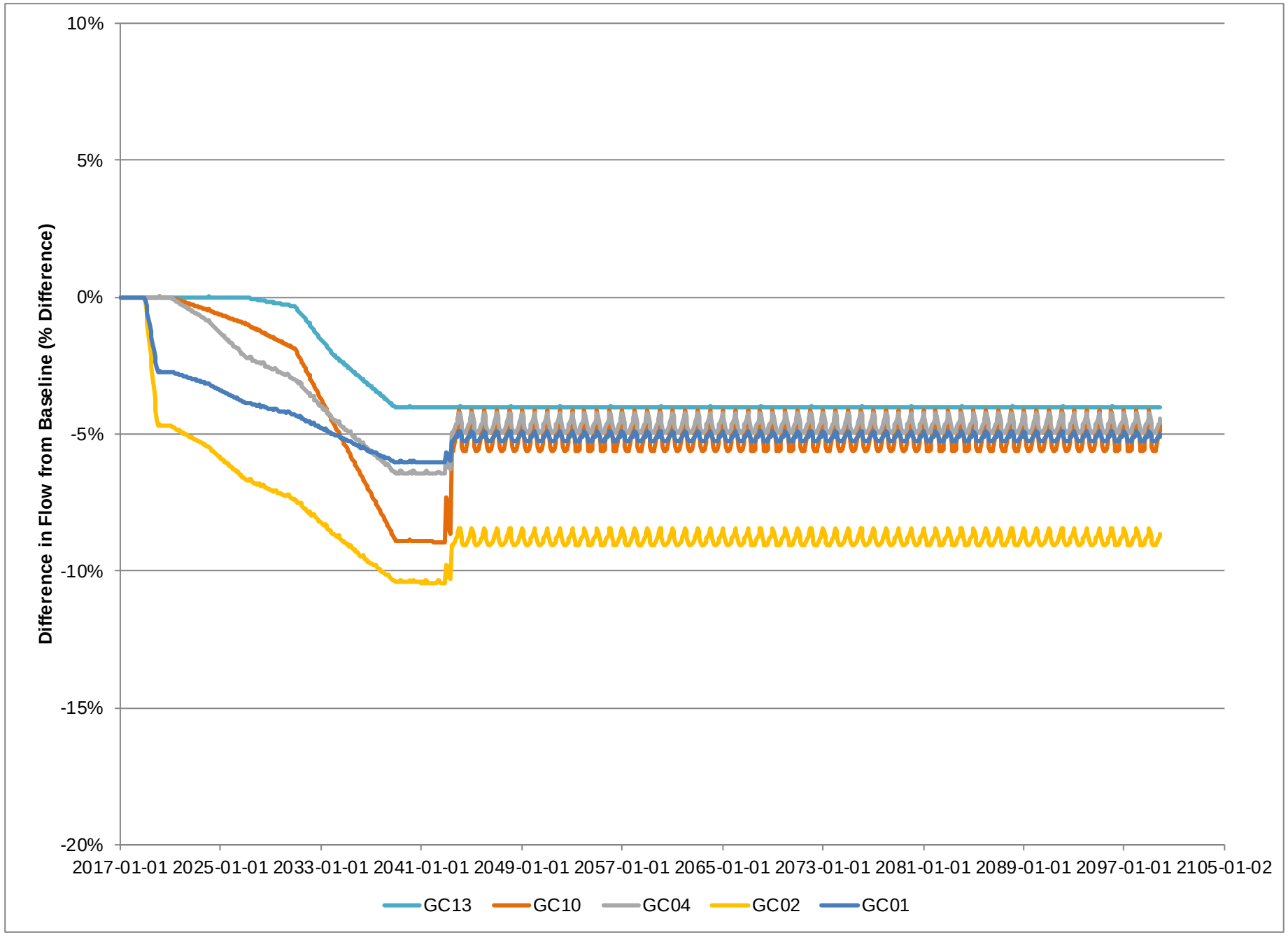


Figure 5.15-1M: Estimated Flow Changes in Blairmore Creek w.r.t. Average Flow Conditions using Runoff Coefficient of 0.51, Mean Annual Precipitation

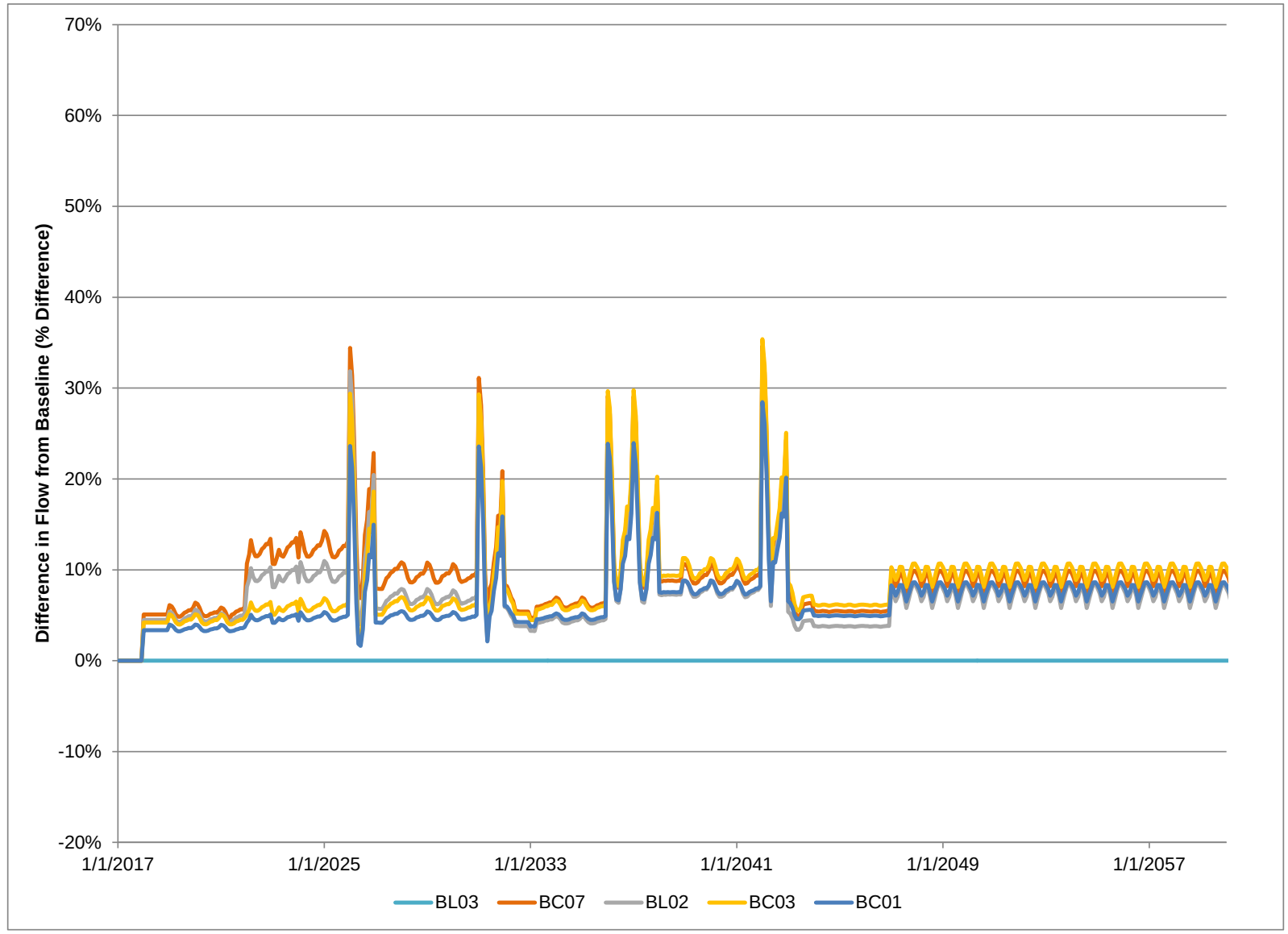


Figure 5.15-1N: Estimated Flow Changes in Blairmore Creek w.r.t. Average Flow Conditions using Runoff Coefficient of 0.41, Mean Annual Precipitation

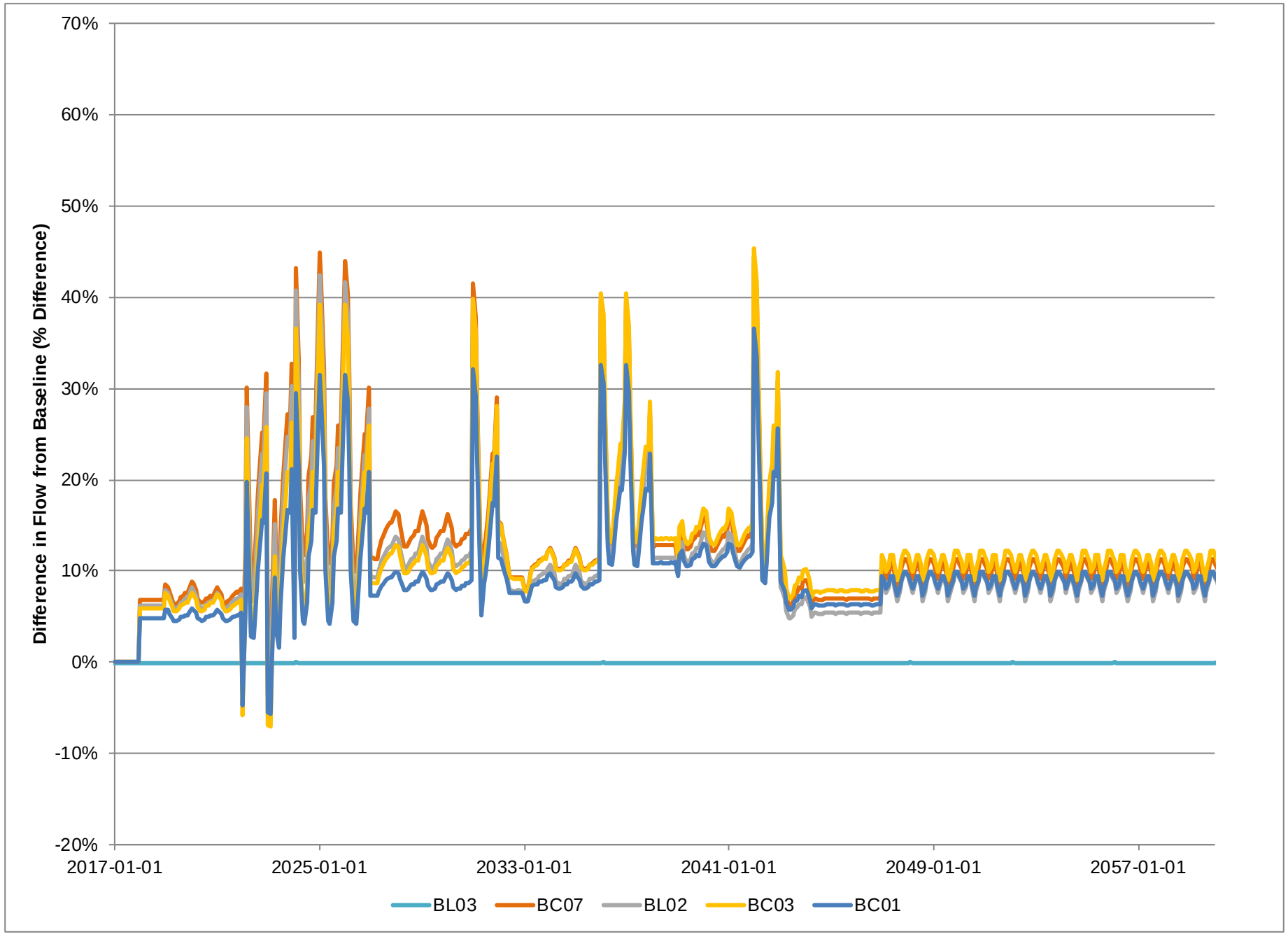


Figure 5.15-1O: Estimated Flow Changes in Blairmore Creek w.r.t. Average Flow Conditions using Runoff Coefficient of 0.61, Mean Annual Precipitation

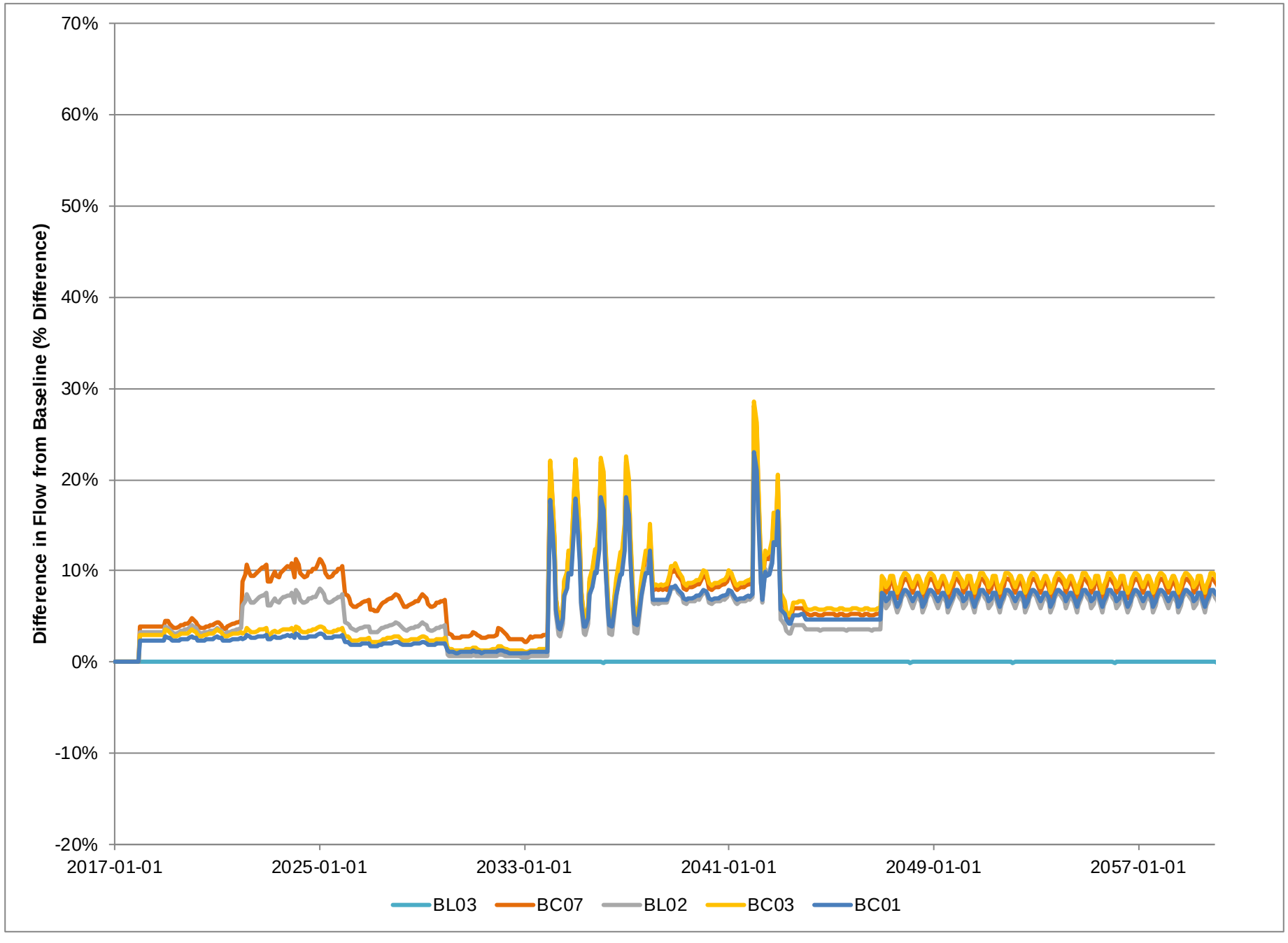


Figure 5.15-1P: Estimated Flow Changes in Blairmore Creek w.r.t. Average Flow Conditions using Runoff Coefficient of 0.51, 1 in 10 Wet Year Precipitation

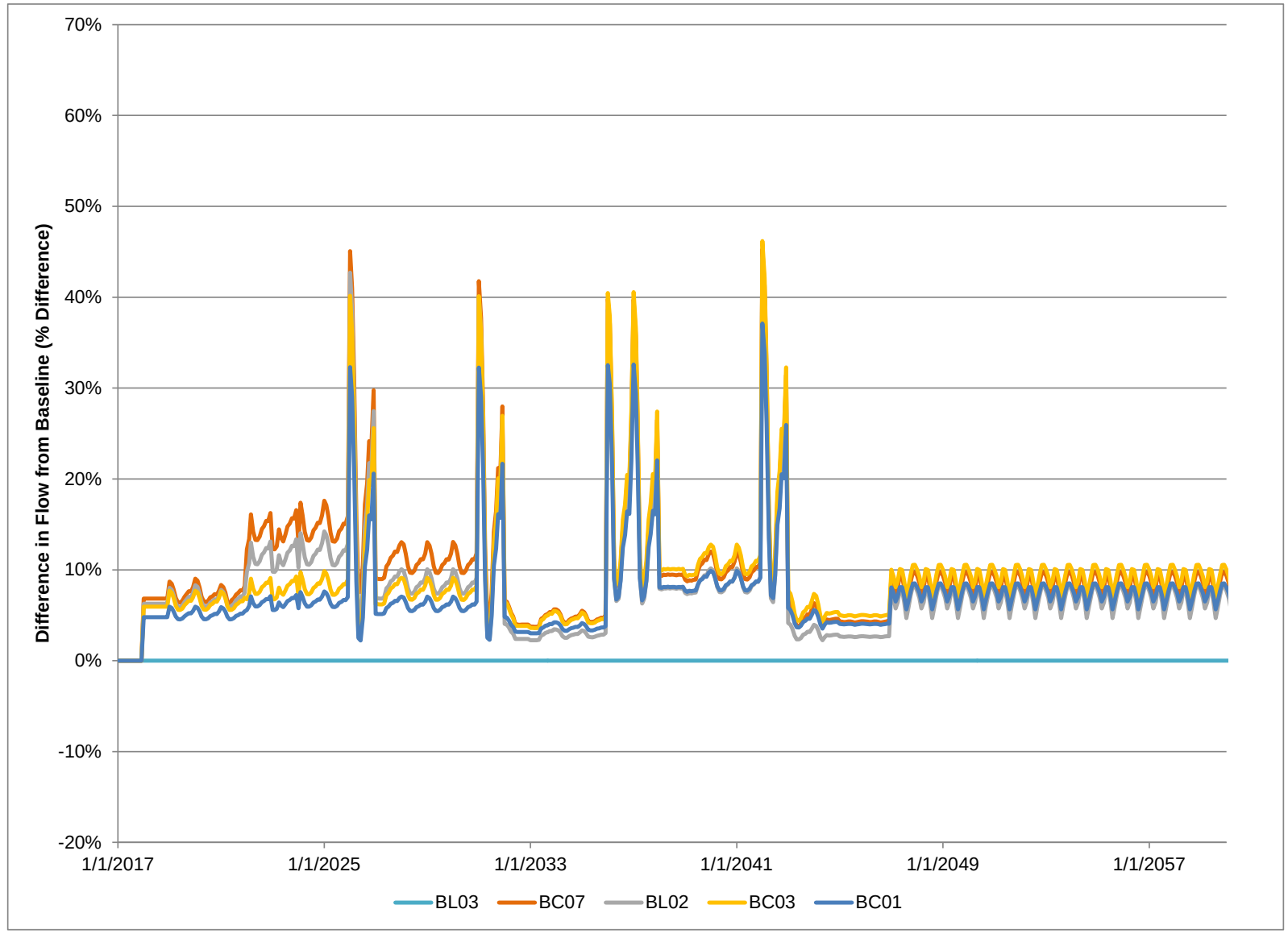


Figure 5.15-1Q: Estimated Flow Changes in Blairmore Creek w.r.t. Average Flow Conditions using Runoff Coefficient of 0.41, 1 in 10 Wet Year Precipitation

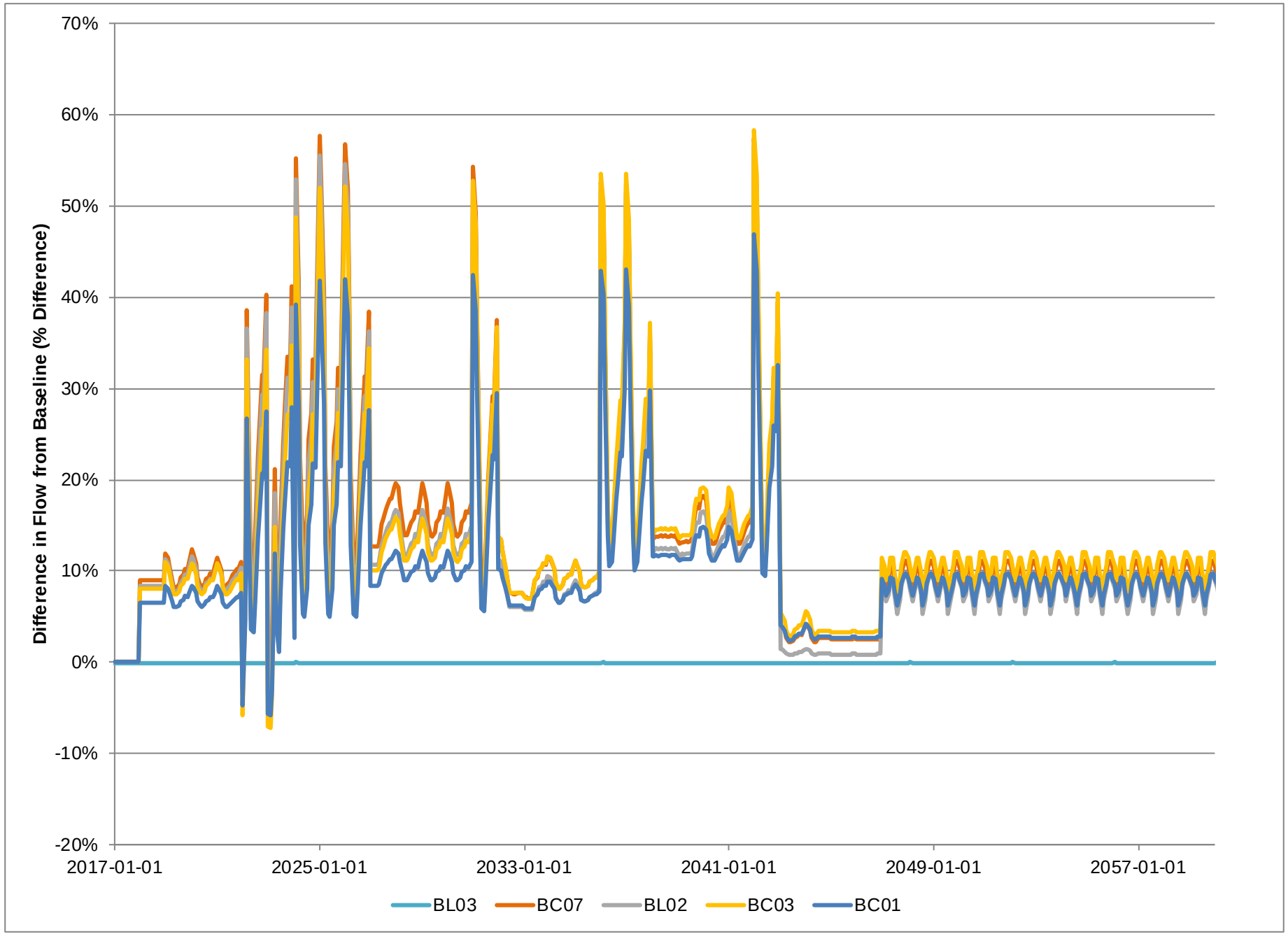


Figure 5.15-1R: Estimated Flow Changes in Blairmore Creek w.r.t. Average Flow Conditions using Runoff Coefficient of 0.61, 1 in 10 Wet Year Precipitation

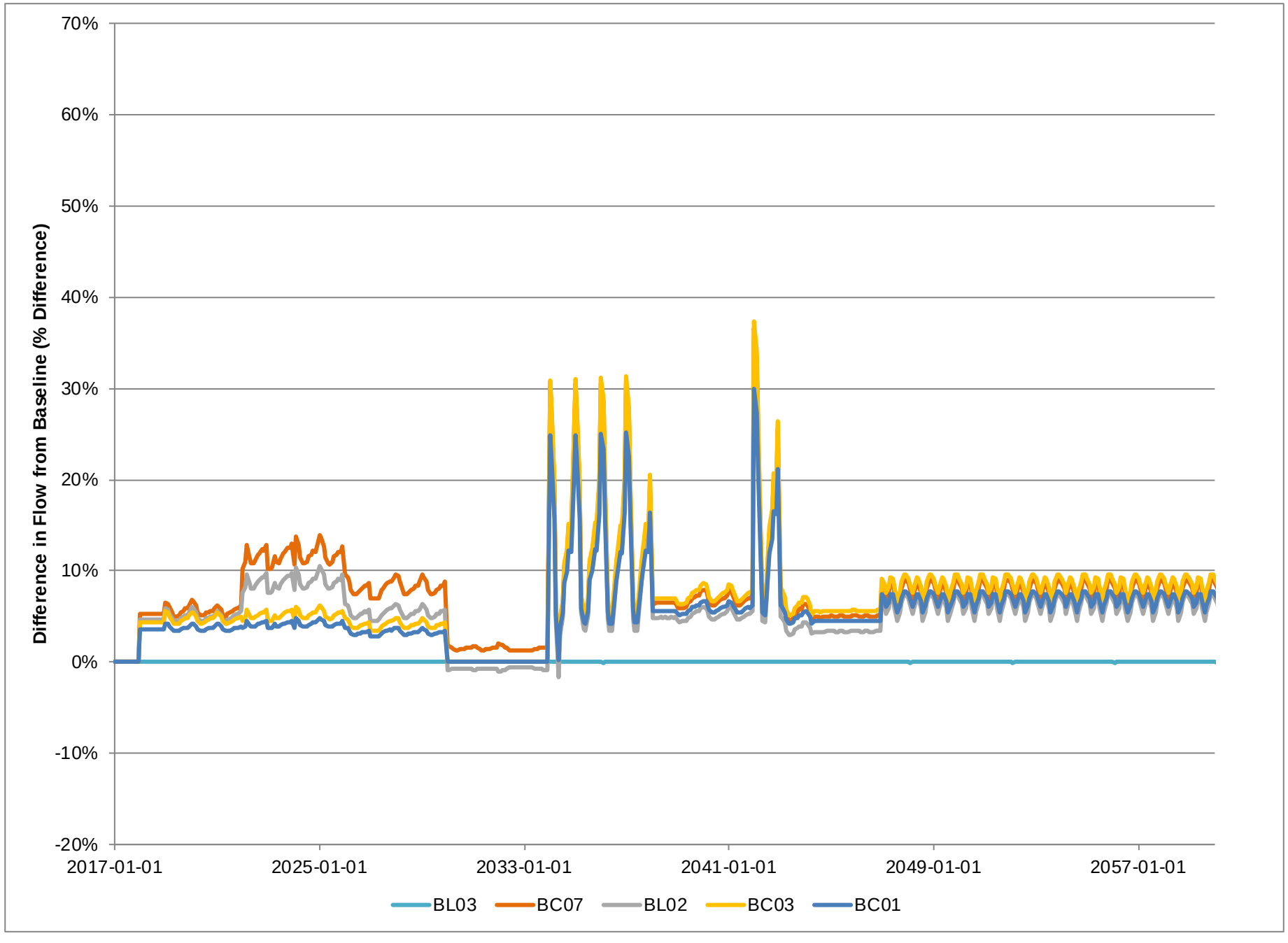


Figure 5.15-1S: Estimated Flow Changes in Blairmore Creek w.r.t. Average Flow Conditions using Runoff Coefficient of 0.51, 1 in 10 Dry Year Precipitation

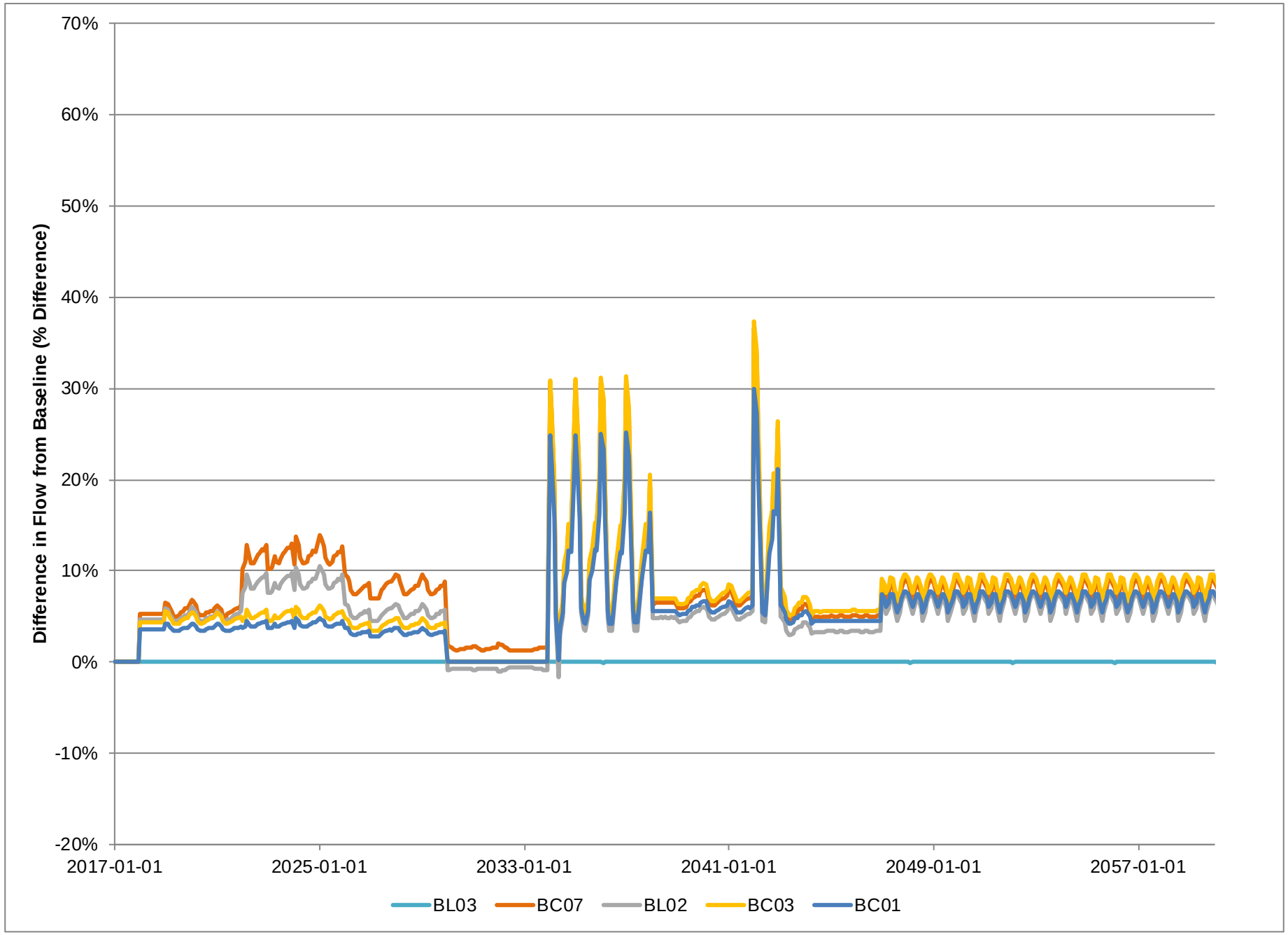


Figure 5.15-1T: Estimated Flow Changes in Blairmore Creek w.r.t. Average Flow Conditions using Runoff Coefficient of 0.41, 1 in 10 Dry Year Precipitation

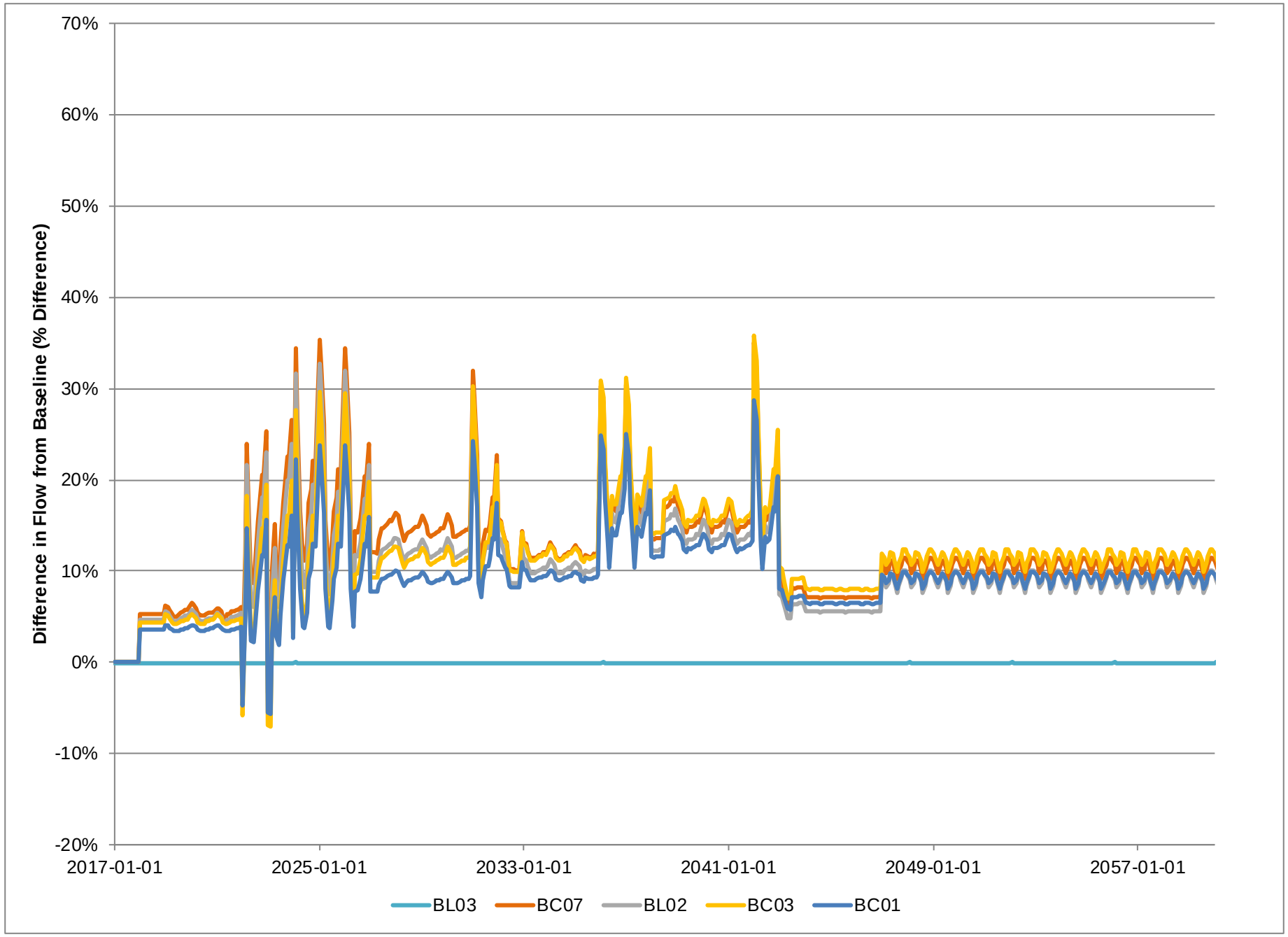
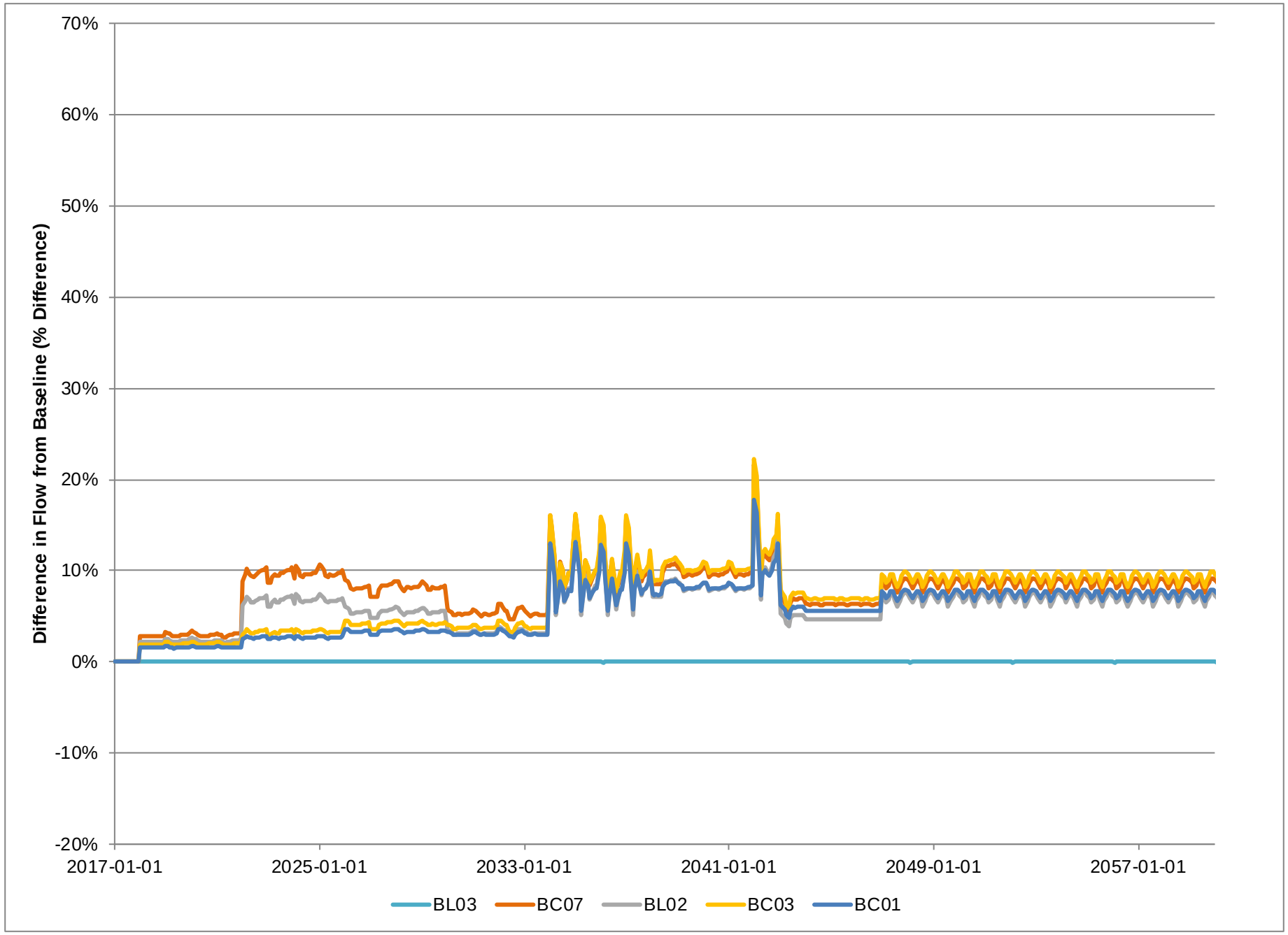


Figure 5.15-1U: Estimated Flow Changes in Blairmore Creek w.r.t. Average Flow Conditions using Runoff Coefficient of 0.61, 1 in 10 Dry Year Precipitation



APPENDIX 5.15-2: MEAN AVERAGE PRECIPITATION

		Runoff coefficient 0.61																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Baseline	2017 Jan	178,779	256,963	285,110	481,544	599,153	178,779	256,963	285,110	481,544	599,153	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Feb	197,934	284,495	315,602	533,082	663,292	197,934	284,495	315,602	533,082	663,292	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Mar	268,168	385,445	427,514	722,165	898,578	268,168	385,445	427,514	722,165	898,578	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Apr	646,583	929,351	1,030,600	1,741,030	2,166,380	646,583	929,351	1,030,600	1,741,030	2,166,380	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 May	2,234,730	3,212,040	3,561,320	6,016,740	7,486,850	2,234,730	3,212,040	3,561,320	6,016,740	7,486,850	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jun	2,493,960	3,584,640	3,973,710	6,713,960	8,354,600	2,493,960	3,584,640	3,973,710	6,713,960	8,354,600	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jul	1,162,060	1,670,260	1,851,210	3,128,030	3,892,490	1,162,060	1,670,260	1,851,210	3,128,030	3,892,490	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Aug	536,336	770,890	854,246	1,443,550	1,796,370	536,336	770,890	854,246	1,443,550	1,796,370	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Sep	461,845	663,822	735,466	1,242,920	1,546,740	461,845	663,822	735,466	1,242,920	1,546,740	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Oct	357,558	513,927	569,289	962,157	1,197,370	357,558	513,927	569,289	962,157	1,197,370	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Nov	369,476	531,058	588,158	994,121	1,237,180	369,476	531,058	588,158	994,121	1,237,180	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Dec	268,168	385,445	426,811	721,461	897,875	268,168	385,445	426,811	721,461	897,875	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Impacted	2018 Jan	178,779	256,963	284,488	480,921	598,530	178,779	256,963	284,488	480,921	598,530	0%	3%	2%	2%	2%	0%	0%	0%	0%	0%
Impacted	2018 Feb	197,934	284,495	314,913	532,393	662,603	197,934	284,495	314,913	532,393	662,603	0%	3%	2%	2%	2%	0%	0%	0%	0%	0%
Impacted	2018 Mar	268,168	385,445	426,580	721,231	897,644	268,168	385,445	426,580	721,231	897,644	0%	3%	2%	2%	2%	0%	0%	0%	0%	0%
Impacted	2018 Apr	646,583	929,351	1,028,340	1,738,780	2,164,130	646,583	929,351	1,028,340	1,738,780	2,164,130	0%	3%	2%	2%	2%	0%	0%	0%	0%	0%
Impacted	2018 May	2,234,730	3,212,040	3,553,540	6,008,960	7,479,070	2,234,730	3,212,040	3,553,540	6,008,960	7,479,070	0%	3%	2%	2%	2%	0%	0%	0%	0%	0%
Impacted	2018 Jun	2,493,960	3,584,640	3,965,020	6,705,270	8,345,910	2,493,960	3,584,640	3,965,020	6,705,270	8,345,910	0%	3%	2%	2%	2%	0%	0%	0%	0%	0%
Impacted	2018 Jul	1,162,060	1,670,260	1,847,160	3,123,980	3,888,440	1,162,060	1,670,260	1,847,160	3,123,980	3,888,440	0%	3%	2%	2%	2%	0%	0%	0%	0%	0%
Impacted	2018 Aug	536,336	770,890	852,378	1,441,680	1,794,510	536,336	770,890	852,378	1,441,680	1,794,510	0%	3%	2%	2%	2%	0%	0%	0%	0%	0%
Impacted	2018 Sep	461,845	663,822	733,857	1,241,310	1,545,130	461,845	663,822	733,857	1,241,310	1,545,130	0%	3%	2%	2%	2%	0%	0%	0%	0%	0%
Impacted	2018 Oct	357,558	513,927	568,044	960,911	1,196,130	357,558	513,927	568,044	960,911	1,196,130	0%	3%	2%	2%	2%	0%	0%	0%	0%	0%
Impacted	2018 Nov	369,476	531,058	586,871	992,834	1,235,890	369,476	531,058	586,871	992,834	1,235,890	0%	3%	2%	2%	2%	0%	0%	0%	0%	0%
Impacted	2018 Dec	268,168	385,445	425,876	720,527	896,940	268,168	385,445	425,876	720,527	896,940	0%	3%	2%	2%	2%	0%	0%	0%	0%	0%
Impacted	2019 Jan	178,779	303,082	335,822	566,860	684,468	178,779	303,082	335,822	566,860	684,468	0%	3%	3%	2%	2%	0%	0%	0%	0%	0%
Impacted	2019 Feb	197,934	330,555	366,110	616,647	746,857	197,934	330,555	366,110	616,647	746,857	0%	3%	2%	2%	2%	0%	0%	0%	-1%	0%
Impacted	2019 Mar	268,168	431,398	477,407	802,328	978,741	268,168	431,398	477,407	802,328	978,741	0%	3%	2%	2%	2%	0%	0%	0%	-1%	-1%
Impacted	2019 Apr	646,583	974,843	1,077,310	1,805,960	2,231,310	646,583	974,843	1,077,310	1,805,960	2,231,310	0%	3%	2%	2%	2%	0%	0%	0%	-1%	-1%
Impacted	2019 May	2,234,730	3,255,270	3,594,300	6,008,810	7,478,920	2,234,730	3,255,270	3,594,300	6,008,810	7,478,920	0%	3%	2%	2%	2%	0%	0%	0%	-2%	-1%
Impacted	2019 Jun	2,493,960	3,662,080	4,043,360	6,741,630	8,382,270	2,493,960	3,662,080	4,043,360	6,741,630	8,382,270	0%	3%	2%	2%	2%	0%	0%	0%	-2%	-1%
Impacted	2019 Jul	1,162,060	1,743,560	1,925,570	3,202,590	3,967,050	1,162,060	1,743,560	1,925,570	3,202,590	3,967,050	0%	3%	2%	2%	2%	0%	0%	0%	-3%	-1%
Impacted	2019 Aug	536,336	830,631	917,750	1,522,880	1,875,710	536,336	830,631	917,750	1,522,880	1,875,710	0%	3%	2%	2%	2%	0%	0%	0%	-3%	-2%
Impacted	2019 Sep	461,845	723,902	799,872	1,324,110	1,627,930	461,845	723,902	799,872	1,324,110	1,627,930	0%	3%	2%	2%	2%	0%	0%	0%	-3%	-2%
Impacted	2019 Oct	357,558	572,584	632,828	1,045,300	1,280,520	357,558	572,584	632,828	1,045,300	1,280,520	0%	3%	2%	2%	2%	0%	0%	0%	-4%	-2%
Impacted	2019 Nov	369,476	591,855	654,016	1,077,620	1,320,670	369,476	591,855	654,016	1,077,620	1,320,670	0%	3%	2%	2%	2%	0%	0%	0%	-4%	-2%
Impacted	2019 Dec	268,168	443,208	489,970	805,842	982,255	268,168	443,208	489,970	805,842	982,255	0%	3%	2%	2%	2%	0%	0%	0%	-4%	-3%
Impacted	2020 Jan	178,779	309,488	342,452	564,692	682,301	178,779	309,488	342,452	564,692	682,301	0%	3%	3%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Feb	191,108	324,859	359,423	595,633	721,353	191,108	324,859	359,423	595,633	721,353	0%	3%	3%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Mar	268,168	434,055	479,916	799,211	975,624	268,168	434,055	479,916	799,211	975,624	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Apr	646,583	974,771	1,076,550	1,802,550	2,227,910	646,583	974,771	1,076,550	1,802,550	2,227,910	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 May	2,234,730	3,234,120	3,569,790	6,014,040	7,484,150	2,234,730	3,234,120	3,569,790	6,014,040	7,484,150	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Jun	2,493,960	3,576,460	3,948,020	6,693,300	8,333,940	2,493,960	3,576,460	3,948,020	6,693,300	8,333,940	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Jul	1,162,060	1,677,000	1,851,990	3,159,060	3,923,510	1,162,060	1,677,000	1,851,990	3,159,060	3,923,510	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Aug	536,336	791,963	875,243	1,501,540	1,854,370	536,336	791,963	875,243	1,501,540	1,854,370	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Sep	461,845	683,869	756,029	1,304,680	1,608,500	461,845	683,869	756,029	1,304,680	1,608,500	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Oct	357,558	536,376	593,279	1,029,440	1,264,660	357,558	536,376	593,279	1,029,440	1,264,660	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Nov	369,476	549,051	607,357	1,060,390	1,303,450	369,476	549,051	607,357	1,060,390	1,303,450	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Dec	268,168	408,231	451,900	792,729	969,143	268,168	408,231	451,900	792,729	969,143	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Jan	178,779	286,562	317,496	557,085	674,694	178,779	286,562	317,496	557,085	674,694	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Feb	197,934	312,291	345,822	606,977	737,187	197,934	312,291	345,822	606,977	737,187	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Mar	268,168	406,585	449,805	790,589	967,003	268,168	406,585	449,805	790,589	967,003	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Apr	646,583	916,002	1,011,770	1,783,250	2,208,600	646,583	916,002	1,011,770	1,783,250	2,208,600	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 May	2,234,730	3,056,800	3,372,980	5,952,430	7,422,540	2,234,730	3,056,800	3,372,980	5,952,430	7,422,540	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Jun	2,493,960	3,756,710	4,067,270	6,659,530	8,300,740	2,493,960	3,756,710	4,067,270	6,659,530	8,300,740	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Jul	1,162,060	1,773,760	1,921,310	3,147,660	3,912,380	1,162,060	1,773,760	1,921,310	3,147,660	3,912,380	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Aug	536,336	842,913	914,022	1,498,870	1,851,810	536,336	842,913	914,022	1,498,870	1,851,810	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Sep	461,845	733,423	795,354	1,303,730	1,607,660	461,845	733,423	795,354	1,303,730	1,607,660	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Oct	357,558	579,138	628,317	1,029,760	1,265,060	357,558	579,138	628,317	1,029,760	1,265,060	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Nov	369,476	597,768	648,301	1,061,840	1,304,980	369,476	597,768	648,301	1,061,840	1,304,980	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Dec	268,168	446,806	485,020	794,759	971,233	268,168	446,806	485,020	794,759	971,233	0%	3%	2%	2%	2%	0%	0%	0%	-5%	-3%
Impacted	2022 Jan	178,779	256,756	276,969	451,892	569,541	178,779	256,756	276,969	451,892	569,541	0%	9%	6%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2022 Feb	197,934	306,965	332,167	543,106	673,360	197,934	306,965	332,167	543,106	673,360	0%	10%	7%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Mar	268,168	446,873	484,894	794,395	970,868	268,168	446,873	484,894	794,395	970,868	0%	10%	7%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Apr	646,583	1,013,530	1,096,810	1,794,720	2,220,220	646,583	1,013,530	1,096,810	1,794,720	2,220,220	0%	10%	7%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 May	2,234,730	3,397,120	3,670,030	5,997,990	7,468,600	2,234,730	3,397,120	3,670,030	5,997,990	7,468,600	0%	9%	7%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Jun	2,493,960	3,788,280	4,091,560	6,684,880	8,326,080	2,493,960	3,788,280	4,091,560	6,684,880	8,326,080	0%	9%	7%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Jul	1,162,060	1,788,470	1,932,620	3,159,550	3,924,270	1,162,060	1,788,470	1,932,620	3,159,550	3,924,270	0%	9%	7%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Aug	536,336	849,701	919,245	1,504,390	1,857,340	536,336	849,701	919,245	1,504,390	1,857,340	0%	10%	7%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Sep	461,845	739,268	799,852	1,308,520	1,612,440	461,845	739,268	799,852	1,308,520	1,612,440	0%	10%	7%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Oct	357,558	583,664	631,800	1,033,490	1,268,790	357,558	583,664	631,800	1,033,490	1,268,790	0%	10%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2022 Nov	369,476	602,444	651,900	1,065,720	1,308,860	369,476	602,444	651,900	1,065,720	1,308,860	0%	10%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2022 Dec	268,168	450,200	487,632	797,594	974,067	268,168	450,200	487,632	797,594	974,067	0%	10%	7%	4%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jan	178,779	255,459	274,699	446,844	564,493	178,779	255,459	274,699	446,844	564,493	0%	9%	6%	3%	2%	0%	0%	-1%	-5%	-3%
Impacted	2023 Feb	197,934	282,541	303,755	494,067	624,321	197,934	282,541	303,755	494,067	624,321	0%	9%	6%	3%	2%	0%	0%	-1%	-5%	-3%
Impacted	2023 Mar	268,168	410,662	442,886	722,151	898,624	268,168	410,662	442,886	722,151	898,624	0%	9%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Apr	646,583	1,021,720	1,103,110	1,799,840	2,225,340	646,583	1,021,720	1,103,110	1,799,840	2,225,340	0%	10%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 May	2,234,730	3,423,420	3,689,550	6,009,480	7,480,090	2,234,730	3,423,420	3,689,550	6,009,480	7,480,090	0%	9%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jun	2,493,960	3,820,670	4,116,770	6,703,500	8,344,700	2,493,960	3,820,670	4,116,770	6,703,500	8,344,700	0%	9%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jul	1,162,060	1,862,300	2,010,540	3,279,180	4,043,900	1,162,060	1,862,300	2,010,540	3,279,180	4,043,900	0%	10%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Aug	536,336	859,897	928,306	1,514,320	1,867,270	536,336	859,897	928,306	1,514,320	1,867,270	0%	10%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Sep	461,845	748,141	807,760	1,317,210	1,621,140	461,845	748,141	807,760	1,317,210	1,621,140	0%	10%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Oct	357,558	590,605	638,003	1,040,310	1,275,600	357,558	590,605	638,003	1,040,310	1,275,600	0%	10%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Nov	369,476	609,681	658,383	1,072,890	1,316,030	369,476	609,681	658,383	1,072,890	1,316,030	0%	10%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Dec	268,168	453,332	489,948	798,726	975,199	268,168	453,332	489,948	798,726	975,199	0%	10%	7%	4%	3%	0%	0%	-1%	-5%	-3%
Impacted	2024 Jan	178,779	274,264	295,126	479,060	596,709	178,779	274,264	295,126	479,060	596,709	0%	9%	6%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2024 Feb	191,108	337,204	365,124	595,948	721,710	191,108	337,204	365,124	595,948	721,710	0%	11%	7%	4%	3%	0%	0%	-1%	-5%	-3%
Impacted	2024 Mar	268,168	453,714	490,514	800,597	977,071	268,168	453,714	490,514	800,597	977,071	0%	10%	7%	3%	3%	0%	0%	-1%	-6%	-3%
Impacted	2024 Apr	646,583	1,028,440	1,108,900	1,808,450	2,233,950	646,583	1,028,440	1,108,900	1,808,450	2,233,950	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2024 May	2,234,730	3,469,360	3,736,290	6,091,140	7,561,750	2,234,730	3,469,360	3,736,290	6,091,140	7,561,750	0%	9%	6%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jun	2,493,960	4,003,620	4,318,560	7,052,010	8,693,220	2,493,960	4,003,620	4,318,560	7,052,010	8,693,220	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jul	1,162,060	1,851,880	1,997,380	3,264,220	4,028,940	1,162,060	1,851,880	1,997,380	3,264,220	4,028,940	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Aug	536,336	856,398	923,986	1,511,350	1,864,290	536,336	856,398	923,986	1,511,350	1,864,290	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Sep	461,845	743,947	802,944	1,313,900	1,617,820	461,845	743,947	802,944	1,313,900	1,617,820	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%

		Runoff coefficient 0.61																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2024 Oct	357,558	586,443	633,426	1,037,060	1,272,360	357,558	586,443	633,426	1,037,060	1,272,360	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Nov	369,476	604,435	652,776	1,069,000	1,312,140	369,476	604,435	652,776	1,069,000	1,312,140	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Dec	268,168	450,960	487,632	799,345	975,819	268,168	450,960	487,632	799,345	975,819	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jan	178,779	315,648	342,031	562,140	679,789	178,779	315,648	342,031	562,140	679,789	0%	11%	7%	4%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Feb	197,934	344,038	372,608	612,655	742,909	197,934	344,038	372,608	612,655	742,909	0%	10%	7%	4%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Mar	268,168	448,897	485,510	798,376	974,850	268,168	448,897	485,510	798,376	974,850	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Apr	646,583	1,016,830	1,096,830	1,802,010	2,227,510	646,583	1,016,830	1,096,830	1,802,010	2,227,510	0%	9%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2025 May	2,234,730	3,433,280	3,699,170	6,074,740	7,545,360	2,234,730	3,433,280	3,699,170	6,074,740	7,545,360	0%	9%	6%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jun	2,493,960	3,964,740	4,278,700	7,036,280	8,677,480	2,493,960	3,964,740	4,278,700	7,036,280	8,677,480	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jul	1,162,060	1,837,620	1,983,150	3,264,560	4,029,280	1,162,060	1,837,620	1,983,150	3,264,560	4,029,280	0%	10%	7%	3%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Aug	536,336	846,763	913,976	1,506,160	1,859,100	536,336	846,763	913,976	1,506,160	1,859,100	0%	10%	7%	3%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Sep	461,845	735,649	794,324	1,309,510	1,613,430	461,845	735,649	794,324	1,309,510	1,613,430	0%	10%	7%	3%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Oct	357,558	580,019	626,752	1,033,830	1,269,120	357,558	580,019	626,752	1,033,830	1,269,120	0%	10%	7%	3%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Nov	369,476	597,797	645,880	1,065,630	1,308,780	369,476	597,797	645,880	1,065,630	1,308,780	0%	10%	7%	3%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Dec	268,168	446,142	482,627	797,103	973,577	268,168	446,142	482,627	797,103	973,577	0%	10%	7%	3%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jan	178,779	312,437	338,695	560,258	677,907	178,779	312,437	338,695	560,258	677,907	0%	9%	6%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Feb	197,934	340,482	368,914	610,543	740,797	197,934	340,482	368,914	610,543	740,797	0%	9%	6%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Mar	268,168	444,080	480,505	795,485	971,958	268,168	444,080	480,505	795,485	971,958	0%	9%	6%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Apr	646,583	1,005,220	1,084,770	1,794,920	2,220,420	646,583	1,005,220	1,084,770	1,794,920	2,220,420	0%	8%	5%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2026 May	2,234,730	3,430,820	3,699,920	6,121,300	7,591,910	2,234,730	3,430,820	3,699,920	6,121,300	7,591,910	0%	8%	5%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jun	2,493,960	3,919,300	4,231,440	7,007,480	8,648,680	2,493,960	3,919,300	4,231,440	7,007,480	8,648,680	0%	8%	5%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jul	1,162,060	1,816,900	1,961,640	3,252,030	4,016,750	1,162,060	1,816,900	1,961,640	3,252,030	4,016,750	0%	8%	5%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Aug	536,336	837,130	903,970	1,500,290	1,853,240	536,336	837,130	903,970	1,500,290	1,853,240	0%	8%	5%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Sep	461,845	727,355	785,707	1,304,470	1,608,390	461,845	727,355	785,707	1,304,470	1,608,390	0%	8%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Oct	357,558	573,597	620,081	1,029,940	1,265,240	357,558	573,597	620,081	1,029,940	1,265,240	0%	8%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Nov	369,476	591,161	638,986	1,061,620	1,304,760	369,476	591,161	638,986	1,061,620	1,304,760	0%	8%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Dec	268,168	438,914	474,907	789,653	966,126	268,168	438,914	474,907	789,653	966,126	0%	8%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jan	178,779	238,483	255,667	424,257	541,906	178,779	238,483	255,667	424,257	541,906	0%	7%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Feb	197,934	263,547	282,573	469,229	599,483	197,934	263,547	282,573	469,229	599,483	0%	7%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Mar	268,168	356,235	382,011	634,953	811,426	268,168	356,235	382,011	634,953	811,426	0%	7%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Apr	646,583	858,367	920,515	1,530,600	1,956,100	646,583	858,367	920,515	1,530,600	1,956,100	0%	7%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 May	2,234,730	3,275,590	3,529,320	5,873,300	7,343,910	2,234,730	3,275,590	3,529,320	5,873,300	7,343,910	0%	8%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jun	2,493,960	3,878,840	4,190,810	6,980,470	8,621,680	2,493,960	3,878,840	4,190,810	6,980,470	8,621,680	0%	8%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jul	1,162,060	1,797,420	1,942,090	3,237,540	4,002,260	1,162,060	1,797,420	1,942,090	3,237,540	4,002,260	0%	8%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Aug	536,336	830,394	897,527	1,497,480	1,850,420	536,336	830,394	897,527	1,497,480	1,850,420	0%	8%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Sep	461,845	721,888	780,570	1,302,390	1,606,320	461,845	721,888	780,570	1,302,390	1,606,320	0%	8%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Oct	357,558	569,623	616,422	1,028,590	1,263,890	357,558	569,623	616,422	1,028,590	1,263,890	0%	9%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Nov	369,476	587,322	635,534	1,060,540	1,303,680	369,476	587,322	635,534	1,060,540	1,303,680	0%	9%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Dec	268,168	438,733	475,357	793,592	970,065	268,168	438,733	475,357	793,592	970,065	0%	9%	6%	5%	4%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jan	178,779	307,628	334,010	558,032	675,681	178,779	307,628	334,010	558,032	675,681	0%	9%	6%	5%	4%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Feb	191,108	325,324	353,140	590,282	716,045	191,108	325,324	353,140	590,282	716,045	0%	9%	6%	5%	4%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Mar	268,168	437,236	473,933	792,626	969,099	268,168	437,236	473,933	792,626	969,099	0%	8%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Apr	646,583	989,183	1,069,500	1,788,710	2,214,210	646,583	989,183	1,069,500	1,788,710	2,214,210	0%	8%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2028 May	2,234,730	3,343,540	3,611,410	6,039,450	7,510,060	2,234,730	3,343,540	3,611,410	6,039,450	7,510,060	0%	8%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jun	2,493,960	3,950,190	4,276,230	7,149,620	8,790,820	2,493,960	3,950,190	4,276,230	7,149,620	8,790,820	0%	8%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jul	1,162,060	1,829,790	1,980,920	3,314,300	4,079,020	1,162,060	1,829,790	1,980,920	3,314,300	4,079,020	0%	8%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Aug	536,336	839,701	909,179	1,522,820	1,875,760	536,336	839,701	909,179	1,522,820	1,875,760	0%	8%	5%	4%	3%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Sep	461,845	727,806	788,267	1,320,430	1,624,360	461,845	727,806	788,267	1,320,430	1,624,360	0%	8%	5%	4%	3%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Oct	357,558	571,650	619,531	1,037,950	1,273,250	357,558	571,650	619,531	1,037,950	1,273,250	0%	8%	6%	4%	3%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Nov	369,476	590,068	639,474	1,071,390	1,314,530	369,476	590,068	639,474	1,071,390	1,314,530	0%	8%	6%	4%	3%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Dec	268,168	437,326	474,424	795,334	971,807	268,168	437,326	474,424	795,334	971,807	0%	8%	6%	4%	3%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Jan	178,779	305,960	332,574	557,560	675,209	178,779	305,960	332,574	557,560	675,209	0%	9%	6%	5%	4%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Feb	197,934	333,450	362,307	607,740	737,995	197,934	333,450	362,307	607,740	737,995	0%	9%	6%	4%	4%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Mar	268,168	434,740	471,785	792,035	968,508	268,168	434,740	471,785	792,035	968,508	0%	8%	6%	4%	3%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Apr	646,583	1,001,200	1,084,430	1,820,310	2,245,800	646,583	1,001,200	1,084,430	1,820,310	2,245,800	0%	8%	5%	4%	3%	0%	-1%	-3%	-7%	-4%
Impacted	2029 May	2,234,730	3,408,950	3,689,370	6,190,860	7,661,470	2,234,730	3,408,950	3,689,370	6,190,860	7,661,470	0%	8%	5%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jun	2,493,960	3,943,510	4,274,590	7,175,600	8,816,800	2,493,960	3,943,510	4,274,590	7,175,600	8,816,800	0%	8%	5%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jul	1,162,060	1,820,010	1,972,700	3,314,040	4,078,760	1,162,060	1,820,010	1,972,700	3,314,040	4,078,760	0%	8%	5%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Aug	536,336	837,821	908,352	1,527,530	1,880,480	536,336	837,821	908,352	1,527,530	1,880,480	0%	8%	5%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Sep	461,845	726,537	787,944	1,325,090	1,629,020	461,845	726,537	787,944	1,325,090	1,629,020	0%	8%	5%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Oct	357,558	570,408	618,992	1,041,020	1,276,320	357,558	570,408	618,992	1,041,020	1,276,320	0%	8%	6%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Nov	369,476	588,885	639,029	1,074,750	1,317,890	369,476	588,885	639,029	1,074,750	1,317,890	0%	8%	6%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Dec	268,168	436,449	474,081	797,670	974,143	268,168	436,449	474,081	797,670	974,143	0%	8%	6%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jan	178,779	304,296	331,141	557,727	675,376	178,779	304,296	331,141	557,727	675,376	0%	6%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Feb	197,934	331,608	360,721	607,904	738,158	197,934	331,608	360,721	607,904	738,158	0%	6%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Mar	268,168	432,244	469,636	792,104	968,578	268,168	432,244	469,636	792,104	968,578	0%	5%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Apr	646,583	977,146	1,059,130	1,787,280	2,212,770	646,583	977,146	1,059,130	1,787,280	2,212,770	0%	5%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2030 May	2,234,730	3,377,990	3,660,010	6,169,290	7,639,900	2,234,730	3,377,990	3,660,010	6,169,290	7,639,900	0%	5%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jun	2,493,960	3,922,800	4,257,340	7,177,130	8,818,330	2,493,960	3,922,800	4,257,340	7,177,130	8,818,330	0%	5%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jul	1,162,060	1,808,390	1,962,500	3,311,610	4,076,330	1,162,060	1,808,390	1,962,500	3,311,610	4,076,330	0%	5%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Aug	536,336	827,996	898,666	1,518,530	1,871,480	536,336	827,996	898,666	1,518,530	1,871,480	0%	5%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Sep	461,845	717,472	778,929	1,316,300	1,620,230	461,845	717,472	778,929	1,316,300	1,620,230	0%	5%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Oct	357,558	561,760	610,195	1,031,360	1,266,660	357,558	561,760	610,195	1,031,360	1,266,660	0%	5%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Nov	369,476	580,233	630,254	1,065,260	1,308,400	369,476	580,233	630,254	1,065,260	1,308,400	0%	5%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Dec	268,168	431,238	468,905	792,829	969,302	268,168	431,238	468,905	792,829	969,302	0%	5%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Jan	178,779	302,621	329,698	557,511	675,160	178,779	302,621	329,698	557,511	675,160	0%	6%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Feb	197,934	329,730	359,100	607,661	737,915	197,934	329,730	359,100	607,661	737,915	0%	6%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Mar	268,168	429,668	467,409	791,772	968,245	268,168	429,668	467,409	791,772	968,245	0%	5%	3%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Apr	646,583	970,857	1,053,690	1,786,460	2,211,960	646,583	970,857	1,053,690	1,786,460	2,211,960	0%	5%	3%	4%	3%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 May	2,234,730	3,329,430	3,611,340	6,118,480	7,589,090	2,234,730	3,329,430	3,611,340	6,118,480	7,589,090	0%	5%	3%	4%	3%	-1%	-2%	-3%	-7%	-4%
Impacted	2031 Jun	2,493,960	3,902,860	4,241,240	7,182,750	8,823,950	2,493,960	3,902,860	4,241,240	7,182,750	8,823,950	0%	5%	3%	4%	3%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Jul	1,162,060	1,792,520	1,947,660	3,302,470	4,067,190	1,162,060	1,792,520	1,947,660	3,302,470	4,067,190	0%	5%	3%	4%	3%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Aug	536,336	816,811	887,532	1,507,500	1,860,440	536,336	816,811	887,532	1,507,500	1,860,440	0%	5%	3%	4%	3%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Sep	461,845	706,313	767,647	1,304,130	1,608,060	461,845	706,313	767,647	1,304,130	1,608,060	0%	5%	3%	4%	3%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Oct	357,558	555,924	604,592	1,027,080	1,262,380	357,558	555,924	604,592	1,027,080	1,262,380	0%	5%	3%	4%	3%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Nov	369,476	573,133	623,280	1,058,980	1,302,120	369,476	573,133	623,280	1,058,980	1,302,120	0%	5%	3%	4%	3%	-1%	-3%	-3%	-8%	-5%
Impacted	2031 Dec	268,168	428,410	466,440	792,537	969,010	268,168	428,410	466,440	792,537	969,010	0%	5%	3%	4%	3%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Jan	178,779	300,732	328,052	557,326	674,975	178,779	300,732	328,052	557,326	674,975	0%	6%	4%	5%	4%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Feb	191,108	317,935	346,756	589,530	715,292	191,108	317,935	346,756	589,530	715,292	0%	6%	4%	5%	4%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Mar	268,168	426,844	464,953	791,524	967,998	268,168	426,844	464,953	791,524	967,998	0%	6%	4%	4%	3%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Apr	646,583	964,067	1,047,790	1,785,910	2,211,400	646,583	964,067	1,047,790	1,785,910	2,211,400	0%	6%	3%	4%	3%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 May	2,234,730	3,309,600	3,594,780	6,121,610	7,592,220	2,234,730	3,309,600	3,594,780	6,121,610	7,592,220	0%	6%	3%	4%	3%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Jun	2,493,960	3,070,880	3,310,440	5,655,140	7,296,350	2,493,960	3,070,880	3,310,440	5,655,140	7,296,350	0%	5%	3%	3%	3%	-1%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.61																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2032 Jul	1,162,060	1,424,990	1,536,610	2,628,580	3,393,300	1,162,060	1,424,990	1,536,610	2,628,580	3,393,300	0%	5%	3%	3%	3%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Aug	536,336	654,306	705,824	1,209,810	1,562,750	536,336	654,306	705,824	1,209,810	1,562,750	0%	5%	3%	3%	3%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Sep	461,845	625,886	678,212	1,160,280	1,464,210	461,845	625,886	678,212	1,160,280	1,464,210	0%	5%	3%	4%	3%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Oct	357,558	552,868	602,110	1,028,050	1,263,350	357,558	552,868	602,110	1,028,050	1,263,350	0%	6%	4%	4%	3%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Nov	369,476	571,801	622,750	1,063,290	1,306,430	369,476	571,801	622,750	1,063,290	1,306,430	0%	6%	4%	4%	3%	-1%	-4%	-4%	-8%	-5%
Impacted	2032 Dec	268,168	425,620	464,022	792,357	968,830	268,168	425,620	464,022	792,357	968,830	0%	6%	4%	4%	3%	-1%	-4%	-4%	-8%	-5%
Impacted	2033 Jan	178,779	298,870	326,439	557,206	674,855	178,779	298,870	326,439	557,206	674,855	0%	6%	3%	4%	3%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Feb	197,934	325,584	355,499	607,335	737,589	197,934	325,584	355,499	607,335	737,589	0%	5%	3%	4%	3%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Mar	268,168	424,060	462,540	791,345	967,818	268,168	424,060	462,540	791,345	967,818	0%	5%	3%	4%	3%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Apr	646,583	969,559	1,055,580	1,807,570	2,233,070	646,583	969,559	1,055,580	1,807,570	2,233,070	0%	5%	3%	4%	3%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 May	2,234,730	3,507,630	3,823,310	6,534,250	8,004,860	2,234,730	3,507,630	3,823,310	6,534,250	8,004,860	0%	5%	3%	4%	3%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jun	2,493,960	3,983,980	4,345,630	7,427,480	9,068,680	2,493,960	3,983,980	4,345,630	7,427,480	9,068,680	0%	5%	3%	4%	3%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jul	1,162,060	1,834,310	2,000,740	3,423,570	4,188,280	1,162,060	1,834,310	2,000,740	3,423,570	4,188,280	0%	5%	3%	4%	3%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Aug	536,336	825,743	900,312	1,543,470	1,896,410	536,336	825,743	900,312	1,543,470	1,896,410	0%	5%	3%	4%	3%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Sep	461,845	715,250	780,039	1,337,350	1,641,270	461,845	715,250	780,039	1,337,350	1,641,270	0%	5%	3%	4%	3%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Oct	357,558	557,578	608,284	1,043,050	1,278,350	357,558	557,578	608,284	1,043,050	1,278,350	0%	5%	3%	4%	3%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Nov	369,476	575,367	627,680	1,076,440	1,319,580	369,476	575,367	627,680	1,076,440	1,319,580	0%	5%	3%	4%	3%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Dec	268,168	424,414	463,370	795,035	971,508	268,168	424,414	463,370	795,035	971,508	0%	5%	3%	4%	3%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Jan	178,779	298,188	326,123	559,094	676,743	178,779	298,188	326,123	559,094	676,743	0%	16%	14%	16%	13%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Feb	197,934	326,822	357,339	612,798	743,052	197,934	326,822	357,339	612,798	743,052	0%	15%	13%	15%	12%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Mar	268,168	430,272	470,044	806,638	983,111	268,168	430,272	470,044	806,638	983,111	0%	12%	10%	12%	9%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Apr	646,583	992,995	1,082,990	1,858,960	2,284,460	646,583	992,995	1,082,990	1,858,960	2,284,460	0%	7%	5%	7%	5%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 May	2,234,730	3,516,460	3,837,270	6,579,110	8,049,720	2,234,730	3,516,460	3,837,270	6,579,110	8,049,720	0%	9%	8%	9%	8%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jun	2,493,960	3,978,420	4,343,410	7,445,360	9,086,560	2,493,960	3,978,420	4,343,410	7,445,360	9,086,560	0%	11%	9%	11%	9%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jul	1,162,060	1,838,090	2,006,630	3,442,240	4,206,960	1,162,060	1,838,090	2,006,630	3,442,240	4,206,960	0%	10%	8%	10%	8%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Aug	536,336	833,520	909,681	1,562,450	1,915,390	536,336	833,520	909,681	1,562,450	1,915,390	0%	8%	6%	8%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Sep	461,845	723,146	789,370	1,355,340	1,659,270	461,845	723,146	789,370	1,355,340	1,659,270	0%	9%	7%	9%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Oct	357,558	563,806	615,562	1,056,670	1,291,960	357,558	563,806	615,562	1,056,670	1,291,960	0%	10%	8%	10%	8%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Nov	369,476	582,161	635,536	1,090,700	1,333,840	369,476	582,161	635,536	1,090,700	1,333,840	0%	10%	8%	10%	8%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Dec	268,168	431,739	471,695	809,399	985,873	268,168	431,739	471,695	809,399	985,873	0%	12%	11%	12%	10%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Jan	178,779	298,261	326,293	559,857	677,506	178,779	298,261	326,293	559,857	677,506	0%	16%	14%	16%	13%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Feb	197,934	326,524	357,106	612,962	743,216	197,934	326,524	357,106	612,962	743,216	0%	15%	13%	15%	12%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Mar	268,168	430,880	470,858	808,698	985,171	268,168	430,880	470,858	808,698	985,171	0%	12%	10%	12%	10%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Apr	646,583	993,440	1,083,820	1,862,090	2,287,590	646,583	993,440	1,083,820	1,862,090	2,287,590	0%	7%	5%	7%	6%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 May	2,234,730	3,527,700	3,851,050	6,608,220	8,078,830	2,234,730	3,527,700	3,851,050	6,608,220	8,078,830	0%	10%	8%	10%	8%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jun	2,493,960	3,982,370	4,349,100	7,461,570	9,102,770	2,493,960	3,982,370	4,349,100	7,461,570	9,102,770	0%	11%	9%	11%	9%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jul	1,162,060	1,842,140	2,011,770	3,453,930	4,218,650	1,162,060	1,842,140	2,011,770	3,453,930	4,218,650	0%	10%	9%	10%	8%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Aug	536,336	835,451	912,133	1,568,040	1,920,990	536,336	835,451	912,133	1,568,040	1,920,990	0%	8%	7%	9%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Sep	461,845	724,425	791,042	1,359,380	1,663,310	461,845	724,425	791,042	1,359,380	1,663,310	0%	9%	8%	9%	8%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Oct	357,558	564,688	616,728	1,059,550	1,294,850	357,558	564,688	616,728	1,059,550	1,294,850	0%	10%	8%	10%	8%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Nov	369,476	583,224	636,917	1,094,000	1,337,140	369,476	583,224	636,917	1,094,000	1,337,140	0%	10%	8%	10%	8%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Dec	268,168	431,598	471,675	810,110	986,583	268,168	431,598	471,675	810,110	986,583	0%	12%	11%	12%	10%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Jan	178,779	297,039	325,022	558,289	675,937	178,779	297,039	325,022	558,289	675,937	0%	16%	14%	16%	13%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Feb	191,108	314,850	344,446	591,892	717,655	191,108	314,850	344,446	591,892	717,655	0%	15%	13%	15%	12%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Mar	268,168	429,341	469,279	806,879	983,352	268,168	429,341	469,279	806,879	983,352	0%	11%	10%	12%	9%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Apr	646,583	992,831	1,083,470	1,863,320	2,288,820	646,583	992,831	1,083,470	1,863,320	2,288,820	0%	7%	5%	7%	6%	-3%	-7%	-5%	-9%	-5%
Impacted	2036 May	2,234,730	3,493,400	3,813,540	6,551,340	8,021,950	2,234,730	3,493,400	3,813,540	6,551,340	8,021,950	0%	9%	7%	9%	7%	-3%	-7%	-5%	-9%	-5%
Impacted	2036 Jun	2,493,960	3,984,830	4,353,140	7,475,150	9,116,350	2,493,960	3,984,830	4,353,140	7,475,150	9,116,350	0%	11%	10%	11%	9%	-3%	-7%	-5%	-9%	-5%
Impacted	2036 Jul	1,162,060	1,834,940	2,004,250	3,444,520	4,209,240	1,162,060	1,834,940	2,004,250	3,444,520	4,209,240	0%	10%	8%	10%	8%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Aug	536,336	827,234	903,160	1,554,510	1,907,450	536,336	827,234	903,160	1,554,510	1,907,450	0%	7%	6%	8%	6%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Sep	461,845	717,997	784,045	1,348,950	1,652,880	461,845	717,997	784,045	1,348,950	1,652,880	0%	8%	7%	9%	7%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Oct	357,558	562,840	614,851	1,057,500	1,292,800	357,558	562,840	614,851	1,057,500	1,292,800	0%	10%	8%	10%	8%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Nov	369,476	581,338	634,997	1,091,880	1,335,020	369,476	581,338	634,997	1,091,880	1,335,020	0%	9%	8%	10%	8%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Dec	268,168	430,562	470,657	809,203	985,676	268,168	430,562	470,657	809,203	985,676	0%	12%	10%	12%	10%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jan	178,779	297,089	325,171	559,027	676,675	178,779	297,089	325,171	559,027	676,675	0%	16%	14%	16%	13%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Feb	197,934	324,696	355,270	611,080	741,334	197,934	324,696	355,270	611,080	741,334	0%	14%	13%	15%	12%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Mar	268,168	429,416	469,500	807,981	984,454	268,168	429,416	469,500	807,981	984,454	0%	11%	10%	12%	10%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Apr	646,583	992,862	1,083,840	1,865,710	2,291,200	646,583	992,862	1,083,840	1,865,710	2,291,200	0%	7%	5%	7%	6%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 May	2,234,730	3,521,570	3,846,390	6,612,450	8,083,070	2,234,730	3,521,570	3,846,390	6,612,450	8,083,070	0%	10%	8%	10%	8%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jun	2,493,960	3,996,850	4,367,920	7,506,640	9,147,850	2,493,960	3,996,850	4,367,920	7,506,640	9,147,850	0%	11%	10%	12%	9%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Jul	1,162,060	1,845,410	2,016,640	3,468,450	4,233,170	1,162,060	1,845,410	2,016,640	3,468,450	4,233,170	0%	10%	9%	11%	9%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Aug	536,336	838,642	916,284	1,577,990	1,930,940	536,336	838,642	916,284	1,577,990	1,930,940	0%	9%	7%	9%	7%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Sep	461,845	725,647	792,900	1,365,090	1,669,010	461,845	725,647	792,900	1,365,090	1,669,010	0%	9%	8%	10%	8%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Oct	357,558	563,043	615,260	1,059,150	1,294,450	357,558	563,043	615,260	1,059,150	1,294,450	0%	10%	8%	10%	8%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Nov	369,476	585,514	639,885	1,101,060	1,344,200	369,476	585,514	639,885	1,101,060	1,344,200	0%	10%	9%	11%	9%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Dec	268,168	430,485	470,708	810,029	986,503	268,168	430,485	470,708	810,029	986,503	0%	12%	10%	12%	10%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jan	178,779	232,650	252,501	436,658	554,307	178,779	232,650	252,501	436,658	554,307	0%	9%	7%	9%	7%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Feb	197,934	255,637	277,388	479,919	610,173	197,934	255,637	277,388	479,919	610,173	0%	8%	7%	9%	7%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Mar	268,168	349,017	378,884	655,669	832,142	268,168	349,017	378,884	655,669	832,142	0%	9%	7%	9%	7%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Apr	646,583	839,399	911,093	1,576,520	2,002,020	646,583	839,399	911,093	1,576,520	2,002,020	0%	9%	7%	9%	7%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 May	2,234,730	2,914,410	3,163,310	5,470,850	6,941,470	2,234,730	2,914,410	3,163,310	5,470,850	6,941,470	0%	9%	7%	9%	7%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jun	2,493,960	3,730,930	4,069,400	7,011,260	8,652,460	2,493,960	3,730,930	4,069,400	7,011,260	8,652,460	0%	10%	8%	10%	8%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jul	1,162,060	1,862,890	2,036,740	3,504,390	4,269,110	1,162,060	1,862,890	2,036,740	3,504,390	4,269,110	0%	11%	9%	11%	9%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Aug	536,336	855,821	935,730	1,611,120	1,964,070	536,336	855,821	935,730	1,611,120	1,964,070	0%	10%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Sep	461,845	742,074	811,467	1,396,570	1,700,500	461,845	742,074	811,467	1,396,570	1,700,500	0%	11%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Oct	357,558	579,220	633,490	1,089,780	1,325,070	357,558	579,220	633,490	1,089,780	1,325,070	0%	11%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Nov	369,476	601,415	657,815	1,131,250	1,374,390	369,476	601,415	657,815	1,131,250	1,374,390	0%	11%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Dec	268,168	445,813	487,938	838,746	1,015,220	268,168	445,813	487,938	838,746	1,015,220	0%	11%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jan	178,779	312,995	343,087	589,084	706,733	178,779	312,995	343,087	589,084	706,733	0%	10%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Feb	197,934	341,400	374,087	642,658	772,912	197,934	341,400	374,087	642,658	772,912	0%	10%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Mar	268,168	445,702	487,907	839,197	1,015,670	268,168	445,702	487,907	839,197	1,015,670	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Apr	646,583	1,010,070	1,103,590	1,900,840	2,326,330	646,583	1,010,070	1,103,590	1,900,840	2,326,330	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 May	2,234,730	3,580,400	3,914,300	6,735,210	8,205,820	2,234,730	3,580,400	3,914,300	6,735,210	8,205,820	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jun	2,493,960	4,018,780	4,394,360	7,560,300	9,201,500	2,493,960	4,018,780	4,394,360	7,560,300	9,201,500	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jul	1,162,060	1,864,480	2,038,780	3,509,180	4,273,900	1,162,060	1,864,480	2,038,780	3,509,180	4,273,900	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Aug	536,336	856,933	937,073	1,613,860	1,966,810	536,336	856,933	937,073	1,613,860	1,966,810	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Sep	461,845	743,151	812,737	1,399,010	1,702,940	461,845	743,151	812,737	1,399,010	1,702,940	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Oct	357,558	580,171	634,588	1,091,760	1,327,060	357,558	580,171	634,588	1,091,760	1,327,060	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Nov	369,476	602,235	658,751	1,132,890	1,376,030	369,476	602,235	658,751	1,132,890	1,376,030	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Dec	268,168	446,480	488,686	839,980	1,016,450	268,168	446,480	488,686	839,980	1,016,450	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jan	178,779	312,928	343,010	588,951	706,600	178,779	312,928	343,010	588,951	706,600	0%	10%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Feb	191,108	331,128	362,878	623,332	749,094	191,108	331,128	362,878	623,332	749,094	0%	10%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Mar	268,168	445,574	487,763	838,951	1,015,420	268,168	445,574	487,763	838,951	1,015,420	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%

		Runoff coefficient 0.61																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2040 Apr	646,583	1,009,760	1,103,240	1,900,240	2,325,740	646,583	1,009,760	1,103,240	1,900,240	2,325,740	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 May	2,234,730	3,579,310	3,913,070	6,733,110	8,203,720	2,234,730	3,579,310	3,913,070	6,733,110	8,203,720	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jun	2,493,960	4,017,850	4,393,310	7,558,500	9,199,700	2,493,960	4,017,850	4,393,310	7,558,500	9,199,700	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jul	1,162,060	1,864,180	2,038,450	3,508,600	4,273,320	1,162,060	1,864,180	2,038,450	3,508,600	4,273,320	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Aug	536,336	856,961	937,103	1,613,910	1,966,850	536,336	856,961	937,103	1,613,910	1,966,850	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Sep	461,845	743,195	812,786	1,399,090	1,703,010	461,845	743,195	812,786	1,399,090	1,703,010	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Oct	357,558	580,284	634,715	1,091,970	1,327,270	357,558	580,284	634,715	1,091,970	1,327,270	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Nov	369,476	602,336	658,864	1,133,070	1,376,210	369,476	602,336	658,864	1,133,070	1,376,210	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Dec	268,168	446,353	488,542	839,734	1,016,210	268,168	446,353	488,542	839,734	1,016,210	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jan	178,779	312,836	342,906	588,774	706,422	178,779	312,836	342,906	588,774	706,422	0%	10%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Feb	197,934	341,189	373,849	642,252	772,506	197,934	341,189	373,849	642,252	772,506	0%	10%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Mar	268,168	445,396	487,561	838,608	1,015,080	268,168	445,396	487,561	838,608	1,015,080	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Apr	646,583	1,009,280	1,102,700	1,899,320	2,324,820	646,583	1,009,280	1,102,700	1,899,320	2,324,820	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 May	2,234,730	3,583,350	3,917,610	6,740,700	8,211,310	2,234,730	3,583,350	3,917,610	6,740,700	8,211,310	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jun	2,493,960	4,016,540	4,391,830	7,555,980	9,197,180	2,493,960	4,016,540	4,391,830	7,555,980	9,197,180	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jul	1,162,060	1,864,010	2,038,250	3,508,250	4,272,970	1,162,060	1,864,010	2,038,250	3,508,250	4,272,970	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Aug	536,336	857,361	937,552	1,614,650	1,967,600	536,336	857,361	937,552	1,614,650	1,967,600	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Sep	461,845	743,652	813,299	1,399,940	1,703,870	461,845	743,652	813,299	1,399,940	1,703,870	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Oct	357,558	580,863	635,366	1,093,060	1,328,360	357,558	580,863	635,366	1,093,060	1,328,360	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Nov	369,476	602,862	659,456	1,134,060	1,377,200	369,476	602,862	659,456	1,134,060	1,377,200	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Dec	268,168	445,985	488,127	839,033	1,015,510	268,168	445,985	488,127	839,033	1,015,510	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jan	178,779	312,583	342,621	588,293	705,942	178,779	312,583	342,621	588,293	705,942	0%	22%	20%	22%	18%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Feb	197,934	340,910	373,534	641,721	771,975	197,934	340,910	373,534	641,721	771,975	0%	20%	18%	20%	16%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Mar	268,168	445,017	487,134	837,889	1,014,360	268,168	445,017	487,134	837,889	1,014,360	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Apr	646,583	1,008,370	1,101,670	1,897,590	2,323,090	646,583	1,008,370	1,101,670	1,897,590	2,323,090	0%	9%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 May	2,234,730	3,581,270	3,915,270	6,736,740	8,207,350	2,234,730	3,581,270	3,915,270	6,736,740	8,207,350	0%	11%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jun	2,493,960	4,013,040	4,387,880	7,549,320	9,190,520	2,493,960	4,013,040	4,387,880	7,549,320	9,190,520	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jul	1,162,060	1,862,380	2,036,410	3,505,150	4,269,870	1,162,060	1,862,380	2,036,410	3,505,150	4,269,870	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Aug	536,336	856,608	936,703	1,613,220	1,966,170	536,336	856,608	936,703	1,613,220	1,966,170	0%	11%	10%	12%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Sep	461,845	743,004	812,569	1,398,710	1,702,640	461,845	743,004	812,569	1,398,710	1,702,640	0%	12%	10%	13%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Oct	357,558	580,362	634,801	1,092,110	1,327,410	357,558	580,362	634,801	1,092,110	1,327,410	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Nov	369,476	602,345	658,873	1,133,080	1,376,220	369,476	602,345	658,873	1,133,080	1,376,220	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Dec	268,168	445,608	487,702	838,320	1,014,790	268,168	445,608	487,702	838,320	1,014,790	0%	16%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jan	178,779	289,232	316,204	544,921	662,642	178,779	289,232	316,204	544,921	662,642	0%	7%	5%	8%	6%	-4%	-7%	-6%	-10%	-6%
Impacted	2043 Feb	197,934	311,600	340,370	587,000	717,334	197,934	311,600	340,370	587,000	717,334	0%	7%	5%	8%	6%	-4%	-7%	-6%	-10%	-6%
Impacted	2043 Mar	268,168	393,613	428,976	741,288	917,870	268,168	393,613	428,976	741,288	917,870	0%	7%	5%	7%	6%	-4%	-8%	-6%	-10%	-6%
Impacted	2043 Apr	646,583	835,490	906,377	1,572,580	1,998,330	646,583	835,490	906,377	1,572,580	1,998,330	0%	6%	4%	6%	5%	-4%	-8%	-6%	-10%	-6%
Impacted	2043 May	2,234,730	2,689,980	2,909,960	5,061,360	6,532,870	2,234,730	2,689,980	2,909,960	5,061,360	6,532,870	0%	5%	4%	6%	5%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jun	2,493,960	3,625,670	3,950,120	6,827,920	8,470,130	2,493,960	3,625,670	3,950,120	6,827,920	8,470,130	0%	6%	5%	7%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2043 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2043 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2043 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	7%	5%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	7%	5%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	7%	5%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	7%	5%	8%	6%	-4%	-5%	-4%	-9%	-5%
Impacted	2044 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	6%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Feb	191,108	298,486	325,964	562,278	688,118	191,108	298,486	325,964	562,278	688,118	0%	6%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	6%	5%	7%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2044 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	6%	5%	7%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2044 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	6%	5%	7%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2044 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	6%	5%	7%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2044 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	6%	5%	7%	6%	-4%	-5%	-4%	-9%	-5%
Impacted	2045 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	6%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	6%	5%	7%	6%	-4%	-4%	-4%	-9%	-5%
Impacted	2045 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	6%	5%	7%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2045 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	6%	5%	7%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2045 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	6%	5%	7%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2045 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	6%	5%	7%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2045 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	6%	5%	7%	6%	-4%	-5%	-4%	-9%	-5%
Impacted	2046 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	6%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	6%	5%	7%	6%	-4%	-4%	-4%	-9%	-5%
Impacted	2046 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	6%	5%	7%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2046 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	6%	5%	7%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2046 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	6%	5%	7%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2046 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	6%	5%	7%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2046 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	6%	5%	7%	6%	-4%	-5%	-4%	-9%	-5%
Impacted	2047 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2047 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2047 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2047 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2047 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2047 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%

		Runoff coefficient 0.61																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2048 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Feb	191,108	298,486	325,964	562,278	688,118	191,108	298,486	325,964	562,278	688,118	0%	9%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2048 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2048 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2048 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2048 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2049 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2049 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2049 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2049 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2049 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2049 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2050 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2050 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2050 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2050 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2050 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2050 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2051 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2051 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2051 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2051 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2051 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2051 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2052 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Feb	191,108	298,486	325,964	562,278	688,118	191,108	298,486	325,964	562,278	688,118	0%	9%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2052 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2052 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2052 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2052 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2053 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2053 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2053 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2053 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2053 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2053 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2054 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2054 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2054 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2054 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2054 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2054 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2055 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2055 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2055 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2055 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2055 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2055 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%

		Runoff coefficient 0.61																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2055 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2056 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Feb	191,108	298,486	325,964	562,278	688,118	191,108	298,486	325,964	562,278	688,118	0%	9%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2056 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2056 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2056 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2056 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2057 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2057 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2057 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2057 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2057 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2057 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2058 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2058 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2058 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2058 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2058 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2058 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2059 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2059 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2059 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2059 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2059 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2059 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2060 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Feb	191,108	298,486	325,964	562,278	688,118	191,108	298,486	325,964	562,278	688,118	0%	9%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2060 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2060 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2060 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2060 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2061 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2061 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2061 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2061 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2061 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2061 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2062 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2062 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2062 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2062 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2062 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2062 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2063 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2063 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2063 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%

		Runoff coefficient 0.61																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2063 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2063 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2063 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2064 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Feb	191,108	298,486	325,964	562,278	688,118	191,108	298,486	325,964	562,278	688,118	0%	9%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2064 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2064 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2064 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2064 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2065 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2065 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2065 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2065 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2065 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2065 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2066 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2066 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2066 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2066 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2066 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2066 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2067 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2067 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2067 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2067 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2067 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2067 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2068 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Feb	191,108	298,486	325,964	562,278	688,118	191,108	298,486	325,964	562,278	688,118	0%	9%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2068 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2068 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2068 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2068 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2069 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2069 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2069 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2069 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2069 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2069 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2070 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2070 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2070 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2070 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2070 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2070 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2071 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2071 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%

		Runoff coefficient 0.61																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2071 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2071 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2071 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2071 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2071 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2072 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Feb	191,108	298,486	325,964	562,278	688,118	191,108	298,486	325,964	562,278	688,118	0%	9%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2072 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2072 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2072 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2072 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2073 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2073 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2073 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2073 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2073 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2073 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2074 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2074 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2074 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2074 Jul	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	1,162,060	1,811,070	1,977,650	3,411,600	4,176,790	0%	8%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2074 Aug	536,336	829,718	905,824	1,562,940	1,916,100	536,336	829,718	905,824	1,562,940	1,916,100	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2074 Sep	461,845	718,073	784,065	1,352,660	1,656,770	461,845	718,073	784,065	1,352,660	1,656,770	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Oct	357,558	558,710	610,153	1,052,480	1,287,920	357,558	558,710	610,153	1,052,480	1,287,920	0%	9%	7%	9%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Nov	369,476	579,817	633,289	1,092,260	1,335,550	369,476	579,817	633,289	1,092,260	1,335,550	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Dec	268,168	420,867	459,681	792,831	969,412	268,168	420,867	459,681	792,831	969,412	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2075 Jan	178,779	280,114	305,931	527,677	645,398	178,779	280,114	305,931	527,677	645,398	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Feb	197,934	309,146	337,605	582,360	712,694	197,934	309,146	337,605	582,360	712,694	0%	9%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2075 Mar	268,168	416,819	455,121	785,176	961,758	268,168	416,819	455,121	785,176	961,758	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Apr	646,583	1,007,660	1,100,340	1,898,170	2,323,930	646,583	1,007,660	1,100,340	1,898,170	2,323,930	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 May	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	2,234,730	3,501,740	3,824,500	6,596,560	8,068,070	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2075 Jun	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	2,493,960	3,906,610	4,266,640	7,359,240	9,001,440	0%	9%	7%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2075 Jul	1,162,060	1,835,250	2,004,900	3,457,350	4,222,530	1,162,060	1,835,250	2,004,900	3,457,350	4,222,530	0%	10%	8%	11%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2075 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2075 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2076 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Feb	191,108	303,108	331,171	571,019	696,859	191,108	303,108	331,171	571,019	696,859	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2076 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2076 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2076 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2076 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2077 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2077 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2077 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2077 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2077 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2077 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2078 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2078 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2078 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2078 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2078 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2078 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%

		Runoff coefficient 0.61																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2079 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2079 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2079 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2079 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2079 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2079 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2080 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Feb	191,108	303,108	331,171	571,019	696,859	191,108	303,108	331,171	571,019	696,859	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2080 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2080 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2080 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2080 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2081 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2081 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2081 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2081 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2081 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2081 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2082 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2082 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2082 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2082 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2082 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2082 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2083 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2083 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2083 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2083 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2083 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2083 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2084 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Feb	191,108	303,108	331,171	571,019	696,859	191,108	303,108	331,171	571,019	696,859	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2084 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2084 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2084 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2084 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2085 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2085 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2085 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2085 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2085 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2085 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2086 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2086 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2086 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2086 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2086 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2086 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%

		Runoff coefficient 0.61																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2086 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2087 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2087 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2087 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2087 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2087 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2087 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2088 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Feb	191,108	303,108	331,171	571,019	696,859	191,108	303,108	331,171	571,019	696,859	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2088 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2088 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2088 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2088 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2089 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2089 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2089 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2089 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2089 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2089 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2090 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2090 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2090 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2090 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2090 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2090 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2091 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2091 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2091 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2091 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2091 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2091 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2092 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Feb	191,108	303,108	331,171	571,019	696,859	191,108	303,108	331,171	571,019	696,859	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2092 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2092 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2092 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2092 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2093 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2093 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2093 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2093 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2093 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2093 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2094 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2094 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2094 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%

		Runoff coefficient 0.61																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2094 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2094 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2094 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2095 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2095 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2095 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2095 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2095 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2095 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2096 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Feb	191,108	303,108	331,171	571,019	696,859	191,108	303,108	331,171	571,019	696,859	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2096 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2096 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2096 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2096 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2097 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2097 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2097 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2097 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2097 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2097 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2098 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2098 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2098 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2098 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2098 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2098 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2099 Jan	178,779	285,878	312,425	538,578	656,299	178,779	285,878	312,425	538,578	656,299	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Feb	197,934	313,991	343,063	591,522	721,855	197,934	313,991	343,063	591,522	721,855	0%	10%	9%	11%	9%	-4%	-4%	-4%	-9%	-5%
Impacted	2099 Mar	268,168	420,424	459,182	791,994	968,576	268,168	420,424	459,182	791,994	968,576	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Apr	646,583	1,023,250	1,117,910	1,927,670	2,353,430	646,583	1,023,250	1,117,910	1,927,670	2,353,430	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 May	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	2,234,730	3,592,850	3,927,140	6,768,870	8,240,380	0%	12%	10%	13%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2099 Jun	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	2,493,960	4,006,150	4,378,780	7,547,490	9,189,700	0%	12%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2099 Jul	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	1,162,060	1,840,510	2,010,820	3,467,280	4,232,470	0%	10%	9%	11%	9%	-4%	-6%	-5%	-9%	-5%
Impacted	2099 Aug	536,336	831,699	908,056	1,566,680	1,919,850	536,336	831,699	908,056	1,566,680	1,919,850	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2099 Sep	461,845	725,824	792,797	1,367,320	1,671,430	461,845	725,824	792,797	1,367,320	1,671,430	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Oct	357,558	569,201	621,971	1,072,320	1,307,770	357,558	569,201	621,971	1,072,320	1,307,770	0%	11%	9%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Nov	369,476	595,042	650,441	1,121,050	1,364,340	369,476	595,042	650,441	1,121,050	1,364,340	0%	12%	11%	13%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Dec	268,168	431,531	471,695	812,999	989,580	268,168	431,531	471,695	812,999	989,580	0%	12%	11%	13%	10%	-4%	-5%	-4%	-9%	-5%

		Runoff coefficient 0.61																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Baseline	2017 Jan	131,667	189,249	209,979	354,649	441,266	33,821	137,830	298,978	331,114	571,356	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Feb	145,775	209,526	232,436	392,606	488,503	37,444	152,597	331,012	366,590	632,573	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Mar	197,501	283,873	314,857	531,862	661,787	50,731	206,745	448,468	496,671	857,034	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Apr	476,197	684,451	759,017	1,282,240	1,595,500	122,318	498,484	1,081,310	1,197,530	2,066,410	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 May	1,645,840	2,365,610	2,622,850	4,431,230	5,513,940	422,758	1,722,870	3,737,230	4,138,920	7,141,950	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jun	1,836,760	2,640,020	2,926,570	4,944,710	6,153,020	471,798	1,922,720	4,170,750	4,619,040	7,970,420	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jul	855,838	1,230,120	1,363,380	2,303,740	2,866,750	219,834	895,893	1,943,360	2,152,240	3,713,820	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Aug	395,002	567,747	629,137	1,063,150	1,323,000	101,462	413,489	896,935	993,341	1,714,070	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Sep	340,141	488,893	541,658	915,389	1,139,150	87,370	356,060	772,361	855,377	1,476,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Oct	263,335	378,498	419,272	708,612	881,845	67,641	275,659	597,957	662,227	1,142,710	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Nov	272,113	391,115	433,168	732,153	911,161	69,896	284,848	617,889	684,302	1,180,800	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Dec	197,501	283,873	314,339	531,344	661,269	50,731	206,745	448,468	496,671	857,034	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Impacted	2018 Jan	131,667	189,249	209,520	354,190	440,807	33,821	137,830	298,978	331,114	571,356	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Feb	145,775	209,526	231,928	392,098	487,995	37,444	152,597	331,012	366,590	632,573	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Mar	197,501	283,873	314,169	531,174	661,099	50,731	206,745	448,468	496,671	857,034	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Apr	476,197	684,451	757,358	1,280,580	1,593,850	122,318	498,484	1,081,310	1,197,530	2,066,410	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 May	1,645,840	2,365,610	2,617,120	4,425,490	5,508,200	422,758	1,722,870	3,737,230	4,138,920	7,141,950	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Jun	1,836,760	2,640,020	2,920,170	4,938,310	6,146,620	471,798	1,922,720	4,170,750	4,619,040	7,970,420	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Jul	855,838	1,230,120	1,360,400	2,300,760	2,863,770	219,834	895,893	1,943,360	2,152,240	3,713,820	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Aug	395,002	567,747	627,761	1,061,770	1,321,620	101,462	413,489	896,935	993,341	1,714,070	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Sep	340,141	488,893	540,473	914,204	1,137,960	87,370	356,060	772,361	855,377	1,476,000	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Oct	263,335	378,498	418,354	707,694	880,928	67,641	275,659	597,957	662,227	1,142,710	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Nov	272,113	391,115	432,220	731,205	910,213	69,896	284,848	617,889	684,302	1,180,800	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Dec	197,501	283,873	313,651	530,656	660,581	50,731	206,745	448,468	496,671	857,034	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2019 Jan	131,667	235,375	261,026	440,479	527,096	33,821	137,830	298,978	330,475	570,717	0%	5%	4%	4%	3%	0%	0%	0%	0%	0%
Impacted	2019 Feb	145,775	255,608	283,333	477,147	573,044	37,444	152,597	331,012	364,491	630,474	0%	4%	4%	3%	3%	0%	0%	0%	-1%	0%
Impacted	2019 Mar	197,501	329,877	365,302	613,897	743,822	50,731	206,745	448,468	491,941	852,305	0%	4%	4%	3%	3%	0%	0%	0%	-1%	-1%
Impacted	2019 Apr	476,197	730,115	807,119	1,353,060	1,666,320	122,318	498,484	1,081,310	1,181,420	2,050,300	0%	4%	3%	3%	2%	0%	0%	0%	-1%	-1%
Impacted	2019 May	1,645,840	2,409,610	2,660,840	4,448,380	5,531,090	422,758	1,722,870	3,737,230	4,067,020	7,070,050	0%	4%	3%	3%	2%	0%	0%	0%	-2%	-1%
Impacted	2019 Jun	1,836,760	2,687,050	2,966,590	4,946,160	6,154,470	471,798	1,922,720	4,170,750	4,520,660	7,872,050	0%	4%	3%	3%	2%	0%	0%	0%	-2%	-1%
Impacted	2019 Jul	855,838	1,295,580	1,431,090	2,380,370	2,943,380	219,834	895,893	1,943,360	2,097,960	3,659,540	0%	4%	3%	3%	2%	0%	0%	0%	-3%	-1%
Impacted	2019 Aug	395,002	623,349	688,980	1,143,520	1,403,370	101,462	413,489	896,935	964,326	1,685,050	0%	4%	3%	3%	2%	0%	0%	0%	-3%	-2%
Impacted	2019 Sep	340,141	544,964	602,412	997,542	1,221,300	87,370	356,060	772,361	827,035	1,447,660	0%	4%	3%	3%	2%	0%	0%	0%	-3%	-2%
Impacted	2019 Oct	263,335	433,708	479,597	792,557	965,790	67,641	275,659	597,957	637,686	1,118,170	0%	4%	4%	3%	3%	0%	0%	0%	-4%	-2%
Impacted	2019 Nov	272,113	447,994	495,307	816,534	995,542	69,896	284,848	617,889	656,257	1,152,760	0%	4%	4%	3%	3%	0%	0%	0%	-4%	-2%
Impacted	2019 Dec	197,501	338,535	374,509	616,410	746,335	50,731	206,745	448,468	474,366	834,730	0%	4%	4%	3%	3%	0%	0%	0%	-4%	-3%
Impacted	2020 Jan	131,667	240,047	265,858	438,798	525,415	33,821	137,830	298,978	315,605	555,847	0%	5%	4%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2020 Feb	140,748	251,327	278,312	461,508	554,099	36,153	147,335	319,598	337,371	594,182	0%	5%	4%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2020 Mar	197,501	331,634	366,923	611,223	741,148	50,731	206,745	448,468	473,407	833,771	0%	4%	4%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2020 Apr	476,197	729,684	806,130	1,349,830	1,663,100	122,318	498,484	1,081,310	1,141,440	2,010,310	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 May	1,645,840	2,393,480	2,642,160	4,451,190	5,533,910	422,758	1,722,870	3,737,230	3,945,060	6,948,090	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Jun	1,836,760	2,645,490	2,920,600	4,951,230	6,159,540	471,798	1,922,720	4,170,750	4,402,690	7,754,070	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Jul	855,838	1,246,570	1,376,900	2,348,310	2,911,320	219,834	895,893	1,943,360	2,051,430	3,613,010	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Aug	395,002	594,871	657,674	1,127,810	1,387,660	101,462	413,489	896,935	946,815	1,667,540	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Sep	340,141	515,481	570,122	983,236	1,207,000	87,370	356,060	772,361	815,313	1,435,940	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Oct	263,335	407,041	450,470	780,881	954,115	67,641	275,659	597,957	631,210	1,111,690	0%	4%	3%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2020 Nov	272,113	416,470	460,943	803,848	982,857	69,896	284,848	617,889	652,250	1,148,750	0%	4%	3%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2020 Dec	197,501	312,774	346,470	606,752	736,677	50,731	206,745	448,468	473,407	833,771	0%	4%	4%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2021 Jan	131,667	223,163	247,479	433,195	519,812	33,821	137,820	298,942	315,568	555,811	0%	4%	4%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2021 Feb	145,775	242,068	268,292	469,857	565,755	37,444	152,568	330,896	349,304	615,287	0%	4%	4%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2021 Mar	197,501	311,402	344,747	604,873	734,799	50,731	206,679	448,209	473,149	833,513	0%	4%	3%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2021 Apr	476,197	686,401	758,427	1,335,610	1,648,880	122,318	498,262	1,080,430	1,140,560	2,009,440	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 May	1,645,840	2,262,890	2,497,220	4,405,810	5,488,520	422,758	1,721,880	3,733,330	3,941,160	6,944,190	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Jun	1,836,760	2,777,650	3,007,910	4,926,370	6,135,080	471,798	1,921,370	4,165,410	4,397,350	7,748,740	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Jul	855,838	1,317,650	1,427,850	2,340,340	2,903,540	219,834	895,148	1,940,420	2,048,490	3,610,070	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Aug	395,002	632,247	686,157	1,126,180	1,386,120	101,462	413,091	895,364	945,244	1,665,970	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Sep	340,141	551,887	599,038	982,746	1,206,580	87,370	355,671	770,827	813,779	1,434,410	0%	4%	4%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Oct	263,335	438,495	476,254	781,206	954,498	67,641	275,323	596,629	629,882	1,110,370	0%	4%	4%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2021 Nov	272,113	452,334	491,090	804,949	984,018	69,896	284,464	616,372	650,733	1,147,240	0%	4%	4%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2021 Dec	197,501	341,174	370,858	608,273	738,242	50,731	206,439	447,262	472,202	832,565	0%	4%	4%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Jan	131,667	189,039	203,926	332,753	419,400	33,821	137,608	298,103	314,730	554,972	0%	9%	6%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Feb	145,775	225,825	244,370	399,626	495,556	37,444	152,333	329,968	348,376	614,359	0%	10%	7%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Mar	197,501	341,021	370,562	607,801	737,771	50,731	206,360	446,952	471,891	832,255	0%	11%	7%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Apr	476,197	758,132	821,000	1,343,080	1,656,450	122,318	497,493	1,077,400	1,137,530	2,006,410	0%	10%	7%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 May	1,645,840	2,512,300	2,714,830	4,432,090	5,515,170	422,758	1,719,230	3,722,850	3,930,680	6,933,710	0%	9%	7%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Jun	1,836,760	2,800,060	3,024,960	4,936,780	6,145,500	471,798	1,918,410	4,153,720	4,385,660	7,737,040	0%	9%	7%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Jul	855,838	1,328,480	1,436,190	2,346,770	2,909,970	219,834	893,766	1,934,970	2,043,040	3,604,620	0%	10%	7%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Aug	395,002	637,247	690,004	1,130,250	1,390,190	101,462	412,453	892,849	942,729	1,663,460	0%	10%	7%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Sep	340,141	556,192	602,351	986,273	1,210,110	87,370	355,122	768,661	811,613	1,432,240	0%	10%	7%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Oct	263,335	441,828	478,819	783,954	957,246	67,641	274,898	594,953	628,206	1,108,690	0%	10%	7%	4%	3%	0%	0%	-1%	-5%	-3%
Impacted	2022 Nov	272,113	455,778	493,740	807,806	986,875	69,896	284,025	614,640	649,001	1,145,500	0%	10%	7%	4%	3%	0%	0%	-1%	-5%	-3%
Impacted	2022 Dec	197,501	343,674	372,781	610,360	740,330	50,731	206,120	446,004	470,944	831,308	0%	11%	8%	4%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jan	131,667	188,084	202,254	328,978	415,625	33,821	137,395	297,265	313,891	554,134	0%	9%	6%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Feb	145,775	207,964	223,588	363,688	459,617	37,444	152,097	329,039	347,447	613,430	0%	9%	6%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Mar	197,501	296,452	319,458	520,684	650,654	50,731	206,041	445,694	470,633	830,997	0%	9%	6%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Apr	476,197	764,162	825,639	1,348,010	1,661,380	122,318	496,725	1,074,360	1,134,500	2,003,370	0%	10%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 May	1,645,840	2,527,700	2,724,740	4,439,500	5,522,580	422,758	1,716,570	3,712,370	3,920,200	6,923,230	0%	9%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jun	1,836,760	2,791,990	3,007,560	4,897,490	6,106,200	471,798	1,915,440	4,142,020	4,373,960	7,725,350	0%	9%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jul	855,838	1,344,890	1,450,800	2,365,340	2,928,540	219,834	892,385	1,929,520	2,037,590	3,599,170	0%	10%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Aug	395,002	644,660	696,570	1,137,320	1,397,260	101,462	411,816	890,333	940,213	1,660,940	0%	10%	7%	4%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Sep	340,141	562,669	608,110	992,502	1,216,340	87,370	354,573	766,495	809,447	1,430,070	0%	10%	7%	4%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Oct	263,335	446,915	483,359	788,872	962,164	67,641	274,473	593,275	626,528	1,107,010	0%	10%	7%	4%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Nov	272,113	461,098	498,504	813,011	992,080	69,896	283,585	612,906	647,268	1,143,770	0%	10%	7%	4%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Dec	197,501	345,710	374,182	610,622	740,592	50,731	205,801	444,746	469,686	830,050	0%	11%	8%	4%	3%	0%	0%	-1%	-5%	-3%
Impacted	2024 Jan	131,667	202,037	217,414	352,880	439,526	33,821	137,182	296,405	313,032	553,274	0%	9%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2024 Feb	140,748	260,372	282,472	461,611	554,233	36,153	146,623	316,730	334,503	591,314	0%	11%	8%	4%	3%	0%	0%	-1%	-5%	-3%
Impacted	2024 Mar	197,501	346,025	374,663	611,890	741,860	50,731	205,718	444,280	469,220	829,584	0%	11%	7%	4%	3%	0%	0%	-1%	-6%	-3%
Impacted	2024 Apr	476,197	769,048	829,834	1,354,080	1,667,450	122,318	495,939	1,070,810	1,130,940	1,999,820	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2024 May	1,645,840	2,546,300	2,742,000	4,470,690	5,553,770	422,758	1,713,840	3,699,550	3,907,390	6,910,420	0%	9%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jun	1,836,760	2,833,270	3,050,890	4,977,250	6,185,960	471,798	1,912,380	4,127,150	4,359,090	7,710,480	0%	9%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jul	855,838	1,341,530	1,445,970	2,362,290	2,925,490	219,834	890,949	1,922,330	2,030,400	3,591,970	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Aug	395,002	642,083	693,388	1,134,990	1,394,930	101,462	411,150	886,889	936,768	1,657,500	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Sep	340,141	559,580	604,563	989,903	1,213,740	87,370	353,997	763,423	806,375	1,427,000	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%

		Runoff coefficient 0.61																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2024 Oct	263,335	443,849	479,988	786,315	959,608	67,641	274,024	590,815	624,068	1,104,550	0%	10%	7%	4%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Nov	272,113	457,234	494,375	809,986	989,055	69,896	283,119	610,279	644,641	1,141,140	0%	10%	7%	4%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Dec	197,501	344,227	372,774	611,417	741,386	50,731	205,461	442,778	467,718	828,082	0%	11%	7%	4%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jan	131,667	244,564	265,534	436,899	523,545	33,821	136,955	295,072	311,699	551,941	0%	11%	8%	4%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Feb	145,775	265,400	287,979	474,028	569,958	37,444	151,608	326,568	344,976	610,959	0%	11%	8%	4%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Mar	197,501	342,476	370,976	610,641	740,611	50,731	205,377	442,286	467,226	827,590	0%	11%	7%	4%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Apr	476,197	760,494	820,947	1,349,520	1,662,890	122,318	495,119	1,066,000	1,126,130	1,995,010	0%	10%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2025 May	1,645,840	2,516,740	2,711,300	4,453,170	5,536,250	422,758	1,711,000	3,682,940	3,890,780	6,893,810	0%	9%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jun	1,836,760	2,800,290	3,016,620	4,957,610	6,166,330	471,798	1,909,220	4,108,620	4,340,560	7,691,940	0%	9%	7%	3%	3%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jul	855,838	1,326,160	1,430,000	2,353,550	2,916,750	219,834	889,475	1,913,690	2,021,760	3,583,340	0%	9%	7%	3%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Aug	395,002	634,987	686,017	1,131,340	1,391,280	101,462	410,469	882,901	932,781	1,653,510	0%	10%	7%	3%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Sep	340,141	553,469	598,215	986,862	1,210,700	87,370	353,411	759,989	802,941	1,423,570	0%	10%	7%	3%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Oct	263,335	439,118	475,073	784,126	957,419	67,641	273,570	588,156	621,409	1,101,890	0%	10%	7%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Nov	272,113	452,345	489,296	807,700	986,769	69,896	282,650	607,532	641,893	1,138,400	0%	10%	7%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Dec	197,501	340,678	369,088	609,959	739,928	50,731	205,121	440,784	465,724	826,088	0%	11%	7%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jan	131,667	242,199	263,077	435,539	522,186	33,821	136,728	293,743	310,370	550,612	0%	7%	4%	3%	2%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Feb	145,775	262,782	285,259	472,494	568,424	37,444	151,357	325,097	343,505	609,487	0%	7%	4%	3%	2%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Mar	197,501	338,929	367,291	608,534	738,503	50,731	205,037	440,293	465,232	825,596	0%	7%	4%	3%	2%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Apr	476,197	751,940	812,061	1,344,320	1,657,690	122,318	494,298	1,061,190	1,121,330	1,990,200	0%	6%	4%	2%	2%	0%	-1%	-2%	-6%	-4%
Impacted	2026 May	1,645,840	2,487,180	2,680,590	4,434,990	5,518,070	422,758	1,708,170	3,666,330	3,874,160	6,877,190	0%	6%	4%	2%	2%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jun	1,836,760	2,767,290	2,982,350	4,937,310	6,146,030	471,798	1,906,050	4,090,080	4,322,010	7,673,400	0%	6%	4%	2%	2%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jul	855,838	1,310,790	1,414,030	2,344,140	2,907,340	219,834	888,001	1,905,050	2,013,120	3,574,700	0%	6%	4%	2%	2%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Aug	395,002	627,892	678,646	1,127,040	1,386,980	101,462	409,789	878,914	928,794	1,649,520	0%	6%	4%	2%	2%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Sep	340,141	547,360	591,867	983,173	1,207,010	87,370	352,824	756,555	799,507	1,420,130	0%	7%	4%	2%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Oct	263,335	434,388	470,159	781,288	954,581	67,641	273,116	585,498	618,751	1,099,240	0%	7%	4%	3%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Nov	272,113	447,458	484,218	804,765	983,834	69,896	282,181	604,785	639,147	1,135,650	0%	7%	4%	3%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Dec	197,501	335,002	363,005	603,826	733,795	50,731	204,780	438,791	463,730	824,094	0%	7%	4%	3%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jan	131,667	175,582	188,238	312,350	398,997	33,819	136,497	292,445	309,071	549,314	0%	6%	3%	2%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Feb	145,775	193,975	207,987	345,394	441,324	37,440	151,093	323,722	342,130	608,113	0%	6%	3%	2%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Mar	197,501	262,107	281,090	467,319	597,289	50,722	204,667	438,517	463,456	823,820	0%	6%	3%	2%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Apr	476,197	631,694	677,464	1,126,740	1,440,110	122,288	493,379	1,057,130	1,117,260	1,986,130	0%	6%	3%	2%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2027 May	1,645,840	2,304,890	2,478,360	4,123,740	5,206,820	422,626	1,704,890	3,653,010	3,860,840	6,863,870	0%	6%	3%	2%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jun	1,836,760	2,741,540	2,956,990	4,925,030	6,133,750	471,618	1,902,290	4,076,030	4,307,970	7,659,360	0%	6%	4%	2%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jul	855,838	1,299,410	1,402,980	2,339,040	2,902,240	219,735	886,195	1,898,890	2,006,960	3,568,540	0%	6%	4%	2%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Aug	395,002	622,931	673,901	1,124,920	1,384,860	101,409	408,932	876,252	926,131	1,646,860	0%	7%	4%	3%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Sep	340,141	543,334	588,085	981,596	1,205,430	87,318	352,066	754,416	797,367	1,417,990	0%	7%	4%	3%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Oct	263,335	431,461	467,464	780,242	953,534	67,596	272,514	583,960	617,213	1,097,700	0%	7%	4%	3%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Nov	272,113	444,630	481,676	803,919	982,988	69,845	281,542	603,318	637,679	1,134,180	0%	7%	4%	3%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Dec	197,501	335,221	363,733	607,343	737,313	50,690	204,305	437,814	462,754	823,117	0%	7%	4%	3%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jan	131,667	238,658	259,626	433,875	520,522	33,791	136,176	291,823	308,450	548,692	0%	7%	4%	3%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Feb	140,748	251,623	273,646	457,550	550,172	36,119	145,539	311,894	329,667	586,479	0%	7%	4%	3%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Mar	197,501	333,889	362,451	606,399	736,369	50,680	204,185	437,581	462,521	822,885	0%	7%	4%	3%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Apr	476,197	740,132	800,814	1,339,710	1,653,080	122,185	492,216	1,054,870	1,115,000	1,983,880	0%	6%	4%	2%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2028 May	1,645,840	2,447,560	2,643,180	4,420,720	5,503,790	422,271	1,700,870	3,645,220	3,853,050	6,856,080	0%	6%	4%	2%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jun	1,836,760	2,724,400	2,942,230	4,922,890	6,131,610	471,221	1,897,800	4,067,340	4,299,280	7,650,660	0%	6%	4%	2%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jul	855,838	1,291,420	1,396,100	2,338,070	2,901,270	219,550	884,105	1,894,830	2,002,910	3,564,480	0%	6%	4%	2%	2%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Aug	395,002	619,243	670,727	1,124,530	1,384,460	101,323	407,967	874,381	924,260	1,644,990	0%	6%	4%	2%	2%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Sep	340,141	540,160	585,352	981,266	1,205,100	87,245	351,236	752,805	795,757	1,416,380	0%	7%	4%	2%	2%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Oct	263,335	429,004	465,349	780,006	953,298	67,540	271,871	582,713	615,966	1,096,450	0%	7%	4%	3%	2%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Nov	272,113	442,091	479,490	803,667	982,736	69,786	280,878	602,030	636,391	1,132,890	0%	7%	4%	3%	2%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Dec	197,501	333,378	362,146	607,189	737,158	50,648	203,823	436,879	461,819	822,182	0%	7%	4%	3%	2%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Jan	131,667	237,429	258,569	433,443	520,089	33,763	135,855	291,200	307,826	548,069	0%	7%	4%	3%	2%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Feb	145,775	257,603	280,393	470,329	566,258	37,378	150,382	322,344	340,752	606,735	0%	7%	4%	3%	2%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Mar	197,501	332,050	360,868	605,890	735,860	50,637	203,704	436,649	461,589	821,953	0%	7%	4%	3%	2%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Apr	476,197	735,700	796,999	1,338,880	1,652,250	122,083	491,056	1,052,620	1,112,750	1,981,630	0%	6%	4%	2%	2%	0%	-1%	-3%	-7%	-4%
Impacted	2029 May	1,645,840	2,432,240	2,629,990	4,418,450	5,501,530	421,916	1,696,870	3,637,450	3,845,280	6,848,310	0%	6%	4%	2%	2%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jun	1,836,760	2,707,310	2,927,520	4,920,400	6,129,120	470,825	1,893,330	4,058,660	4,290,600	7,641,990	0%	6%	3%	2%	2%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jul	855,838	1,291,090	1,397,760	2,350,610	2,913,810	219,365	882,021	1,890,790	1,998,870	3,560,440	0%	6%	4%	2%	2%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Aug	395,002	624,913	677,985	1,140,690	1,400,630	101,238	407,004	872,515	922,395	1,643,120	0%	7%	4%	2%	2%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Sep	340,141	543,403	589,775	992,192	1,216,030	87,171	350,407	751,198	794,150	1,414,780	0%	7%	4%	3%	2%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Oct	263,335	428,737	465,674	783,372	956,664	67,483	271,229	581,469	614,722	1,095,210	0%	7%	4%	3%	2%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Nov	272,113	442,777	480,899	808,908	987,977	69,727	280,215	600,744	635,106	1,131,610	0%	7%	4%	3%	2%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Dec	197,501	331,540	360,564	606,673	736,643	50,605	203,341	435,946	460,886	821,250	0%	7%	4%	3%	2%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jan	131,667	236,204	257,514	433,673	520,319	33,734	135,534	290,578	307,205	547,447	0%	3%	1%	2%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Feb	145,775	256,246	279,225	470,550	566,479	37,346	150,027	321,656	340,064	606,046	0%	3%	1%	2%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Mar	197,501	330,212	359,286	606,049	736,019	50,595	203,223	435,716	460,656	821,020	0%	3%	1%	1%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Apr	476,197	731,267	793,183	1,338,690	1,652,060	121,980	489,896	1,050,370	1,110,500	1,979,380	0%	3%	1%	1%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2030 May	1,645,840	2,471,060	2,677,180	4,514,890	5,597,970	421,562	1,692,860	3,629,670	3,837,500	6,840,540	0%	3%	1%	1%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jun	1,836,760	2,781,390	3,014,480	5,083,670	6,292,390	470,430	1,888,850	4,049,990	4,281,930	7,633,310	0%	3%	1%	1%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jul	855,838	1,307,830	1,418,450	2,394,680	2,957,880	219,181	879,936	1,886,750	1,994,830	3,556,400	0%	3%	1%	1%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Aug	395,002	615,447	668,363	1,130,130	1,390,070	101,153	406,042	870,650	920,529	1,641,260	0%	3%	1%	1%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Sep	340,141	534,899	581,096	982,511	1,206,350	87,098	349,578	749,592	792,544	1,413,170	0%	3%	1%	1%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Oct	263,335	424,102	461,129	779,496	952,788	67,426	270,588	580,226	613,479	1,093,960	0%	3%	1%	1%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Nov	272,113	437,025	475,129	803,136	982,205	69,669	279,552	599,459	633,821	1,130,320	0%	3%	1%	1%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Dec	197,501	329,701	358,981	606,838	736,807	50,562	202,860	435,013	459,953	820,317	0%	3%	1%	1%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Jan	131,667	234,970	256,450	433,523	520,169	33,698	135,172	289,920	306,547	546,789	0%	3%	1%	2%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Feb	145,775	254,862	278,031	470,371	566,301	37,291	149,545	320,856	339,264	605,247	0%	3%	1%	2%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Mar	197,501	328,315	357,646	605,804	735,774	50,500	202,460	434,536	459,476	819,839	0%	3%	1%	1%	1%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Apr	476,197	726,636	789,174	1,338,100	1,651,470	121,700	487,781	1,047,290	1,107,420	1,976,300	0%	3%	1%	1%	1%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 May	1,645,840	2,411,790	2,615,100	4,434,820	5,517,900	420,418	1,684,600	3,618,170	3,826,000	6,829,030	0%	3%	1%	1%	1%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Jun	1,836,760	2,764,900	3,000,610	5,084,610	6,293,330	468,954	1,878,570	4,036,210	4,268,150	7,619,540	0%	3%	1%	1%	1%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Jul	855,838	1,295,240	1,406,540	2,386,420	2,949,620	218,401	874,645	1,879,900	1,987,970	3,549,550	0%	3%	1%	1%	1%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Aug	395,002	607,867	660,896	1,123,190	1,383,130	100,750	403,368	867,283	917,163	1,637,890	0%	3%	1%	1%	1%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Sep	340,141	530,332	576,859	980,154	1,203,990	86,715	347,079	746,521	789,473	1,410,100	0%	3%	1%	1%	1%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Oct	263,335	421,372	458,751	779,185	952,478	67,101	268,500	577,713	610,966	1,091,450	0%	3%	1%	1%	1%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Nov	272,113	434,180	472,651	802,828	981,897	69,303	277,237	596,725	631,087	1,127,590	0%	3%	1%	1%	1%	-1%	-3%	-3%	-8%	-5%
Impacted	2031 Dec	197,501	327,620	357,167	606,623	736,592	50,276	201,067	432,930	457,870	818,234	0%	3%	1%	1%	1%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Jan	131,667	233,579	255,239	433,386	520,033	33,501	133,940	288,499	305,126	545,369	0%	4%	1%	2%	1%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Feb	140,748	246,181	268,944	457,023	549,644	35,794	143,069	308,271	326,044	582,855	0%	4%	1%	2%	1%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Mar	197,501	326,235	355,837	605,622	735,591	50,202	200,606	432,399	457,339	817,702	0%	3%	1%	2%	1%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Apr	476,197	721,635	784,828	1,337,690	1,651,060	120,984	483,312	1,042,130	1,102,260	1,971,140	0%	3%	1%	2%	1%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 May	1,645,840	2,380,660	2,584,490	4,407,270	5,490,350	417,939	1,669,140	3,600,340	3,808,180	6,811,210	0%	3%	1%	1%	1%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Jun	1,836,760	2,258,900	2,435,340	4,161,310	5,370,020	466,188	1,861,320	4,016,320	4,248,260	7,599,650	0%	3%	1%	1%	1%	-1%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.61																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2032 Jul	855,838	1,047,980	1,130,190	1,934,400	2,497,600	217,112	866,607	1,870,630	1,978,700	3,540,280	0%	3%	1%	1%	1%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Aug	395,002	480,560	518,502	889,676	1,149,620	100,155	399,658	863,004	912,884	1,633,610	0%	3%	1%	1%	1%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Sep	340,141	413,646	446,318	765,939	989,775	86,203	343,887	742,839	785,791	1,406,420	0%	3%	1%	1%	1%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Oct	263,335	320,303	345,598	593,046	766,338	66,705	266,029	574,864	608,117	1,088,600	0%	3%	1%	1%	1%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Nov	272,113	330,967	357,105	612,800	791,869	68,894	274,684	593,780	628,142	1,124,640	0%	3%	1%	1%	1%	-1%	-4%	-4%	-8%	-5%
Impacted	2032 Dec	197,501	239,872	258,844	444,428	574,398	49,979	199,213	430,792	455,731	816,095	0%	3%	1%	1%	1%	-1%	-4%	-4%	-8%	-5%
Impacted	2033 Jan	131,667	159,588	172,236	295,959	382,605	33,302	132,704	287,074	303,700	543,943	0%	2%	1%	1%	1%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Feb	145,775	176,250	190,252	327,230	423,160	36,853	146,812	317,704	336,112	602,095	0%	2%	1%	1%	1%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Mar	197,501	254,184	275,196	473,103	603,073	49,906	198,757	430,265	455,205	815,569	0%	2%	1%	1%	1%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Apr	476,197	716,693	780,545	1,337,370	1,650,740	120,268	478,852	1,036,990	1,097,120	1,966,000	0%	3%	1%	1%	1%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 May	1,645,840	2,445,830	2,661,570	4,556,170	5,639,250	415,467	1,653,730	3,582,570	3,790,400	6,793,430	0%	3%	1%	1%	1%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jun	1,836,760	2,760,100	3,004,740	5,142,560	6,351,280	463,430	1,844,120	3,996,480	4,228,420	7,579,810	0%	3%	1%	1%	1%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jul	855,838	1,297,990	1,414,020	2,422,440	2,985,640	215,827	858,595	1,861,390	1,969,460	3,531,040	0%	3%	1%	1%	1%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Aug	395,002	610,816	666,225	1,142,860	1,402,800	99,563	395,962	858,741	908,621	1,629,350	0%	3%	1%	1%	1%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Sep	340,141	530,431	578,725	992,671	1,216,510	85,692	340,702	739,166	782,118	1,402,740	0%	3%	1%	1%	1%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Oct	263,335	416,909	455,134	780,656	953,949	66,309	263,563	572,020	605,273	1,085,760	0%	3%	1%	1%	1%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Nov	272,113	430,780	470,264	806,542	985,611	68,485	272,136	590,841	625,203	1,121,700	0%	3%	1%	1%	1%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Dec	197,501	323,516	353,611	606,358	736,328	49,682	197,363	428,658	453,598	813,962	0%	3%	1%	1%	1%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Jan	131,667	230,888	252,906	433,207	519,854	33,108	131,473	285,662	302,288	542,531	0%	22%	20%	22%	18%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Feb	145,775	250,441	274,191	470,025	565,954	36,643	145,453	316,162	334,570	600,553	0%	20%	18%	20%	16%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Mar	197,501	322,456	352,556	605,339	735,309	49,630	196,922	428,205	453,145	813,509	0%	14%	12%	14%	11%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Apr	476,197	733,007	799,677	1,373,500	1,686,870	119,623	474,440	1,032,090	1,092,220	1,961,100	0%	7%	5%	7%	6%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 May	1,645,840	2,479,470	2,702,040	4,637,870	5,720,950	413,307	1,638,540	3,565,900	3,773,730	6,776,760	0%	5%	3%	5%	4%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jun	1,836,760	2,763,140	3,011,120	5,169,020	6,377,740	461,098	1,827,230	3,978,160	4,210,100	7,561,490	0%	5%	3%	5%	4%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jul	855,838	1,302,740	1,420,560	2,439,770	3,002,970	214,777	850,750	1,852,980	1,961,050	3,522,630	0%	6%	4%	6%	5%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Aug	395,002	617,530	674,217	1,158,560	1,418,500	99,094	392,351	854,918	904,798	1,625,530	0%	9%	7%	9%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Sep	340,141	536,512	585,884	1,006,320	1,230,160	85,303	337,603	735,924	778,876	1,399,500	0%	10%	8%	10%	8%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Oct	263,335	423,743	463,001	794,757	968,049	66,019	261,172	569,550	602,803	1,083,290	0%	12%	10%	12%	10%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Nov	272,113	437,053	477,466	819,353	998,422	68,197	269,672	588,330	622,691	1,119,190	0%	12%	10%	12%	10%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Dec	197,501	326,440	356,987	612,467	742,436	49,482	195,581	426,865	451,805	812,168	0%	15%	14%	15%	12%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Jan	131,667	230,821	252,898	433,553	520,199	32,977	130,288	284,477	301,103	541,346	0%	22%	20%	22%	18%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Feb	145,775	250,400	274,219	470,469	566,398	36,498	144,141	314,850	333,258	599,241	0%	20%	18%	20%	16%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Mar	197,501	322,445	352,644	606,024	735,994	49,433	195,144	426,428	451,367	811,731	0%	14%	12%	14%	11%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Apr	476,197	738,866	806,454	1,385,820	1,699,190	119,149	470,155	1,027,810	1,087,940	1,956,810	0%	8%	6%	8%	6%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 May	1,645,840	2,480,910	2,704,490	4,646,400	5,729,480	411,670	1,623,720	3,551,080	3,758,920	6,761,950	0%	5%	3%	5%	4%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jun	1,836,760	2,765,740	3,014,960	5,180,350	6,389,070	459,271	1,810,690	3,961,630	4,193,570	7,544,950	0%	5%	3%	5%	4%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jul	855,838	1,303,450	1,421,800	2,444,150	3,007,350	213,926	843,048	1,845,280	1,953,350	3,514,920	0%	6%	4%	6%	5%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Aug	395,002	618,049	674,998	1,160,930	1,420,860	98,702	388,797	851,363	901,243	1,621,970	0%	9%	7%	9%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Sep	340,141	537,273	586,906	1,008,930	1,232,760	84,965	334,541	732,862	775,814	1,396,440	0%	10%	8%	10%	8%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Oct	263,335	424,014	463,438	796,195	969,488	65,757	258,801	567,179	600,432	1,080,920	0%	12%	11%	12%	10%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Nov	272,113	437,417	478,012	820,993	1,000,060	67,927	267,223	585,881	620,242	1,116,740	0%	12%	10%	12%	10%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Dec	197,501	326,503	357,158	613,292	743,262	49,285	193,804	425,087	450,027	810,391	0%	15%	14%	15%	12%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Jan	131,667	230,859	253,007	434,095	520,741	32,846	129,103	283,291	299,918	540,160	0%	22%	20%	22%	18%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Feb	140,748	243,397	266,672	457,835	550,457	35,100	137,902	302,725	320,498	577,309	0%	20%	19%	21%	17%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Mar	197,501	322,501	352,808	606,840	736,809	49,236	193,361	424,645	449,585	809,949	0%	14%	12%	14%	11%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Apr	476,197	732,966	800,120	1,376,860	1,690,230	118,675	465,856	1,023,510	1,083,640	1,952,520	0%	7%	5%	7%	6%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 May	1,645,840	2,481,550	2,706,050	4,653,510	5,736,590	410,029	1,608,870	3,536,230	3,744,590	6,747,630	0%	5%	3%	5%	4%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Jun	1,836,760	2,765,630	3,015,780	5,186,800	6,395,520	457,440	1,794,110	3,945,050	4,180,010	7,531,390	0%	5%	3%	5%	4%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Jul	855,838	1,303,420	1,422,200	2,447,190	3,010,390	213,073	835,320	1,837,550	1,946,820	3,508,390	0%	6%	4%	6%	5%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Aug	395,002	616,709	673,707	1,159,930	1,419,870	98,308	385,229	847,796	897,985	1,618,710	0%	9%	7%	9%	7%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Sep	340,141	536,055	585,722	1,007,950	1,231,790	84,626	331,469	729,790	772,947	1,393,570	0%	10%	8%	10%	8%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Oct	263,335	422,143	461,487	793,759	967,052	65,495	256,423	564,801	598,103	1,078,590	0%	12%	10%	12%	10%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Nov	272,113	436,238	476,836	819,841	998,910	67,655	264,766	583,423	617,861	1,114,360	0%	12%	10%	12%	10%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Dec	197,501	325,323	355,944	611,871	741,840	49,088	192,021	423,304	448,244	808,608	0%	15%	13%	15%	12%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jan	131,667	230,896	253,116	434,638	521,285	32,715	127,914	282,103	298,903	539,146	0%	22%	21%	23%	18%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Feb	145,775	250,483	274,460	471,671	567,600	36,208	141,513	312,222	330,906	596,889	0%	20%	18%	20%	16%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Mar	197,501	322,557	352,972	607,653	737,622	49,040	191,584	422,867	448,181	808,545	0%	14%	12%	14%	11%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Apr	476,197	732,830	800,211	1,378,330	1,691,700	118,201	461,570	1,019,220	1,080,250	1,949,130	0%	7%	5%	7%	6%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 May	1,645,840	2,483,150	2,708,670	4,662,330	5,745,410	408,393	1,594,050	3,521,410	3,732,360	6,735,400	0%	5%	3%	5%	4%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jun	1,836,760	2,767,700	3,019,030	5,197,160	6,405,880	455,613	1,777,580	3,928,510	4,163,940	7,515,320	0%	5%	3%	5%	4%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Jul	855,838	1,303,730	1,422,980	2,450,830	3,014,030	212,222	827,616	1,829,840	1,939,540	3,501,120	0%	6%	4%	6%	5%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Aug	395,002	616,996	674,229	1,161,870	1,421,810	97,915	381,674	844,241	894,870	1,615,600	0%	9%	7%	9%	7%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Sep	340,141	535,920	585,746	1,008,930	1,232,770	84,288	328,408	726,729	770,326	1,390,950	0%	10%	8%	10%	8%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Oct	263,335	422,330	461,830	795,047	968,340	65,233	254,053	562,431	596,184	1,076,670	0%	12%	10%	12%	10%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Nov	272,113	436,260	477,000	820,861	999,931	67,385	262,317	580,974	615,852	1,112,350	0%	12%	10%	12%	10%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Dec	197,501	324,913	355,587	611,839	741,809	48,892	190,242	421,526	446,841	807,204	0%	14%	13%	15%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jan	131,667	177,217	192,586	332,739	419,386	32,584	126,728	280,917	297,793	538,036	0%	8%	6%	8%	7%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Feb	145,775	193,829	210,570	364,082	460,012	36,063	140,200	310,909	329,594	595,576	0%	8%	6%	8%	7%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Mar	197,501	265,327	288,406	498,790	628,760	48,844	189,805	421,088	446,403	806,767	0%	8%	6%	8%	7%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Apr	476,197	637,655	692,982	1,198,310	1,511,680	117,728	457,283	1,014,930	1,075,970	1,944,850	0%	8%	6%	8%	7%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 May	1,645,840	2,215,860	2,408,190	4,161,390	5,244,470	406,756	1,579,240	3,506,600	3,717,560	6,720,590	0%	8%	6%	8%	7%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jun	1,836,760	2,462,320	2,675,730	4,624,860	5,833,580	453,787	1,761,040	3,911,980	4,147,410	7,498,790	0%	8%	6%	8%	7%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jul	855,838	1,149,770	1,249,780	2,161,450	2,724,650	211,371	819,910	1,822,140	1,931,840	3,493,410	0%	8%	6%	8%	7%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Aug	395,002	529,324	575,483	996,252	1,256,190	97,522	378,118	840,685	891,315	1,612,040	0%	8%	6%	8%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Sep	340,141	519,595	567,346	978,010	1,201,850	83,949	325,347	723,668	767,267	1,387,890	0%	9%	7%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Oct	263,335	437,914	479,344	824,211	997,504	64,971	251,683	560,061	593,815	1,074,300	0%	10%	8%	11%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Nov	272,113	451,561	494,202	849,544	1,028,610	67,114	259,868	578,525	613,405	1,109,910	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Dec	197,501	340,209	372,747	640,246	770,215	48,696	188,465	419,749	445,065	805,428	0%	10%	8%	11%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jan	131,667	242,607	266,307	456,768	543,414	32,458	125,595	279,784	296,661	536,904	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Feb	145,775	263,457	289,069	496,145	592,075	35,936	139,050	309,760	328,445	594,428	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Mar	197,501	340,123	372,742	640,732	770,701	48,688	188,389	419,673	444,988	805,352	0%	9%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Apr	476,197	755,515	825,924	1,422,330	1,735,700	117,391	454,224	1,011,870	1,072,910	1,941,790	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 May	1,645,840	2,549,360	2,784,420	4,795,650	5,878,720	405,730	1,569,880	3,497,240	3,708,210	6,711,240	0%	8%	6%	8%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jun	1,836,760	2,955,080	3,231,360	5,560,180	6,768,890	452,795	1,751,980	3,902,910	4,138,350	7,489,730	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jul	855,838	1,369,650	1,497,680	2,578,570	3,141,780	210,980	816,325	1,818,550	1,928,260	3,489,830	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Aug	395,002	633,176	692,548	1,193,110	1,453,050	97,375	376,762	839,329	889,960	1,610,690	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Sep	340,141	552,407	604,354	1,040,350	1,264,190	83,851	324,431	722,753	766,352	1,386,980	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Oct	263,335	438,681	480,225	825,784	999,077	64,917	251,170	559,548	593,303	1,073,790	0%	9%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Nov	272,113	452,291	495,032	850,974	1,030,040	67,081	259,541	578,198	613,077	1,109,580	0%	9%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Dec	197,501	340,927	373,550	641,564	771,533	48,688	188,375	419,658	444,974	805,338	0%	9%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jan	131,667	242,561	266,255	456,678	543,324	32,458	125,582	279,771	296,648	536,891	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Feb	140,748	255,897	280,818	481,917	574,539	34,697	134,242	299,064	317,105	573,916	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Mar	197,501	340,030	372,636	640,551	770,520	48,688	188,370	419,653	444,969	805,333	0%	9%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%

		Runoff coefficient 0.61																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2040 Apr	476,197	755,289	825,668	1,421,890	1,735,260	117,391	454,176	1,011,830	1,072,870	1,941,740	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 May	1,645,840	2,549,400	2,784,460	4,795,690	5,878,770	405,730	1,569,720	3,497,080	3,708,050	6,711,080	0%	8%	6%	8%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jun	1,836,760	2,954,460	3,230,660	5,558,980	6,767,700	452,795	1,751,790	3,902,730	4,138,160	7,489,550	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jul	855,838	1,369,500	1,497,510	2,578,280	3,141,480	210,980	816,240	1,818,470	1,928,170	3,489,750	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Aug	395,002	632,989	692,336	1,192,740	1,452,680	97,375	376,723	839,290	889,921	1,610,650	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Sep	340,141	552,246	604,171	1,040,040	1,263,870	83,851	324,397	722,719	766,318	1,386,940	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Oct	263,335	438,556	480,083	825,543	998,835	64,917	251,144	559,522	593,276	1,073,760	0%	9%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Nov	272,113	452,162	494,886	850,725	1,029,790	67,081	259,513	578,171	613,050	1,109,550	0%	9%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Dec	197,501	340,833	373,444	641,382	771,352	48,688	188,355	419,638	444,954	805,318	0%	9%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jan	131,667	242,493	266,178	456,547	543,193	32,458	125,567	279,756	296,634	536,876	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Feb	145,775	263,302	288,893	495,846	591,776	35,936	139,017	309,726	328,412	594,395	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Mar	197,501	339,898	372,487	640,298	770,268	48,688	188,341	419,624	444,940	805,304	0%	9%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Apr	476,197	754,934	825,267	1,421,210	1,734,580	117,391	454,097	1,011,750	1,072,790	1,941,660	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 May	1,645,840	2,555,010	2,790,780	4,806,280	5,889,360	405,730	1,569,410	3,496,780	3,707,740	6,710,770	0%	8%	6%	8%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jun	1,836,760	2,953,750	3,229,850	5,557,600	6,766,310	452,795	1,751,420	3,902,350	4,137,790	7,489,170	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jul	855,838	1,369,630	1,497,660	2,578,510	3,141,710	210,980	816,048	1,818,280	1,927,980	3,489,550	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Aug	395,002	632,570	691,863	1,191,940	1,451,880	97,375	376,626	839,193	889,825	1,610,550	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Sep	340,141	551,859	603,735	1,039,300	1,263,140	83,851	324,308	722,629	766,228	1,386,860	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Oct	263,335	438,235	479,722	824,932	998,225	64,917	251,070	559,448	593,202	1,073,690	0%	9%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Nov	272,113	451,810	494,488	850,054	1,029,120	67,081	259,431	578,088	612,968	1,109,470	0%	9%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Dec	197,501	340,563	373,138	640,866	770,836	48,688	188,291	419,575	444,890	805,254	0%	9%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jan	131,667	242,307	265,968	456,193	542,839	32,458	125,526	279,715	296,592	536,834	0%	28%	27%	29%	23%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Feb	145,775	263,096	288,661	495,455	591,385	35,936	138,975	309,684	328,369	594,352	0%	26%	24%	26%	21%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Mar	197,501	339,619	372,173	639,769	769,738	48,688	188,289	419,572	444,888	805,252	0%	20%	18%	20%	16%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Apr	476,197	754,263	824,511	1,419,940	1,733,310	117,391	453,985	1,011,630	1,072,670	1,941,550	0%	10%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 May	1,645,840	2,557,660	2,793,760	4,811,260	5,894,340	405,730	1,569,070	3,496,430	3,707,400	6,710,430	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jun	1,836,760	2,951,170	3,226,940	5,552,690	6,761,410	452,795	1,751,080	3,902,020	4,137,460	7,488,840	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jul	855,838	1,368,430	1,496,300	2,576,230	3,139,430	210,980	815,917	1,818,150	1,927,850	3,489,420	0%	11%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Aug	395,002	632,014	691,237	1,190,890	1,450,830	97,375	376,577	839,144	889,775	1,610,500	0%	11%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Sep	340,141	551,380	603,195	1,038,390	1,262,230	83,851	324,275	722,596	766,196	1,386,820	0%	13%	11%	13%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Oct	263,335	437,865	479,305	824,231	997,524	64,917	251,051	559,429	593,184	1,073,670	0%	16%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Nov	272,113	451,427	494,057	849,330	1,028,400	67,081	259,420	578,077	612,956	1,109,460	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Dec	197,501	340,285	372,825	640,341	770,311	48,688	188,289	419,572	444,888	805,252	0%	20%	19%	21%	16%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jan	131,667	234,220	256,770	441,429	528,129	32,458	128,569	282,758	299,636	539,878	0%	7%	5%	8%	6%	-4%	-7%	-5%	-10%	-6%
Impacted	2043 Feb	145,775	250,694	274,567	472,420	568,408	35,936	142,019	312,728	331,413	597,396	0%	7%	4%	7%	6%	-4%	-7%	-6%	-10%	-6%
Impacted	2043 Mar	197,501	311,095	339,824	586,050	716,099	48,688	191,332	422,616	447,931	808,295	0%	6%	4%	7%	5%	-4%	-7%	-6%	-10%	-6%
Impacted	2043 Apr	476,197	636,530	691,422	1,198,280	1,511,840	117,391	457,028	1,014,680	1,075,720	1,944,590	0%	5%	3%	6%	5%	-4%	-8%	-6%	-10%	-6%
Impacted	2043 May	1,645,840	2,002,330	2,167,020	3,767,710	4,851,450	405,730	1,572,120	3,499,480	3,710,440	6,713,470	0%	5%	3%	5%	4%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jun	1,836,760	2,229,220	2,412,340	4,194,590	5,404,040	452,795	1,785,410	3,936,340	4,171,780	7,523,160	0%	5%	3%	5%	4%	-4%	-7%	-6%	-10%	-6%
Impacted	2043 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	6%	4%	7%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2043 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	6%	4%	7%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2043 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	6%	4%	7%	5%	-4%	-5%	-4%	-9%	-5%
Impacted	2043 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	6%	4%	7%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	5%	4%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Feb	140,748	219,260	239,424	413,030	505,709	34,697	141,697	306,519	324,560	581,371	0%	5%	4%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	5%	4%	6%	5%	-4%	-5%	-4%	-9%	-5%
Impacted	2044 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	5%	4%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	5%	4%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2044 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	5%	4%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2044 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	5%	4%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2044 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	5%	4%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2044 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	5%	4%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	5%	4%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	5%	4%	6%	5%	-4%	-5%	-4%	-9%	-5%
Impacted	2044 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	5%	4%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	5%	4%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	5%	4%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	5%	4%	6%	5%	-4%	-5%	-4%	-9%	-5%
Impacted	2045 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	5%	4%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	5%	4%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2045 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	5%	4%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2045 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	5%	4%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2045 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	5%	4%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2045 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	5%	4%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	5%	4%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	5%	4%	6%	5%	-4%	-5%	-4%	-9%	-5%
Impacted	2045 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	5%	4%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	5%	4%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	5%	4%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	5%	4%	6%	5%	-4%	-5%	-4%	-9%	-5%
Impacted	2046 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	5%	4%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	5%	4%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2046 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	5%	4%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2046 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	5%	4%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2046 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	5%	4%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2046 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	5%	4%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	5%	4%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	5%	4%	6%	5%	-4%	-5%	-4%	-9%	-5%
Impacted	2046 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	5%	4%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2047 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2047 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2047 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2047 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2047 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2047 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.61																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2048 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Feb	140,748	219,260	239,424	413,030	505,709	34,697	141,697	306,519	324,560	581,371	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2048 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2048 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2048 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2048 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2048 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2048 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2049 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2049 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2049 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2049 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2049 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2049 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2050 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2050 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2050 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2050 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2050 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2050 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2051 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2051 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2051 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2051 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2051 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2051 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Feb	140,748	219,260	239,424	413,030	505,709	34,697	141,697	306,519	324,560	581,371	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2052 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2052 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2052 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2052 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2052 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2052 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2053 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2053 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2053 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2053 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2053 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2053 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2054 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2054 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2054 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2054 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2054 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2054 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2055 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2055 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2055 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2055 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2055 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%

		Runoff coefficient 0.61																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2055 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2055 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Feb	140,748	219,260	239,424	413,030	505,709	34,697	141,697	306,519	324,560	581,371	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2056 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2056 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2056 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2056 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2056 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2056 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2057 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2057 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2057 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2057 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2057 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2057 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2058 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2058 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2058 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2058 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2058 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2058 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2059 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2059 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2059 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2059 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2059 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2059 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Feb	140,748	219,260	239,424	413,030	505,709	34,697	141,697	306,519	324,560	581,371	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2060 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2060 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2060 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2060 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2060 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2060 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2061 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2061 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2061 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2061 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2061 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2061 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2062 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2062 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2062 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2062 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2062 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2062 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2063 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2063 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%

		Runoff coefficient 0.61																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2063 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2063 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2063 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2063 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Feb	140,748	219,260	239,424	413,030	505,709	34,697	141,697	306,519	324,560	581,371	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2064 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2064 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2064 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2064 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2064 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2064 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2065 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2065 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2065 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2065 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2065 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2065 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2066 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2066 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2066 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2066 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2066 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2066 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2067 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2067 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2067 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2067 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2067 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2067 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Feb	140,748	219,260	239,424	413,030	505,709	34,697	141,697	306,519	324,560	581,371	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2068 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2068 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2068 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2068 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2068 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2068 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2069 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2069 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2069 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2069 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2069 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2069 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2070 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2070 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2070 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2070 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2070 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2070 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%

		Runoff coefficient 0.61																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2071 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2071 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2071 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2071 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2071 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2071 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Feb	140,748	219,260	239,424	413,030	505,709	34,697	141,697	306,519	324,560	581,371	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2072 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2072 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2072 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2072 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2072 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2072 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2073 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2073 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2073 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2073 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2073 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2073 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2074 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2074 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2074 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2074 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2074 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2074 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2075 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2075 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2075 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2075 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2075 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2075 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Feb	140,748	219,260	239,424	413,030	505,709	34,697	141,697	306,519	324,560	581,371	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2076 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2076 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2076 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2076 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2076 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2076 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2077 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2077 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2077 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2077 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2077 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2077 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2078 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2078 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2078 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2078 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2078 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2078 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.61																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2079 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2079 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2079 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2079 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2079 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2079 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2079 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Feb	140,748	219,260	239,424	413,030	505,709	34,697	141,697	306,519	324,560	581,371	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2080 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2080 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2080 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2080 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2080 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2080 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2081 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2081 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2081 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2081 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2081 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2081 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2082 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2082 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2082 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2082 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2082 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2082 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2083 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2083 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2083 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2083 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2083 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2083 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Feb	140,748	219,260	239,424	413,030	505,709	34,697	141,697	306,519	324,560	581,371	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2084 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2084 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2084 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2084 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2084 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2084 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2085 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2085 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2085 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2085 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2085 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2085 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2086 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2086 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2086 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2086 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2086 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%

		Runoff coefficient 0.61																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2086 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2086 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2087 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2087 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2087 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2087 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2087 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2087 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Feb	140,748	219,260	239,424	413,030	505,709	34,697	141,697	306,519	324,560	581,371	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2088 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2088 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2088 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2088 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2088 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2088 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2089 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2089 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2089 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2089 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2089 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2089 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2090 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2090 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2090 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2090 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2090 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2090 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2091 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2091 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2091 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2091 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2091 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2091 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Feb	140,748	219,260	239,424	413,030	505,709	34,697	141,697	306,519	324,560	581,371	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2092 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2092 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2092 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2092 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2092 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2092 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2093 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2093 Jun	1,836,760	2,872,710	3,137,300	5,411,550	6,621,010	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2093 Jul	855,838	1,329,320	1,451,440	2,504,070	3,067,620	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	8%	6%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2093 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2093 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Oct	263,335	410,481	448,240	773,245	946,643	64,917	262,505	570,883	604,637	1,085,120	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Nov	272,113	426,647	465,979	803,716	982,895	67,081	271,605	590,262	625,142	1,121,640	0%	9%	8%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2093 Dec	197,501	309,695	338,246	583,402	713,451	48,688	197,973	429,256	454,572	814,936	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Jan	131,667	205,999	224,975	388,057	474,757	32,458	132,912	287,101	303,978	544,221	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Feb	145,775	227,090	247,975	427,781	523,770	35,936	146,649	317,358	336,043	602,026	0%	8%	7%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2094 Apr	476,197	739,607	807,550	1,393,220	1,706,780	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 May	1,645,840	2,575,310	2,812,550	4,851,320	5,935,060	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	9%	7%	9%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2094 Jun	1,836,760	2,931,760	3,203,830	5,523,230	6,732,680	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	11%	9%	12%	9%	-4%	-6%	-5%	-9%	-5%

		Runoff coefficient 0.61																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2094 Jul	855,838	1,342,730	1,466,550	2,529,440	3,092,990	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	9%	8%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2094 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2094 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Oct	263,335	411,964	449,911	776,050	949,448	64,917	262,505	570,883	604,637	1,085,120	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Nov	272,113	436,774	477,390	822,870	1,002,050	67,081	271,605	590,262	625,142	1,121,640	0%	12%	10%	12%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2094 Dec	197,501	316,659	346,093	596,574	726,623	48,688	197,973	429,256	454,572	814,936	0%	12%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Jan	131,667	209,297	228,691	394,294	480,994	32,458	132,912	287,101	303,978	544,221	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Feb	145,775	229,204	250,357	431,779	527,768	35,936	146,649	317,358	336,043	602,026	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2095 Apr	476,197	746,188	814,964	1,405,660	1,719,230	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 May	1,645,840	2,635,590	2,880,460	4,965,320	6,049,070	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	11%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2095 Jun	1,836,760	2,937,850	3,210,680	5,534,740	6,744,190	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	11%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2095 Jul	855,838	1,342,730	1,466,550	2,529,440	3,092,990	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	9%	8%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2095 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2095 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Oct	263,335	411,964	449,911	776,050	949,448	64,917	262,505	570,883	604,637	1,085,120	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Nov	272,113	436,774	477,390	822,870	1,002,050	67,081	271,605	590,262	625,142	1,121,640	0%	12%	10%	12%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2095 Dec	197,501	316,659	346,093	596,574	726,623	48,688	197,973	429,256	454,572	814,936	0%	12%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Jan	131,667	209,297	228,691	394,294	480,994	32,458	132,912	287,101	303,978	544,221	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Feb	140,748	221,245	241,662	416,785	509,464	34,697	141,697	306,519	324,560	581,371	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2096 Apr	476,197	746,188	814,964	1,405,660	1,719,230	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 May	1,645,840	2,635,590	2,880,460	4,965,320	6,049,070	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	11%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2096 Jun	1,836,760	2,937,850	3,210,680	5,534,740	6,744,190	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	11%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2096 Jul	855,838	1,342,730	1,466,550	2,529,440	3,092,990	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	9%	8%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2096 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2096 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Oct	263,335	411,964	449,911	776,050	949,448	64,917	262,505	570,883	604,637	1,085,120	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Nov	272,113	436,774	477,390	822,870	1,002,050	67,081	271,605	590,262	625,142	1,121,640	0%	12%	10%	12%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2096 Dec	197,501	316,659	346,093	596,574	726,623	48,688	197,973	429,256	454,572	814,936	0%	12%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Jan	131,667	209,297	228,691	394,294	480,994	32,458	132,912	287,101	303,978	544,221	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Feb	145,775	229,204	250,357	431,779	527,768	35,936	146,649	317,358	336,043	602,026	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2097 Apr	476,197	746,188	814,964	1,405,660	1,719,230	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 May	1,645,840	2,635,590	2,880,460	4,965,320	6,049,070	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	11%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2097 Jun	1,836,760	2,937,850	3,210,680	5,534,740	6,744,190	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	11%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2097 Jul	855,838	1,342,730	1,466,550	2,529,440	3,092,990	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	9%	8%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2097 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2097 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Oct	263,335	411,964	449,911	776,050	949,448	64,917	262,505	570,883	604,637	1,085,120	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Nov	272,113	436,774	477,390	822,870	1,002,050	67,081	271,605	590,262	625,142	1,121,640	0%	12%	10%	12%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2097 Dec	197,501	316,659	346,093	596,574	726,623	48,688	197,973	429,256	454,572	814,936	0%	12%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Jan	131,667	209,297	228,691	394,294	480,994	32,458	132,912	287,101	303,978	544,221	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Feb	145,775	229,204	250,357	431,779	527,768	35,936	146,649	317,358	336,043	602,026	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2098 Apr	476,197	746,188	814,964	1,405,660	1,719,230	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 May	1,645,840	2,635,590	2,880,460	4,965,320	6,049,070	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	11%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2098 Jun	1,836,760	2,937,850	3,210,680	5,534,740	6,744,190	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	11%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2098 Jul	855,838	1,342,730	1,466,550	2,529,440	3,092,990	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	9%	8%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2098 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2098 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Oct	263,335	411,964	449,911	776,050	949,448	64,917	262,505	570,883	604,637	1,085,120	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Nov	272,113	436,774	477,390	822,870	1,002,050	67,081	271,605	590,262	625,142	1,121,640	0%	12%	10%	12%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2098 Dec	197,501	316,659	346,093	596,574	726,623	48,688	197,973	429,256	454,572	814,936	0%	12%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Jan	131,667	209,297	228,691	394,294	480,994	32,458	132,912	287,101	303,978	544,221	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Feb	145,775	229,204	250,357	431,779	527,768	35,936	146,649	317,358	336,043	602,026	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Mar	197,501	305,647	333,687	575,747	705,796	48,688	197,237	428,521	453,836	814,200	0%	8%	6%	8%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2099 Apr	476,197	746,188	814,964	1,405,660	1,719,230	117,391	471,749	1,029,400	1,090,440	1,959,320	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 May	1,645,840	2,635,590	2,880,460	4,965,320	6,049,070	405,730	1,626,460	3,553,820	3,764,780	6,767,810	0%	11%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2099 Jun	1,836,760	2,937,850	3,210,680	5,534,740	6,744,190	452,795	1,814,530	3,965,470	4,200,900	7,552,290	0%	11%	10%	12%	10%	-4%	-6%	-5%	-9%	-5%
Impacted	2099 Jul	855,838	1,342,730	1,466,550	2,529,440	3,092,990	210,980	845,430	1,847,660	1,957,360	3,518,940	0%	9%	8%	10%	8%	-4%	-6%	-5%	-9%	-5%
Impacted	2099 Aug	395,002	607,373	662,956	1,144,080	1,404,180	97,375	390,717	853,284	903,916	1,624,640	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2099 Sep	340,141	526,610	574,928	991,977	1,215,950	83,851	337,527	735,849	779,448	1,400,080	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Oct	263,335	411,964	449,911	776,050	949,448	64,917	262,505	570,883	604,637	1,085,120	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Nov	272,113	436,774	477,390	822,870	1,002,050	67,081	271,605	590,262	625,142	1,121,640	0%	12%	10%	12%	10%	-4%	-5%	-4%	-9%	-5%
Impacted	2099 Dec	197,501	316,659	346,093	596,574	726,623	48,688	197,973	429,256	454,572	814,936	0%	12%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.61																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Baseline	2017 Jan	9.71E+04	1.40E+05	1.55E+05	2.62E+05	3.26E+05	24954	101695	220596	244307	421565	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Feb	1.08E+05	1.55E+05	1.71E+05	2.90E+05	3.60E+05	27627.6	112591	244231	270482	466733	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Mar	1.46E+05	2.09E+05	2.32E+05	3.92E+05	4.88E+05	37431	152543	330894	366460	632348	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Apr	3.51E+05	5.05E+05	5.60E+05	9.46E+05	1.18E+06	90250.3	367798	797822	883575	1524660	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 May	1.21E+06	1.75E+06	1.94E+06	3.27E+06	4.07E+06	311925	1271190	2757450	3053830	5269570	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jun	1.36E+06	1.95E+06	2.16E+06	3.65E+06	4.54E+06	348108	1418650	3077310	3408070	5880840	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jul	6.31E+05	9.08E+05	1.01E+06	1.70E+06	2.12E+06	162201	661019	1433870	1587990	2740170	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Aug	2.91E+05	4.19E+05	4.64E+05	7.84E+05	9.76E+05	74862	305086	661788	732919	1264700	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Sep	2.51E+05	3.61E+05	4.00E+05	6.75E+05	8.41E+05	64464.5	262713	569873	631125	1089040	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Oct	1.94E+05	2.79E+05	3.09E+05	5.23E+05	6.51E+05	49908	203391	441192	488613	843131	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Nov	2.01E+05	2.89E+05	3.20E+05	5.40E+05	6.72E+05	51571.6	210170	455898	504900	871235	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Dec	1.46E+05	2.09E+05	2.32E+05	3.92E+05	4.88E+05	37431	152543	330894	366460	632348	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Impacted	2018 Jan	9.71E+04	1.40E+05	1.55E+05	2.61E+05	3.25E+05	24954	101695	220596	244307	421565	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Feb	1.08E+05	1.55E+05	1.71E+05	2.89E+05	3.60E+05	27627.6	112591	244231	270482	466733	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Mar	1.46E+05	2.09E+05	2.32E+05	3.92E+05	4.88E+05	37431	152543	330894	366460	632348	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Apr	3.51E+05	5.05E+05	5.59E+05	9.45E+05	1.18E+06	90250.3	367798	797822	883575	1524660	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 May	1.21E+06	1.75E+06	1.93E+06	3.27E+06	4.06E+06	311925	1271190	2757450	3053830	5269570	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Jun	1.36E+06	1.95E+06	2.15E+06	3.64E+06	4.54E+06	348108	1418650	3077310	3408070	5880840	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Jul	6.31E+05	9.08E+05	1.00E+06	1.70E+06	2.11E+06	162201	661019	1433870	1587990	2740170	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Aug	2.91E+05	4.19E+05	4.63E+05	7.83E+05	9.75E+05	74862	305086	661788	732919	1264700	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Sep	2.51E+05	3.61E+05	3.99E+05	6.75E+05	8.40E+05	64464.5	262713	569873	631125	1089040	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Oct	1.94E+05	2.79E+05	3.09E+05	5.22E+05	6.50E+05	49908	203391	441192	488613	843131	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Nov	2.01E+05	2.89E+05	3.19E+05	5.40E+05	6.72E+05	51571.6	210170	455898	504900	871235	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Dec	1.46E+05	2.09E+05	2.31E+05	3.92E+05	4.87E+05	37431	152543	330894	366460	632348	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2019 Jan	9.71E+04	1.86E+05	2.06E+05	3.48E+05	4.12E+05	24954	101695	220596	243835	421094	0%	7%	6%	6%	4%	0%	0%	0%	0%	0%
Impacted	2019 Feb	1.08E+05	2.01E+05	2.23E+05	3.75E+05	4.46E+05	27627.6	112591	244231	268933	465184	0%	6%	6%	5%	4%	0%	0%	0%	-1%	0%
Impacted	2019 Mar	1.46E+05	2.55E+05	2.83E+05	4.76E+05	5.72E+05	37431	152543	330894	362970	628858	0%	6%	5%	5%	4%	0%	0%	0%	-1%	-1%
Impacted	2019 Apr	3.51E+05	5.51E+05	6.09E+05	1.02E+06	1.25E+06	90250.3	367798	797822	871694	1512780	0%	5%	5%	4%	4%	0%	0%	0%	-1%	-1%
Impacted	2019 May	1.21E+06	1.79E+06	1.98E+06	3.31E+06	4.10E+06	311925	1271190	2757450	3000780	5216510	0%	5%	4%	4%	3%	0%	0%	0%	-2%	-1%
Impacted	2019 Jun	1.36E+06	1.99E+06	2.20E+06	3.67E+06	4.56E+06	348108	1418650	3077310	3335500	5808260	0%	5%	4%	4%	3%	0%	0%	0%	-2%	-1%
Impacted	2019 Jul	6.31E+05	9.53E+05	1.05E+06	1.75E+06	2.17E+06	162201	661019	1433870	1547940	2700120	0%	5%	5%	4%	3%	0%	0%	0%	-3%	-1%
Impacted	2019 Aug	2.91E+05	4.68E+05	5.17E+05	8.58E+05	1.05E+06	74862	305086	661788	711510	1243290	0%	6%	5%	5%	4%	0%	0%	0%	-3%	-2%
Impacted	2019 Sep	2.51E+05	4.14E+05	4.58E+05	7.58E+05	9.23E+05	64464.5	262713	569873	610213	1068130	0%	6%	5%	5%	4%	0%	0%	0%	-3%	-2%
Impacted	2019 Oct	1.94E+05	3.32E+05	3.67E+05	6.07E+05	7.35E+05	49908	203391	441192	470506	825023	0%	6%	5%	5%	4%	0%	0%	0%	-4%	-2%
Impacted	2019 Nov	2.01E+05	3.43E+05	3.79E+05	6.25E+05	7.57E+05	51571.6	210170	455898	484208	850542	0%	6%	5%	5%	4%	0%	0%	0%	-4%	-2%
Impacted	2019 Dec	1.46E+05	2.62E+05	2.90E+05	4.78E+05	5.73E+05	37431	152543	330894	350003	615891	0%	6%	5%	5%	4%	0%	0%	0%	-4%	-3%
Impacted	2020 Jan	9.71E+04	1.89E+05	2.10E+05	3.47E+05	4.10E+05	24954	101695	220596	232864	410122	0%	7%	6%	6%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 Feb	1.04E+05	1.97E+05	2.19E+05	3.63E+05	4.32E+05	26675	108709	235810	248923	438407	0%	7%	6%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 Mar	1.46E+05	2.57E+05	2.84E+05	4.73E+05	5.69E+05	37431	152543	330894	349295	615184	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 Apr	3.51E+05	5.50E+05	6.08E+05	1.02E+06	1.25E+06	90250.3	367798	797822	842190	1483280	0%	5%	5%	4%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 May	1.21E+06	1.78E+06	1.96E+06	3.31E+06	4.10E+06	311925	1271190	2757450	2910790	5126530	0%	5%	5%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2020 Jun	1.36E+06	1.96E+06	2.17E+06	3.67E+06	4.57E+06	348108	1418650	3077310	3248450	5721210	0%	5%	4%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2020 Jul	6.31E+05	9.31E+05	1.03E+06	1.75E+06	2.17E+06	162201	661019	1433870	1513610	2665800	0%	5%	5%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2020 Aug	2.91E+05	4.50E+05	4.98E+05	8.54E+05	1.05E+06	74862	305086	661788	698591	1230370	0%	5%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 Sep	2.51E+05	3.92E+05	4.34E+05	7.48E+05	9.13E+05	64464.5	262713	569873	601564	1059480	0%	5%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 Oct	1.94E+05	3.12E+05	3.46E+05	5.99E+05	7.27E+05	49908	203391	441192	465727	820245	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 Nov	2.01E+05	3.19E+05	3.54E+05	6.16E+05	7.48E+05	51571.6	210170	455898	481251	847586	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 Dec	1.46E+05	2.43E+05	2.69E+05	4.70E+05	5.66E+05	37431	152543	330894	349295	615184	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Jan	9.71E+04	1.77E+05	1.96E+05	3.42E+05	4.06E+05	24954	101688	220569	232837	410095	0%	6%	6%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Feb	1.08E+05	1.91E+05	2.11E+05	3.69E+05	4.40E+05	27627.6	112570	244146	257728	453979	0%	6%	6%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Mar	1.46E+05	2.42E+05	2.68E+05	4.69E+05	5.65E+05	37431	152495	330703	349105	614993	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Apr	3.51E+05	5.18E+05	5.73E+05	1.01E+06	1.24E+06	90250.3	367634	797176	841543	1482630	0%	5%	5%	4%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 May	1.21E+06	1.68E+06	1.86E+06	3.27E+06	4.07E+06	311925	1270460	2754570	2907910	5123650	0%	5%	4%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2021 Jun	1.36E+06	2.06E+06	2.23E+06	3.66E+06	4.55E+06	348108	1417650	3073380	3244510	5717270	0%	5%	5%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2021 Jul	6.31E+05	9.83E+05	1.07E+06	1.75E+06	2.16E+06	162201	660469	1431700	1511440	2663630	0%	5%	5%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2021 Aug	2.91E+05	4.78E+05	5.19E+05	8.53E+05	1.04E+06	74862	304792	660629	697432	1229210	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Sep	2.51E+05	4.19E+05	4.55E+05	7.48E+05	9.13E+05	64464.5	262426	568741	600433	1058350	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Oct	1.94E+05	3.35E+05	3.65E+05	5.99E+05	7.27E+05	49908	203142	440213	464748	819265	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Nov	2.01E+05	3.46E+05	3.76E+05	6.17E+05	7.49E+05	51571.6	209887	454779	480133	846467	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Dec	1.46E+05	2.64E+05	2.87E+05	4.72E+05	5.68E+05	37431	152317	330004	348406	614294	0%	6%	6%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Jan	9.71E+04	1.39E+05	1.50E+05	2.45E+05	3.09E+05	24954	101532	219950	232218	409477	0%	10%	8%	4%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Feb	1.08E+05	1.66E+05	1.80E+05	2.95E+05	3.65E+05	27627.6	112396	243461	257043	453294	0%	11%	8%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Mar	1.46E+05	2.63E+05	2.87E+05	4.71E+05	5.67E+05	37431	152259	329775	348177	614065	0%	13%	10%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2022 Apr	3.51E+05	5.71E+05	6.19E+05	1.01E+06	1.24E+06	90250.3	367067	794939	839306	1480390	0%	12%	9%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 May	1.21E+06	1.87E+06	2.02E+06	3.29E+06	4.09E+06	311925	1268500	2746840	2900180	5115920	0%	11%	8%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Jun	1.36E+06	2.08E+06	2.24E+06	3.66E+06	4.56E+06	348108	1415460	3064750	3235880	5708640	0%	11%	8%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Jul	6.31E+05	9.91E+05	1.07E+06	1.75E+06	2.17E+06	162201	659450	1427680	1507420	2659610	0%	11%	8%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Aug	2.91E+05	4.82E+05	5.22E+05	8.55E+05	1.05E+06	74862	304322	658773	695576	1227350	0%	12%	9%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Sep	2.51E+05	4.22E+05	4.58E+05	7.49E+05	9.14E+05	64464.5	262021	567144	598835	1056750	0%	12%	9%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Oct	1.94E+05	3.38E+05	3.67E+05	6.00E+05	7.28E+05	49908	202829	438975	463511	818028	0%	12%	9%	5%	4%	0%	0%	0%	-1%	-5%	-3%
Impacted	2022 Nov	2.01E+05	3.48E+05	3.78E+05	6.18E+05	7.50E+05	51571.6	209563	453501	478854	845189	0%	12%	9%	5%	4%	0%	0%	0%	-1%	-5%	-3%
Impacted	2022 Dec	1.46E+05	2.66E+05	2.89E+05	4.73E+05	5.68E+05	37431	152082	329076	347478	613366	0%	13%	10%	6%	5%	0%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jan	9.71E+04	1.39E+05	1.49E+05	2.42E+05	3.06E+05	24954	101375	219332	231599	408858	0%	10%	8%	4%	4%	0%	0%	0%	-1%	-5%	-3%
Impacted	2023 Feb	1.08E+05	1.53E+05	1.65E+05	2.68E+05	3.39E+05	27627.6	112222	242776	256358	452609	0%	10%	8%	4%	4%	0%	0%	0%	-1%	-5%	-3%
Impacted	2023 Mar	1.46E+05	2.13E+05	2.29E+05	3.73E+05	4.69E+05	37431	152024	328848	347249	613137	0%	10%	8%	5%	4%	0%	0%	0%	-1%	-5%	-3%
Impacted	2023 Apr	3.51E+05	5.75E+05	6.22E+05	1.02E+06	1.25E+06	90250.3	366500	792702	837069	1478160	0%	12%	9%	5%	4%	0%	0%	0%	-1%	-5%	-3%
Impacted	2023 May	1.21E+06	1.88E+06	2.03E+06	3.30E+06	4.10E+06	311925	1266540	2739110	2892450	5108190	0%	11%	8%	5%	4%	0%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jun	1.36E+06	2.05E+06	2.21E+06	3.59E+06	4.48E+06	348108	1413280	3056120	3227250	5700010	0%	11%	8%	5%	4%	0%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jul	6.31E+05	1.00E+06	1.08E+06	1.77E+06	2.18E+06	162201	658431	1423660	1503400	2655580	0%	11%	8%	5%	4%	0%	0%	0%	-1%	-5%	-3%
Impacted	2023 Aug	2.91E+05	4.87E+05	5.27E+05	8.61E+05	1.05E+06	74862	303851	656917	693720	1225500	0%	12%	9%	5%	4%	0%	0%	0%	-1%	-5%	-3%
Impacted	2023 Sep	2.51E+05	4.27E+05	4.62E+05	7.55E+05	9.20E+05	64464.5	261616	565545	597236	1055150	0%	12%	9%	5%	4%	0%	0%	0%	-1%	-5%	-3%
Impacted	2023 Oct	1.94E+05	3.42E+05	3.70E+05	6.05E+05	7.32E+05	49908	202515	437738	462273	816791	0%	13%	9%	6%	4%	0%	0%	0%	-1%	-5%	-3%
Impacted	2023 Nov	2.01E+05	3.52E+05	3.81E+05	6.23E+05	7.55E+05	51571.6	209238	452222	477575	843910	0%	12%	9%	6%	4%	0%	0%	0%	-1%	-5%	-3%
Impacted	2023 Dec	1.46E+05	2.67E+05	2.89E+05	4.73E+05	5.69E+05	37431	151847	328148	346550	612438	0%	13%	10%	6%	5%	0%	0%	0%	-1%	-5%	-3%
Impacted	2024 Jan	9.71E+04	1.49E+05	1.60E+05	2.60E+05	3.24E+05	24954	101217	218697	230965	408224	0%	11%	8%	5%	4%	0%	0%	0%	-1%	-5%	-3%
Impacted	2024 Feb	1.04E+05	2.04E+05	2.22E+05	3.63E+05	4.32E+05	26675	108183	233694	246807	436291	0%	14%	10%	6%	5%	0%	0%	0%	-1%	-5%	-3%
Impacted	2024 Mar	1.46E+05	2.67E+05	2.90E+05	4.74E+05	5.70E+05	37431	151785	327804	346206	612094	0%	13%	10%	6%	4%	0%	0%	0%	-1%	-6%	-3%
Impacted	2024 Apr	3.51E+05	5.79E+05	6.25E+05	1.02E+06	1.25E+06	90250.3	365920	790076	834444	1475530	0%	11%	9%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 May	1.21E+06	1.89E+06	2.04E+06	3.32E+06	4.12E+06	311925	1264530	2729650	2883000	5098730	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jun	1.36E+06	2.10E+06	2.26E+06	3.69E+06	4.59E+06	348108	1411020	3045150	3216280	5689040	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jul	6.31E+05	1.00E+06	1.08E+06	1.76E+06	2.18E+06	162201	657372	1418350	1498090	2650280	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Aug	2.91E+05	4.85E+05	5.24E+05	8.59E+05	1.05E+06	74862	303360	654376	691178	1222960	0%	12%	9%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Sep	2.51E+05	4.24E+05	4.59E+05	7.53E+05	9.18E+05	64464.5	261190	563278	594969	1052890	0%	12%	9%	5%	4%	0%	-1%	-1%	-6%	-3%

		Runoff coefficient 0.61																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2024 Oct	1.94E+05	3.39E+05	3.68E+05	6.03E+05	7.30E+05	49908	202184	435923	460458	814975	0%	12%	9%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Nov	2.01E+05	3.49E+05	3.78E+05	6.20E+05	7.52E+05	51571.6	208894	450284	475637	841972	0%	12%	9%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Dec	1.46E+05	2.66E+05	2.89E+05	4.74E+05	5.70E+05	37431	151596	326696	345098	610986	0%	13%	10%	6%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jan	9.71E+04	1.92E+05	2.09E+05	3.45E+05	4.09E+05	24954	101050	217714	229981	407240	0%	14%	10%	6%	5%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Feb	1.08E+05	2.08E+05	2.26E+05	3.72E+05	4.43E+05	27627.6	111861	240952	254534	450785	0%	14%	10%	6%	5%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Mar	1.46E+05	2.65E+05	2.87E+05	4.73E+05	5.69E+05	37431	151534	326333	344734	610623	0%	13%	10%	6%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Apr	3.51E+05	5.73E+05	6.19E+05	1.02E+06	1.25E+06	90250.3	365315	786529	830897	1471980	0%	11%	9%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2025 May	1.21E+06	1.87E+06	2.01E+06	3.31E+06	4.11E+06	311925	1262430	2717390	2870740	5086470	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jun	1.36E+06	2.08E+06	2.24E+06	3.68E+06	4.57E+06	348108	1408680	3031470	3202600	5675360	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jul	6.31E+05	9.90E+05	1.07E+06	1.76E+06	2.17E+06	162201	656284	1411980	1491720	2643900	0%	11%	8%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Aug	2.91E+05	4.80E+05	5.19E+05	8.57E+05	1.05E+06	74862	302858	651433	688236	1220010	0%	12%	9%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Sep	2.51E+05	4.20E+05	4.55E+05	7.50E+05	9.16E+05	64464.5	260758	560744	592436	1050350	0%	12%	9%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Oct	1.94E+05	3.36E+05	3.64E+05	6.01E+05	7.29E+05	49908	201849	433961	458496	813014	0%	12%	9%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Nov	2.01E+05	3.46E+05	3.75E+05	6.19E+05	7.51E+05	51571.6	208548	448257	473610	839945	0%	12%	9%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Dec	1.46E+05	2.63E+05	2.86E+05	4.73E+05	5.69E+05	37431	151345	325225	343626	609514	0%	13%	10%	6%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jan	9.71E+04	1.91E+05	2.08E+05	3.44E+05	4.08E+05	24954	100882	216733	229001	406260	0%	10%	6%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Feb	1.08E+05	2.06E+05	2.24E+05	3.71E+05	4.42E+05	27627.6	111676	239867	253449	449700	0%	9%	6%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Mar	1.46E+05	2.62E+05	2.84E+05	4.72E+05	5.67E+05	37431	151283	324862	343264	609152	0%	9%	6%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Apr	3.51E+05	5.66E+05	6.12E+05	1.01E+06	1.25E+06	90250.3	364709	782983	827351	1468440	0%	8%	5%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2026 May	1.21E+06	1.85E+06	1.99E+06	3.29E+06	4.09E+06	311925	1260340	2705140	2858480	5074220	0%	7%	5%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jun	1.36E+06	2.05E+06	2.21E+06	3.66E+06	4.56E+06	348108	1406350	3017790	3188920	5661680	0%	7%	5%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jul	6.31E+05	9.78E+05	1.06E+06	1.75E+06	2.17E+06	162201	655196	1405610	1485350	2637530	0%	8%	5%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Aug	2.91E+05	4.75E+05	5.14E+05	8.54E+05	1.05E+06	74862	302355	648491	685294	1217070	0%	8%	5%	4%	3%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Sep	2.51E+05	4.15E+05	4.50E+05	7.48E+05	9.13E+05	64464.5	260325	558211	589903	1047820	0%	8%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Oct	1.94E+05	3.32E+05	3.60E+05	5.99E+05	7.27E+05	49908	201514	432000	456535	811052	0%	8%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Nov	2.01E+05	3.42E+05	3.71E+05	6.17E+05	7.49E+05	51571.6	208202	446230	471583	837918	0%	8%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Dec	1.46E+05	2.59E+05	2.81E+05	4.68E+05	5.64E+05	37431	151094	323754	342155	608044	0%	9%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jan	9.71E+04	1.29E+05	1.39E+05	2.30E+05	2.94E+05	24953.1	100712	215776	228043	405302	0%	7%	5%	3%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Feb	1.08E+05	1.43E+05	1.53E+05	2.55E+05	3.25E+05	27624.7	111481	238853	252435	448686	0%	7%	5%	3%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Mar	1.46E+05	1.93E+05	2.07E+05	3.44E+05	4.40E+05	37424.5	151010	323552	341954	607842	0%	7%	5%	3%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Apr	3.51E+05	4.66E+05	4.99E+05	8.31E+05	1.06E+06	90228.3	364031	779981	824349	1465440	0%	7%	5%	3%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 May	1.21E+06	1.64E+06	1.76E+06	2.92E+06	3.72E+06	311827	1257930	2695310	2848660	5064390	0%	7%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jun	1.36E+06	2.03E+06	2.19E+06	3.66E+06	4.55E+06	347975	1403570	3007430	3178560	5651320	0%	8%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jul	6.31E+05	9.70E+05	1.05E+06	1.75E+06	2.16E+06	162127	653863	1401060	1480800	2632980	0%	8%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Aug	2.91E+05	4.71E+05	5.10E+05	8.52E+05	1.04E+06	74822.7	301723	646527	683330	1215110	0%	8%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Sep	2.51E+05	4.13E+05	4.47E+05	7.47E+05	9.12E+05	64426.2	259766	556633	588324	1046240	0%	9%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Oct	1.94E+05	3.30E+05	3.58E+05	5.98E+05	7.26E+05	49874.8	201070	430865	455400	809917	0%	9%	6%	5%	4%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Nov	2.01E+05	3.40E+05	3.69E+05	6.16E+05	7.48E+05	51533.7	207731	445147	470501	836835	0%	9%	6%	4%	4%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Dec	1.46E+05	2.59E+05	2.82E+05	4.71E+05	5.67E+05	37400.9	150743	323033	341435	607323	0%	9%	6%	5%	4%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jan	9.71E+04	1.88E+05	2.05E+05	3.43E+05	4.07E+05	24932.1	100475	215317	227584	404843	0%	10%	6%	5%	4%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Feb	1.04E+05	1.98E+05	2.15E+05	3.60E+05	4.29E+05	26649.8	107384	230126	243239	432723	0%	9%	6%	5%	4%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Mar	1.46E+05	2.58E+05	2.81E+05	4.70E+05	5.66E+05	37393	150654	322862	341263	607152	0%	9%	6%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Apr	3.51E+05	5.58E+05	6.04E+05	1.01E+06	1.24E+06	90152.5	363173	778318	822685	1463770	0%	8%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2028 May	1.21E+06	1.82E+06	1.96E+06	3.28E+06	4.08E+06	311565	1254960	2689560	2842910	5058640	0%	7%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jun	1.36E+06	2.02E+06	2.18E+06	3.65E+06	4.55E+06	347682	1400260	3001010	3172150	5644910	0%	7%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jul	6.31E+05	9.64E+05	1.04E+06	1.75E+06	2.16E+06	161991	652322	1398070	1477810	2629990	0%	8%	5%	4%	3%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Aug	2.91E+05	4.68E+05	5.08E+05	8.52E+05	1.04E+06	74759.8	301011	645147	681950	1213730	0%	8%	5%	4%	3%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Sep	2.51E+05	4.10E+05	4.45E+05	7.46E+05	9.11E+05	64371.9	259153	555444	587136	1045050	0%	8%	5%	4%	3%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Oct	1.94E+05	3.28E+05	3.57E+05	5.98E+05	7.26E+05	49832.8	200595	429945	454480	808997	0%	8%	6%	4%	3%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Nov	2.01E+05	3.38E+05	3.67E+05	6.16E+05	7.48E+05	51490.3	207241	444197	469550	835885	0%	8%	6%	4%	3%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Dec	1.46E+05	2.58E+05	2.81E+05	4.71E+05	5.67E+05	37369.4	150387	322344	340745	606633	0%	9%	6%	4%	3%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Jan	9.71E+04	1.87E+05	2.04E+05	3.43E+05	4.06E+05	24911.1	100238	214857	227124	404383	0%	10%	6%	5%	4%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Feb	1.08E+05	2.02E+05	2.20E+05	3.70E+05	4.40E+05	27578.3	110957	237836	251418	447669	0%	9%	6%	5%	4%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Mar	1.46E+05	2.57E+05	2.80E+05	4.70E+05	5.65E+05	37361.7	150300	322174	340575	606463	0%	9%	6%	4%	3%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Apr	3.51E+05	5.54E+05	6.01E+05	1.01E+06	1.24E+06	90076.8	362317	776659	821026	1462110	0%	8%	5%	4%	3%	0%	-1%	-3%	-7%	-4%
Impacted	2029 May	1.21E+06	1.81E+06	1.95E+06	3.28E+06	4.08E+06	311304	1252000	2683830	2837170	5052910	0%	7%	5%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jun	1.36E+06	2.01E+06	2.17E+06	3.65E+06	4.54E+06	347390	1396960	2994610	3165750	5638510	0%	7%	5%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jul	6.31E+05	9.58E+05	1.04E+06	1.75E+06	2.16E+06	161855	650784	1395090	1474830	2627010	0%	8%	5%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Aug	2.91E+05	4.65E+05	5.05E+05	8.51E+05	1.04E+06	74697	300302	643771	680574	1212350	0%	8%	5%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Sep	2.51E+05	4.08E+05	4.43E+05	7.46E+05	9.11E+05	64317.9	258542	554259	585950	1043870	0%	8%	5%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Oct	1.94E+05	3.27E+05	3.55E+05	5.98E+05	7.25E+05	49791	200122	429027	453562	808080	0%	8%	6%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Nov	2.01E+05	3.36E+05	3.66E+05	6.15E+05	7.47E+05	51447.1	206752	443249	468602	834937	0%	8%	6%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Dec	1.46E+05	2.57E+05	2.80E+05	4.70E+05	5.66E+05	37338	150032	321656	340057	605945	0%	9%	6%	4%	3%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jan	9.71E+04	1.86E+05	2.04E+05	3.43E+05	4.07E+05	24890.2	100001	214398	226666	403925	0%	2%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Feb	1.08E+05	2.01E+05	2.20E+05	3.70E+05	4.41E+05	27555.2	110695	237329	250910	447161	0%	2%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Mar	1.46E+05	2.55E+05	2.78E+05	4.70E+05	5.66E+05	37330.3	149945	321486	339887	605775	0%	2%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Apr	3.51E+05	5.51E+05	5.98E+05	1.01E+06	1.24E+06	90001.1	361462	774999	819367	1460450	0%	1%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2030 May	1.21E+06	1.79E+06	1.94E+06	3.28E+06	4.08E+06	311042	1249050	2678090	2831440	5047170	0%	1%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jun	1.36E+06	2.00E+06	2.16E+06	3.65E+06	4.54E+06	347098	1393660	2988220	3159350	5632110	0%	1%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jul	6.31E+05	9.52E+05	1.03E+06	1.75E+06	2.16E+06	161719	649245	1392110	1471850	2624030	0%	1%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Aug	2.91E+05	4.63E+05	5.03E+05	8.51E+05	1.04E+06	74634.2	299591	642394	679197	1210970	0%	1%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Sep	2.51E+05	4.05E+05	4.41E+05	7.46E+05	9.11E+05	64263.8	257930	553074	584765	1042680	0%	1%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Oct	1.94E+05	3.25E+05	3.54E+05	5.98E+05	7.26E+05	49749.1	199649	428110	452645	807162	0%	2%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Nov	2.01E+05	3.34E+05	3.64E+05	6.15E+05	7.47E+05	51403.8	206263	442300	467654	833988	0%	2%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Dec	1.46E+05	2.55E+05	2.78E+05	4.71E+05	5.66E+05	37306.6	149677	320967	339369	605257	0%	2%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Jan	9.71E+04	1.85E+05	2.03E+05	3.43E+05	4.07E+05	24863.8	99734.9	213913	226181	403440	0%	2%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Feb	1.08E+05	2.00E+05	2.19E+05	3.70E+05	4.41E+05	27514.8	110340	236739	250321	446572	0%	2%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Mar	1.46E+05	2.54E+05	2.77E+05	4.70E+05	5.65E+05	37260.3	149382	320615	339017	604905	0%	2%	-1%	0%	0%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Apr	3.51E+05	5.48E+05	5.95E+05	1.01E+06	1.24E+06	89794.4	359900	772721	817089	1458170	0%	1%	-1%	0%	0%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 May	1.21E+06	1.78E+06	1.93E+06	3.28E+06	4.08E+06	310198	1242950	2669600	2822950	5038680	0%	1%	-1%	0%	0%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Jun	1.36E+06	1.98E+06	2.15E+06	3.65E+06	4.54E+06	346010	1386070	2978050	3149190	5621950	0%	1%	-1%	0%	0%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Jul	6.31E+05	9.46E+05	1.03E+06	1.74E+06	2.16E+06	161144	645343	1387050	1466790	2618970	0%	1%	-1%	0%	0%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Aug	2.91E+05	4.60E+05	5.00E+05	8.51E+05	1.04E+06	74336.9	297618	639910	676713	1208490	0%	1%	-1%	0%	0%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Sep	2.51E+05	4.03E+05	4.39E+05	7.46E+05	9.11E+05	63980.8	256086	550807	582499	1040420	0%	1%	-1%	0%	0%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Oct	1.94E+05	3.23E+05	3.52E+05	5.98E+05	7.25E+05	49509.4	198109	426257	450793	805310	0%	2%	-1%	0%	0%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Nov	2.01E+05	3.32E+05	3.62E+05	6.15E+05	7.47E+05	51134.5	204556	440285	465638	831973	0%	2%	-1%	0%	0%	-1%	-3%	-3%	-8%	-5%
Impacted	2031 Dec	1.46E+05	2.54E+05	2.77E+05	4.70E+05	5.66E+05	37095.5	148354	319430	337832	603720	0%	2%	-1%	0%	0%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Jan	9.71E+04	1.84E+05	2.02E+05	3.43E+05	4.07E+05	24717.9	98825.5	212864	225132	402391	0%	2%	-1%	0%	0%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Feb	1.04E+05	1.94E+05	2.12E+05	3.60E+05	4.28E+05	26409.8	105561	227453	240566	430050	0%	2%	-1%	0%	0%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Mar	1.46E+05	2.53E+05	2.76E+05	4.69E+05	5.65E+05	37040.9	148014	319038	337439	603327	0%	2%	-1%	0%	0%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Apr	3.51E+05	5.44E+05	5.92E+05	1.01E+06	1.24E+06	89265.7	356603	768919	813286	1454370	0%	2%	-1%	0%	0%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 May	1.21E+06	1.76E+06	1.91E+06	3.26E+06	4.06E+06	308369	1231550	2656460	2809800	5025530	0%	2%	-1%	0%	0%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Jun	1.36E+06	1.66E+06	1.79E+06	3.06E+06	3.95E+06	343969	1373340	2963370	3134510	5607270	0%	1%	-1%	0%	0%	-1%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.61																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2032 Jul	6.31E+05	7.70E+05	8.31E+05	1.42E+06	1.84E+06	160193	639412	1380210	1459950	2612130	0%	1%	-1%	0%	0%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Aug	2.91E+05	3.54E+05	3.82E+05	6.56E+05	8.47E+05	73898.3	294884	636756	673559	1205330	0%	1%	-1%	0%	0%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Sep	2.51E+05	3.05E+05	3.29E+05	5.65E+05	7.30E+05	63603.2	253731	548091	579783	1037700	0%	1%	-1%	0%	0%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Oct	1.94E+05	2.36E+05	2.55E+05	4.37E+05	5.65E+05	49216.8	196285	424153	448689	803206	0%	1%	-1%	0%	0%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Nov	2.01E+05	2.44E+05	2.63E+05	4.52E+05	5.84E+05	50832.1	202671	438111	463464	829798	0%	1%	-1%	0%	0%	-1%	-4%	-4%	-8%	-5%
Impacted	2032 Dec	1.46E+05	1.77E+05	1.91E+05	3.28E+05	4.24E+05	36876	146986	317852	336253	602142	0%	1%	-1%	0%	0%	-1%	-4%	-4%	-8%	-5%
Impacted	2033 Jan	9.71E+04	1.18E+05	1.27E+05	2.18E+05	2.82E+05	24571.6	97913.3	211812	224080	401339	0%	1%	-1%	0%	0%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Feb	1.08E+05	1.30E+05	1.40E+05	2.41E+05	3.12E+05	27191.2	108323	234412	247995	444245	0%	1%	-1%	0%	0%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Mar	1.46E+05	1.75E+05	1.89E+05	3.26E+05	4.22E+05	36822	146649	317464	335865	601753	0%	1%	-1%	0%	0%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Apr	3.51E+05	4.23E+05	4.57E+05	7.87E+05	1.02E+06	88737.9	353313	765124	809492	1450580	0%	1%	-1%	0%	0%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 May	1.21E+06	1.51E+06	1.64E+06	2.82E+06	3.62E+06	306545	1220180	2643340	2796690	5012420	0%	1%	-1%	0%	0%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jun	1.36E+06	1.95E+06	2.13E+06	3.65E+06	4.54E+06	341935	1360660	2948750	3119880	5592640	0%	1%	-1%	0%	0%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jul	6.31E+05	9.33E+05	1.02E+06	1.74E+06	2.16E+06	159245	633500	1373390	1453130	2605320	0%	1%	-1%	0%	0%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Aug	2.91E+05	4.54E+05	4.95E+05	8.50E+05	1.04E+06	73460.6	292155	633608	670411	1202190	0%	2%	-1%	0%	0%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Sep	2.51E+05	3.98E+05	4.34E+05	7.45E+05	9.10E+05	63226.3	251381	545381	577072	1034990	0%	2%	-1%	0%	0%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Oct	1.94E+05	3.19E+05	3.48E+05	5.97E+05	7.25E+05	48925	194465	422055	446590	801108	0%	2%	-1%	0%	0%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Nov	2.01E+05	3.28E+05	3.59E+05	6.15E+05	7.47E+05	50530.6	200791	435942	461295	827630	0%	2%	-1%	0%	0%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Dec	1.46E+05	2.51E+05	2.74E+05	4.70E+05	5.66E+05	36657.2	145621	316278	334680	600568	0%	2%	-1%	0%	0%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Jan	9.71E+04	1.82E+05	2.00E+05	3.42E+05	4.06E+05	24427.9	97005	210771	223038	400297	0%	31%	29%	31%	25%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Feb	1.08E+05	1.97E+05	2.16E+05	3.70E+05	4.40E+05	27036.5	107320	233275	246857	443108	0%	27%	26%	28%	22%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Mar	1.46E+05	2.50E+05	2.73E+05	4.69E+05	5.65E+05	36618.4	145296	315944	334345	600234	0%	19%	18%	20%	16%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Apr	3.51E+05	5.38E+05	5.87E+05	1.01E+06	1.24E+06	88261.8	350059	761512	805879	1446960	0%	6%	5%	7%	5%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 May	1.21E+06	1.75E+06	1.90E+06	3.28E+06	4.08E+06	304951	1208970	2631040	2784380	5000120	0%	0%	-2%	0%	0%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jun	1.36E+06	2.04E+06	2.22E+06	3.82E+06	4.71E+06	340213	1348190	2935220	3106350	5579110	0%	5%	3%	5%	4%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jul	6.31E+05	9.69E+05	1.06E+06	1.82E+06	2.23E+06	158469	627711	1367190	1446930	2599110	0%	7%	5%	7%	5%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Aug	2.91E+05	4.63E+05	5.06E+05	8.70E+05	1.06E+06	73115.1	289490	630787	667590	1199370	0%	11%	9%	11%	9%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Sep	2.51E+05	4.04E+05	4.42E+05	7.59E+05	9.24E+05	62939.4	249094	542989	574680	1032600	0%	12%	11%	12%	10%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Oct	1.94E+05	3.21E+05	3.51E+05	6.02E+05	7.30E+05	48711.1	192701	420232	444767	799285	0%	15%	13%	15%	12%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Nov	2.01E+05	3.31E+05	3.62E+05	6.21E+05	7.53E+05	50318.2	198973	434089	459442	825777	0%	15%	13%	15%	12%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Dec	1.46E+05	2.51E+05	2.74E+05	4.71E+05	5.66E+05	36509.2	144307	314956	333357	599245	0%	20%	18%	20%	16%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Jan	9.71E+04	1.82E+05	2.00E+05	3.43E+05	4.07E+05	24331.3	96130.5	209896	222164	399423	0%	31%	29%	31%	25%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Feb	1.08E+05	1.97E+05	2.16E+05	3.70E+05	4.41E+05	26929.6	106352	232307	245889	442140	0%	27%	26%	28%	22%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Mar	1.46E+05	2.50E+05	2.74E+05	4.70E+05	5.66E+05	36473.5	143984	314632	333034	598922	0%	19%	18%	20%	16%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Apr	3.51E+05	5.41E+05	5.90E+05	1.02E+06	1.25E+06	87912.4	346896	758349	802716	1443800	0%	7%	5%	7%	6%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 May	1.21E+06	1.84E+06	2.00E+06	3.44E+06	4.24E+06	303744	1198030	2620110	2773450	4989190	0%	5%	4%	5%	4%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jun	1.36E+06	2.05E+06	2.23E+06	3.84E+06	4.73E+06	338865	1335990	2923020	3094150	5566910	0%	5%	3%	5%	4%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jul	6.31E+05	9.70E+05	1.06E+06	1.82E+06	2.23E+06	157842	622027	1361500	1441240	2593420	0%	7%	5%	7%	6%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Aug	2.91E+05	4.63E+05	5.07E+05	8.72E+05	1.06E+06	72825.4	286866	628163	664966	1196740	0%	11%	9%	11%	9%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Sep	2.51E+05	4.04E+05	4.42E+05	7.60E+05	9.25E+05	62689.9	246835	540730	572421	1030340	0%	12%	11%	13%	10%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Oct	1.94E+05	3.21E+05	3.51E+05	6.03E+05	7.31E+05	48518	190952	418484	443019	797536	0%	15%	13%	15%	12%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Nov	2.01E+05	3.31E+05	3.62E+05	6.22E+05	7.54E+05	50118.5	197166	432281	457634	823969	0%	15%	13%	15%	12%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Dec	1.46E+05	2.51E+05	2.75E+05	4.71E+05	5.67E+05	36364.3	142995	313644	332045	597934	0%	20%	18%	20%	16%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Jan	9.71E+04	1.82E+05	2.00E+05	3.43E+05	4.07E+05	24234.7	95256	209022	221289	398548	0%	31%	29%	31%	25%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Feb	1.04E+05	1.92E+05	2.10E+05	3.61E+05	4.29E+05	25897.5	101749	223360	236474	425957	0%	28%	27%	29%	23%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Mar	1.46E+05	2.50E+05	2.74E+05	4.70E+05	5.66E+05	36328.2	142668	313317	331718	597606	0%	19%	18%	20%	16%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Apr	3.51E+05	5.38E+05	5.87E+05	1.01E+06	1.24E+06	87562.1	343725	755177	799545	1440630	0%	6%	5%	7%	6%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 May	1.21E+06	1.84E+06	2.00E+06	3.44E+06	4.24E+06	302533	1187070	2609140	2762490	4978220	0%	5%	3%	5%	4%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Jun	1.36E+06	2.05E+06	2.23E+06	3.84E+06	4.73E+06	337514	1323750	2910780	3081920	5554680	0%	5%	3%	5%	4%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Jul	6.31E+05	9.69E+05	1.06E+06	1.82E+06	2.24E+06	157212	616326	1355800	1435540	2587720	0%	7%	5%	7%	6%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Aug	2.91E+05	4.62E+05	5.05E+05	8.70E+05	1.06E+06	72534.8	284236	625533	662336	1194110	0%	10%	9%	11%	9%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Sep	2.51E+05	4.03E+05	4.41E+05	7.58E+05	9.24E+05	62439.7	244570	538464	570156	1028070	0%	12%	10%	12%	10%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Oct	1.94E+05	3.20E+05	3.50E+05	6.02E+05	7.29E+05	48324.3	189198	416730	441265	795782	0%	14%	13%	15%	12%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Nov	2.01E+05	3.30E+05	3.61E+05	6.20E+05	7.52E+05	49918.4	195354	430470	455823	822157	0%	14%	13%	15%	12%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Dec	1.46E+05	2.51E+05	2.75E+05	4.72E+05	5.68E+05	36219	141680	312328	330730	596618	0%	20%	18%	20%	16%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jan	9.71E+04	1.82E+05	2.00E+05	3.43E+05	4.07E+05	24137.8	94379.1	208145	220412	397671	0%	31%	29%	31%	25%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Feb	1.08E+05	1.97E+05	2.16E+05	3.71E+05	4.42E+05	26715.4	104413	230368	243950	440201	0%	27%	26%	28%	23%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Mar	1.46E+05	2.50E+05	2.74E+05	4.71E+05	5.67E+05	36183.3	141357	312005	330406	596295	0%	19%	18%	20%	16%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Apr	3.51E+05	5.38E+05	5.87E+05	1.01E+06	1.24E+06	87212.8	340562	752015	796383	1437470	0%	6%	5%	7%	6%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 May	1.21E+06	1.83E+06	2.00E+06	3.45E+06	4.25E+06	301326	1176140	2598210	2751560	4967290	0%	5%	3%	5%	4%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jun	1.36E+06	2.05E+06	2.23E+06	3.85E+06	4.74E+06	336167	1311560	2898590	3069720	5542480	0%	5%	4%	5%	4%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Jul	6.31E+05	9.70E+05	1.06E+06	1.82E+06	2.24E+06	156584	610645	1350120	1429860	2582040	0%	7%	5%	7%	6%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Aug	2.91E+05	4.62E+05	5.05E+05	8.71E+05	1.06E+06	72245	281612	622909	659712	1191490	0%	10%	9%	11%	9%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Sep	2.51E+05	4.03E+05	4.41E+05	7.59E+05	9.25E+05	62190.2	242311	536206	567897	1025810	0%	12%	10%	12%	10%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Oct	1.94E+05	3.19E+05	3.50E+05	6.02E+05	7.30E+05	48131	187449	414980	439515	794033	0%	14%	13%	15%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Nov	2.01E+05	3.30E+05	3.61E+05	6.21E+05	7.53E+05	49718.8	193547	428663	454016	820351	0%	14%	13%	15%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Dec	1.46E+05	2.51E+05	2.75E+05	4.72E+05	5.68E+05	36074.2	140368	311017	329418	595306	0%	20%	18%	20%	16%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jan	9.71E+04	1.35E+05	1.47E+05	2.55E+05	3.19E+05	24041.2	93504.5	207270	219538	396797	0%	6%	5%	7%	6%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Feb	1.08E+05	1.49E+05	1.62E+05	2.79E+05	3.50E+05	26608.4	103445	229399	242981	439232	0%	6%	5%	7%	6%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Mar	1.46E+05	2.04E+05	2.22E+05	3.84E+05	4.80E+05	36038.4	140045	310693	329095	594983	0%	6%	5%	7%	6%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Apr	3.51E+05	4.90E+05	5.33E+05	9.21E+05	1.15E+06	86863.4	337399	748852	793220	1434310	0%	6%	5%	7%	6%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 May	1.21E+06	1.71E+06	1.86E+06	3.20E+06	4.00E+06	300118	1165210	2587280	2740630	4956360	0%	7%	5%	7%	6%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jun	1.36E+06	1.89E+06	2.06E+06	3.56E+06	4.45E+06	334819	1299360	2886390	3057520	5530280	0%	6%	5%	7%	6%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jul	6.31E+05	8.84E+05	9.63E+05	1.66E+06	2.08E+06	155956	604960	1344440	1424180	2576360	0%	7%	5%	7%	6%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Aug	2.91E+05	4.07E+05	4.43E+05	7.67E+05	9.58E+05	71955.3	278990	620287	657089	1188870	0%	6%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Sep	2.51E+05	3.49E+05	3.80E+05	6.57E+05	8.22E+05	61940.7	240052	533947	565638	1023560	0%	6%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Oct	1.94E+05	2.72E+05	2.96E+05	5.12E+05	6.40E+05	47937.9	185701	413232	437767	792285	0%	7%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Nov	2.01E+05	2.80E+05	3.05E+05	5.27E+05	6.59E+05	49519.2	191740	426855	452208	818543	0%	6%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Dec	1.46E+05	2.04E+05	2.22E+05	3.84E+05	4.80E+05	35929.2	139056	309705	328106	593994	0%	7%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jan	9.71E+04	1.36E+05	1.48E+05	2.56E+05	3.20E+05	23948.9	92668.1	206434	218701	395960	0%	6%	4%	6%	5%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Feb	1.08E+05	1.48E+05	1.61E+05	2.79E+05	3.50E+05	26514.8	102596	228551	242133	438384	0%	6%	4%	6%	5%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Mar	1.46E+05	2.04E+05	2.22E+05	3.83E+05	4.79E+05	35923.3	139000	309648	328050	593938	0%	6%	4%	6%	5%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Apr	3.51E+05	4.89E+05	5.32E+05	9.20E+05	1.15E+06	86615.1	335141	746593	790961	1432050	0%	6%	4%	6%	5%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 May	1.21E+06	1.73E+06	1.88E+06	3.25E+06	4.05E+06	299361	1158310	2580380	2733730	4949460	0%	6%	5%	7%	5%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jun	1.36E+06	2.07E+06	2.26E+06	3.89E+06	4.78E+06	334087	1292660	2879700	3050830	5523590	0%	6%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jul	6.31E+05	9.86E+05	1.08E+06	1.86E+06	2.27E+06	155668	602311	1341790	1421530	2573710	0%	7%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Aug	2.91E+05	4.78E+05	5.24E+05	9.02E+05	1.09E+06	71846.6	277987	619284	656087	1187860	0%	7%	5%	8%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Sep	2.51E+05	4.19E+05	4.59E+05	7.90E+05	9.55E+05	61867.9	239376	533271	564962	1022880	0%	7%	5%	8%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Oct	1.94E+05	3.36E+05	3.68E+05	6.32E+05	7.60E+05	47897.7	185322	412853	437388	791906	0%	7%	6%	8%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Nov	2.01E+05	3.46E+05	3.79E+05	6.51E+05	7.83E+05	49494.3	191497	426613	451966	818301	0%	7%	6%	8%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Dec	1.46E+05	2.64E+05	2.89E+05	4.96E+05	5.92E+05	35923.3	138989	309637	328039	593927	0%	8%	6%	8%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jan	9.71E+04	1.91E+05	2.10E+05	3.60E+05	4.24E+05	23948.9	92658.4	206424	218692	395950	0%	8%	6%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Feb	1.04E+05	2.01E+05	2.21E+05	3.78E+05	4.47E+05	25600.5	99047.8	220659	233773	423257	0%	8%	6%	8%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Mar	1.46E+05	2.63E+05	2.88E+05	4.95E+05	5.91E+05	35923.3	138985	309634	328035	593923	0%	7%	6%	8%	6%	-4%	-9%	-6%	-10%	-6%

		Runoff coefficient 0.61																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2040 Apr	3.51E+05	5.69E+05	6.22E+05	1.07E+06	1.30E+06	86615.1	335106	746558	790926	1432010	0%	7%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 May	1.21E+06	1.86E+06	2.03E+06	3.49E+06	4.29E+06	299361	1158190	2580260	2733610	4949340	0%	6%	5%	7%	5%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jun	1.36E+06	2.07E+06	2.26E+06	3.89E+06	4.78E+06	334087	1292530	2879560	3050690	5523450	0%	6%	5%	7%	5%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jul	6.31E+05	9.85E+05	1.08E+06	1.86E+06	2.27E+06	155668	602249	1341730	1421470	2573650	0%	6%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Aug	2.91E+05	4.78E+05	5.24E+05	9.02E+05	1.09E+06	71846.6	277958	619255	656058	1187830	0%	7%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Sep	2.51E+05	4.19E+05	4.59E+05	7.90E+05	9.55E+05	61867.9	239351	533246	564937	1022860	0%	7%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Oct	1.94E+05	3.35E+05	3.68E+05	6.32E+05	7.60E+05	47897.7	185302	412834	437369	791886	0%	7%	5%	8%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Nov	2.01E+05	3.46E+05	3.79E+05	6.50E+05	7.83E+05	49494.3	191477	426593	451946	818281	0%	7%	5%	8%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Dec	1.46E+05	2.64E+05	2.89E+05	4.96E+05	5.92E+05	35923.3	138974	309623	328024	593912	0%	7%	6%	8%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jan	9.71E+04	1.91E+05	2.10E+05	3.60E+05	4.24E+05	23948.9	92647.8	206413	218681	395940	0%	8%	6%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Feb	1.08E+05	2.06E+05	2.27E+05	3.89E+05	4.59E+05	26514.8	102571	228526	242108	438359	0%	8%	6%	8%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Mar	1.46E+05	2.63E+05	2.88E+05	4.95E+05	5.91E+05	35923.3	138964	309612	328014	593902	0%	7%	6%	8%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Apr	3.51E+05	5.69E+05	6.22E+05	1.07E+06	1.30E+06	86615.1	335048	746500	790868	1431950	0%	7%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 May	1.21E+06	1.86E+06	2.03E+06	3.49E+06	4.29E+06	299361	1157970	2580040	2735560	4951300	0%	6%	5%	7%	5%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jun	1.36E+06	2.07E+06	2.25E+06	3.89E+06	4.78E+06	334087	1292250	2879280	3052990	5525750	0%	6%	5%	7%	5%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jul	6.31E+05	9.85E+05	1.08E+06	1.85E+06	2.27E+06	155668	602107	1341580	1422520	2574710	0%	6%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Aug	2.91E+05	4.78E+05	5.23E+05	9.01E+05	1.09E+06	71846.6	277887	619184	656542	1188320	0%	7%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Sep	2.51E+05	4.19E+05	4.59E+05	7.89E+05	9.54E+05	61867.9	239285	533179	565348	1023270	0%	7%	5%	7%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Oct	1.94E+05	3.35E+05	3.67E+05	6.31E+05	7.59E+05	47897.7	185247	412779	437684	792201	0%	7%	5%	8%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Nov	2.01E+05	3.45E+05	3.78E+05	6.50E+05	7.82E+05	49494.3	191417	426532	452268	818602	0%	7%	5%	8%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Dec	1.46E+05	2.63E+05	2.89E+05	4.96E+05	5.92E+05	35923.3	138927	309576	328255	594143	0%	7%	6%	8%	6%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jan	9.71E+04	1.91E+05	2.10E+05	3.59E+05	4.23E+05	23948.9	92617	206383	218835	396094	0%	37%	35%	37%	30%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Feb	1.08E+05	2.06E+05	2.26E+05	3.88E+05	4.59E+05	26514.8	102540	228495	242282	438533	0%	33%	32%	34%	27%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Mar	1.46E+05	2.62E+05	2.88E+05	4.95E+05	5.91E+05	35923.3	138925	309574	328253	594141	0%	25%	24%	26%	21%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Apr	3.51E+05	5.68E+05	6.21E+05	1.07E+06	1.30E+06	86615.1	334965	746417	791454	1432540	0%	12%	11%	13%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 May	1.21E+06	1.85E+06	2.02E+06	3.49E+06	4.29E+06	299361	1157710	2579780	2735440	4951170	0%	6%	5%	7%	5%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jun	1.36E+06	2.06E+06	2.25E+06	3.88E+06	4.77E+06	334087	1292010	2879040	3052750	5525510	0%	6%	4%	6%	5%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jul	6.31E+05	9.84E+05	1.08E+06	1.85E+06	2.27E+06	155668	602010	1341490	1422430	2574610	0%	8%	7%	9%	7%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Aug	2.91E+05	4.78E+05	5.23E+05	9.01E+05	1.09E+06	71846.6	277851	619148	656505	1188280	0%	14%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Sep	2.51E+05	4.18E+05	4.58E+05	7.89E+05	9.54E+05	61867.9	239261	533155	565324	1023240	0%	16%	15%	17%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Oct	1.94E+05	3.35E+05	3.67E+05	6.31E+05	7.59E+05	47897.7	185234	412765	437670	792188	0%	20%	19%	21%	17%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Nov	2.01E+05	3.45E+05	3.78E+05	6.49E+05	7.82E+05	49494.3	191408	426524	452259	818594	0%	20%	18%	20%	16%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Dec	1.46E+05	2.63E+05	2.89E+05	4.95E+05	5.91E+05	35923.3	138925	309574	328253	594141	0%	26%	24%	26%	21%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jan	9.71E+04	1.94E+05	2.13E+05	3.66E+05	4.30E+05	23948.9	95660.7	209426	221879	399138	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2043 Feb	1.08E+05	2.06E+05	2.26E+05	3.88E+05	4.59E+05	26514.8	105584	231539	245326	441576	0%	7%	5%	8%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2043 Mar	1.46E+05	2.51E+05	2.75E+05	4.72E+05	5.68E+05	35923.3	141969	312618	331296	597185	0%	6%	4%	7%	6%	-4%	-7%	-6%	-10%	-6%
Impacted	2043 Apr	3.51E+05	4.91E+05	5.34E+05	9.24E+05	1.16E+06	86615.1	338008	749461	794497	1435580	0%	5%	3%	6%	5%	-4%	-8%	-6%	-10%	-6%
Impacted	2043 May	1.21E+06	1.50E+06	1.62E+06	2.82E+06	3.62E+06	299361	1160760	2582830	2738480	4954220	0%	5%	3%	5%	4%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jun	1.36E+06	1.66E+06	1.80E+06	3.13E+06	4.02E+06	334087	1295050	2882080	3055790	5528550	0%	5%	3%	5%	4%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jul	6.31E+05	8.18E+05	8.87E+05	1.54E+06	1.96E+06	155668	614231	1353710	1434650	2586830	0%	5%	3%	5%	4%	-4%	-7%	-6%	-10%	-6%
Impacted	2043 Aug	2.91E+05	4.21E+05	4.58E+05	7.92E+05	9.84E+05	71846.6	288413	629710	667067	1198840	0%	5%	4%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Sep	2.51E+05	3.74E+05	4.07E+05	7.04E+05	8.69E+05	61867.9	249432	543326	575495	1033410	0%	6%	4%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Oct	1.94E+05	3.07E+05	3.36E+05	5.79E+05	7.07E+05	47897.7	194302	421833	446738	801256	0%	6%	4%	7%	5%	-4%	-4%	-4%	-9%	-5%
Impacted	2043 Nov	2.01E+05	3.15E+05	3.44E+05	5.93E+05	7.25E+05	49494.3	201128	436244	461979	828314	0%	6%	4%	7%	5%	-4%	-4%	-4%	-9%	-5%
Impacted	2043 Dec	1.46E+05	2.51E+05	2.75E+05	4.72E+05	5.68E+05	35923.3	146821	317469	336148	602036	0%	6%	4%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Jan	9.71E+04	1.94E+05	2.13E+05	3.66E+05	4.30E+05	23948.9	98810.7	212576	225029	402288	0%	6%	4%	7%	6%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Feb	1.04E+05	2.02E+05	2.22E+05	3.80E+05	4.49E+05	25600.5	105243	226855	240166	429650	0%	6%	4%	7%	5%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Mar	1.46E+05	2.51E+05	2.75E+05	4.72E+05	5.68E+05	35923.3	146085	316733	335412	601300	0%	6%	4%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Apr	3.51E+05	5.10E+05	5.56E+05	9.60E+05	1.19E+06	86615.1	348415	759867	804904	1445990	0%	5%	3%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	5%	3%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2044 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	5%	3%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2044 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	5%	3%	6%	4%	-4%	-6%	-5%	-9%	-5%
Impacted	2044 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	5%	3%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	5%	3%	6%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	5%	3%	6%	5%	-4%	-4%	-4%	-9%	-5%
Impacted	2044 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	5%	3%	6%	5%	-4%	-4%	-4%	-9%	-5%
Impacted	2044 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	5%	3%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	5%	3%	6%	5%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	5%	3%	6%	5%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	5%	3%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	5%	3%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	5%	3%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2045 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	5%	3%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2045 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	5%	3%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2045 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	5%	3%	6%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	5%	3%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	5%	3%	6%	5%	-4%	-4%	-4%	-9%	-5%
Impacted	2045 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	5%	3%	6%	5%	-4%	-4%	-4%	-9%	-5%
Impacted	2045 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	5%	3%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	5%	3%	6%	5%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	5%	3%	6%	5%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	5%	3%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	5%	3%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	5%	3%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2046 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	5%	3%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2046 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	5%	3%	6%	5%	-4%	-6%	-5%	-9%	-5%
Impacted	2046 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	5%	3%	6%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	5%	3%	6%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	5%	3%	6%	5%	-4%	-4%	-4%	-9%	-5%
Impacted	2046 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	5%	3%	6%	5%	-4%	-4%	-4%	-9%	-5%
Impacted	2046 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	5%	3%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2047 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2047 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2047 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2047 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2047 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.61																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2048 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2048 Feb	1.04E+05	1.61E+05	1.76E+05	3.04E+05	3.72E+05	25600.5	105243	226855	240166	429650	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2048 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2048 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2048 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2048 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2048 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2048 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2049 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2049 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2049 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2049 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2049 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2050 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2050 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2050 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2050 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2050 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2051 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2051 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2051 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2051 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2051 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Feb	1.04E+05	1.61E+05	1.76E+05	3.04E+05	3.72E+05	25600.5	105243	226855	240166	429650	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2052 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2052 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2052 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2052 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2052 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2053 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2053 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2053 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2053 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2053 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2054 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2054 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2054 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2054 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2054 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2055 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2055 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2055 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%

		Runoff coefficient 0.61																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2055 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2055 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2055 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Feb	1.04E+05	1.61E+05	1.76E+05	3.04E+05	3.72E+05	25600.5	105243	226855	240166	429650	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2056 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2056 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2056 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2056 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2056 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2057 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2057 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2057 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2057 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2057 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2058 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2058 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2058 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2058 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2058 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2059 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2059 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2059 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2059 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2059 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Feb	1.04E+05	1.61E+05	1.76E+05	3.04E+05	3.72E+05	25600.5	105243	226855	240166	429650	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2060 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2060 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2060 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2060 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2060 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2061 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2061 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2061 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2061 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2061 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2062 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2062 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2062 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2062 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2062 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2063 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%

		Runoff coefficient 0.61																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2063 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2063 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2063 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2063 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Feb	1.04E+05	1.61E+05	1.76E+05	3.04E+05	3.72E+05	25600.5	105243	226855	240166	429650	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2064 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2064 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2064 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2064 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2064 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2065 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2065 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2065 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2065 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2065 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2066 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2066 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2066 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2066 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2066 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2067 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2067 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2067 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2067 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2067 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Feb	1.04E+05	1.61E+05	1.76E+05	3.04E+05	3.72E+05	25600.5	105243	226855	240166	429650	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2068 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2068 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2068 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2068 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2068 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2069 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2069 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2069 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2069 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2069 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2070 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2070 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2070 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2070 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2070 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2071 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2071 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.61																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2071 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2071 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2071 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2071 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2071 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2071 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Feb	1.04E+05	1.61E+05	1.76E+05	3.04E+05	3.72E+05	25600.5	105243	226855	240166	429650	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2072 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2072 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2072 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2072 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2072 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2073 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2073 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2073 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2073 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2073 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2074 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2074 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2074 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2074 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2074 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2075 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2075 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2075 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2075 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2075 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Feb	1.04E+05	1.61E+05	1.76E+05	3.04E+05	3.72E+05	25600.5	105243	226855	240166	429650	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2076 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2076 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2076 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2076 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2076 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2077 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2077 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2077 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2077 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2077 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2077 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2077 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2078 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2078 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2078 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2078 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2078 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2078 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2078 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.61																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2079 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2079 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2079 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2079 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2079 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2079 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Feb	1.04E+05	1.61E+05	1.76E+05	3.04E+05	3.72E+05	25600.5	105243	226855	240166	429650	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2080 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2080 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2080 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2080 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2080 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2081 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2081 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2081 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2081 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2081 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2082 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2082 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2082 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2082 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2082 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2083 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2083 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2083 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2083 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2083 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 Feb	1.04E+05	1.61E+05	1.76E+05	3.04E+05	3.72E+05	25600.5	105243	226855	240166	429650	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2084 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2084 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2084 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2084 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2084 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2085 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2085 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2085 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2085 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2085 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2086 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2086 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2086 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%

		Runoff coefficient 0.61																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2086 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2086 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2086 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2087 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2087 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2087 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2087 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2087 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Feb	1.04E+05	1.61E+05	1.76E+05	3.04E+05	3.72E+05	25600.5	105243	226855	240166	429650	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2088 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2088 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2088 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2088 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2088 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2089 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2089 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2089 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2089 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2089 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2090 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2090 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2090 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2090 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2090 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2091 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2091 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2091 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2091 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2091 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Feb	1.04E+05	1.61E+05	1.76E+05	3.04E+05	3.72E+05	25600.5	105243	226855	240166	429650	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2092 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2092 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2092 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2092 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2092 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2093 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2093 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2093 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2093 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2093 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2094 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%

		Runoff coefficient 0.61																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2094 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2094 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2094 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2094 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2095 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2095 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2095 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2095 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2095 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Feb	1.04E+05	1.61E+05	1.76E+05	3.04E+05	3.72E+05	25600.5	105243	226855	240166	429650	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2096 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2096 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2096 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2096 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2096 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2097 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2097 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2097 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2097 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2097 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2098 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2098 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2098 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2098 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2098 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Jan	9.71E+04	1.52E+05	1.66E+05	2.86E+05	3.50E+05	23948.9	98810.7	212576	225029	402288	0%	9%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Feb	1.08E+05	1.67E+05	1.82E+05	3.15E+05	3.85E+05	26514.8	108893	234848	248635	444886	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Mar	1.46E+05	2.24E+05	2.45E+05	4.22E+05	5.18E+05	35923.3	146085	316733	335412	601300	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Apr	3.51E+05	5.43E+05	5.93E+05	1.02E+06	1.25E+06	86615.1	348415	759867	804904	1445990	0%	8%	6%	8%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 May	1.21E+06	1.90E+06	2.07E+06	3.57E+06	4.37E+06	299361	1200190	2622260	2777920	4993650	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2099 Jun	1.36E+06	2.12E+06	2.31E+06	3.98E+06	4.88E+06	334087	1338810	2925850	3099560	5572320	0%	9%	7%	9%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2099 Jul	6.31E+05	9.76E+05	1.07E+06	1.84E+06	2.25E+06	155668	623770	1363250	1444190	2596370	0%	8%	6%	8%	7%	-4%	-6%	-5%	-9%	-5%
Impacted	2099 Aug	2.91E+05	4.44E+05	4.85E+05	8.37E+05	1.03E+06	71846.6	288413	629710	667067	1198840	0%	6%	4%	7%	5%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Sep	2.51E+05	3.86E+05	4.22E+05	7.28E+05	8.93E+05	61867.9	249432	543326	575495	1033410	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Oct	1.94E+05	3.02E+05	3.30E+05	5.69E+05	6.97E+05	47897.7	194302	421833	446738	801256	0%	8%	7%	9%	7%	-4%	-4%	-4%	-9%	-5%
Impacted	2099 Nov	2.01E+05	3.14E+05	3.43E+05	5.92E+05	7.24E+05	49494.3	201128	436244	461979	828314	0%	9%	7%	10%	8%	-4%	-4%	-4%	-9%	-5%
Impacted	2099 Dec	1.46E+05	2.28E+05	2.49E+05	4.30E+05	5.26E+05	35923.3	146821	317469	336148	602036	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Baseline	2017 Jan	150,703	216,609	240,336	405,921	505,061	150,703	216,609	240,336	405,921	505,061	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Feb	166,850	239,817	266,039	449,366	559,127	166,850	239,817	266,039	449,366	559,127	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Mar	226,054	324,914	360,377	608,755	757,464	226,054	324,914	360,377	608,755	757,464	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Apr	545,042	783,403	868,750	1,468,000	1,826,000	545,042	783,403	868,750	1,468,000	1,826,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 May	1,884,000	2,708,000	3,002,000	5,072,000	6,311,000	1,884,000	2,708,000	3,002,000	5,072,000	6,311,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jun	2,102,000	3,022,000	3,350,000	5,660,000	7,043,000	2,102,000	3,022,000	3,350,000	5,660,000	7,043,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jul	979,569	1,408,000	1,560,000	2,637,000	3,281,000	979,569	1,408,000	1,560,000	2,637,000	3,281,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Aug	452,109	649,828	720,093	1,217,000	1,514,000	452,109	649,828	720,093	1,217,000	1,514,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Sep	389,316	559,574	619,967	1,048,000	1,304,000	389,316	559,574	619,967	1,048,000	1,304,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Oct	301,406	433,219	479,887	811,057	1,009,000	301,406	433,219	479,887	811,057	1,009,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Nov	311,453	447,659	495,792	838,002	1,043,000	311,453	447,659	495,792	838,002	1,043,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Dec	226,054	324,914	359,783	608,161	756,870	226,054	324,914	359,783	608,161	756,870	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Impacted	2018 Jan	150,703	216,609	239,811	405,396	504,536	150,703	216,609	239,811	405,396	504,536	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Feb	166,850	239,817	265,458	448,785	558,546	166,850	239,817	265,458	448,785	558,546	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Mar	226,054	324,914	359,589	607,967	756,676	226,054	324,914	359,589	607,967	756,676	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Apr	545,042	783,403	866,851	1,466,000	1,824,000	545,042	783,403	866,851	1,466,000	1,824,000	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 May	1,884,000	2,708,000	2,995,000	5,065,000	6,305,000	1,884,000	2,708,000	2,995,000	5,065,000	6,305,000	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Jun	2,102,000	3,022,000	3,342,000	5,652,000	7,035,000	2,102,000	3,022,000	3,342,000	5,652,000	7,035,000	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Jul	979,569	1,408,000	1,557,000	2,633,000	3,278,000	979,569	1,408,000	1,557,000	2,633,000	3,278,000	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Aug	452,109	649,828	718,518	1,215,000	1,513,000	452,109	649,828	718,518	1,215,000	1,513,000	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Sep	389,316	559,574	618,611	1,046,000	1,302,000	389,316	559,574	618,611	1,046,000	1,302,000	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Oct	301,406	433,219	478,837	810,008	1,008,000	301,406	433,219	478,837	810,008	1,008,000	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Nov	311,453	447,659	494,707	836,917	1,042,000	311,453	447,659	494,707	836,917	1,042,000	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2018 Dec	226,054	324,914	358,996	607,374	756,083	226,054	324,914	358,996	607,374	756,083	0%	4%	3%	3%	2%	0%	0%	0%	0%	0%
Impacted	2019 Jan	150,703	262,732	291,248	491,544	590,683	150,703	262,732	291,248	491,544	590,683	0%	4%	4%	3%	3%	0%	0%	0%	0%	0%
Impacted	2019 Feb	166,850	285,891	316,780	533,513	643,274	166,850	285,891	316,780	533,513	643,274	0%	4%	4%	3%	3%	0%	0%	0%	-1%	0%
Impacted	2019 Mar	226,054	370,897	410,598	690,033	838,742	226,054	370,897	410,598	690,033	838,742	0%	4%	3%	3%	2%	0%	0%	0%	-1%	-1%
Impacted	2019 Apr	545,042	828,998	916,290	1,536,000	1,895,000	545,042	828,998	916,290	1,536,000	1,895,000	0%	4%	3%	3%	2%	0%	0%	0%	-1%	-1%
Impacted	2019 May	1,884,000	2,751,000	3,038,000	5,079,000	6,318,000	1,884,000	2,751,000	3,038,000	5,079,000	6,318,000	0%	4%	3%	3%	2%	0%	0%	0%	-2%	-1%
Impacted	2019 Jun	2,102,000	3,097,000	3,420,000	5,702,000	7,085,000	2,102,000	3,097,000	3,420,000	5,702,000	7,085,000	0%	4%	3%	3%	2%	0%	0%	0%	-2%	-1%
Impacted	2019 Jul	979,569	1,481,000	1,636,000	2,721,000	3,365,000	979,569	1,481,000	1,636,000	2,721,000	3,365,000	0%	4%	3%	3%	2%	0%	0%	0%	-3%	-1%
Impacted	2019 Aug	452,109	709,339	783,935	1,301,000	1,598,000	452,109	709,339	783,935	1,301,000	1,598,000	0%	4%	3%	3%	2%	0%	0%	0%	-3%	-2%
Impacted	2019 Sep	389,316	619,427	684,633	1,134,000	1,390,000	389,316	619,427	684,633	1,134,000	1,390,000	0%	4%	3%	3%	2%	0%	0%	0%	-3%	-2%
Impacted	2019 Oct	301,406	491,679	543,603	898,192	1,096,000	301,406	491,679	543,603	898,192	1,096,000	0%	4%	3%	3%	2%	0%	0%	0%	-4%	-2%
Impacted	2019 Nov	311,453	508,231	561,811	926,014	1,131,000	311,453	508,231	561,811	926,014	1,131,000	0%	4%	3%	3%	2%	0%	0%	0%	-4%	-2%
Impacted	2019 Dec	226,054	382,498	423,041	696,106	844,815	226,054	382,498	423,041	696,106	844,815	0%	4%	4%	3%	3%	0%	0%	0%	-4%	-3%
Impacted	2020 Jan	150,703	269,272	298,121	491,873	591,013	150,703	269,272	298,121	491,873	591,013	0%	5%	4%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2020 Feb	161,096	282,304	312,513	518,098	624,074	161,096	282,304	312,513	518,098	624,074	0%	4%	4%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2020 Mar	226,054	374,822	414,611	690,592	839,301	226,054	374,822	414,611	690,592	839,301	0%	4%	4%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Apr	545,042	833,128	920,367	1,541,000	1,900,000	545,042	833,128	920,367	1,541,000	1,900,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 May	1,884,000	2,749,000	3,034,000	5,112,000	6,351,000	1,884,000	2,749,000	3,034,000	5,112,000	6,351,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Jun	2,102,000	3,039,000	3,355,000	5,688,000	7,071,000	2,102,000	3,039,000	3,355,000	5,688,000	7,071,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Jul	979,569	1,429,000	1,578,000	2,692,000	3,336,000	979,569	1,429,000	1,578,000	2,692,000	3,336,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Aug	452,109	678,388	749,956	1,286,000	1,584,000	452,109	678,388	749,956	1,286,000	1,584,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Sep	389,316	586,907	649,056	1,120,000	1,376,000	389,316	586,907	649,056	1,120,000	1,376,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Oct	301,406	461,959	511,169	886,344	1,085,000	301,406	461,959	511,169	886,344	1,085,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Nov	311,453	472,826	523,241	912,774	1,118,000	311,453	472,826	523,241	912,774	1,118,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2020 Dec	226,054	353,393	391,379	685,773	834,482	226,054	353,393	391,379	685,773	834,482	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Jan	150,703	250,169	277,335	485,881	585,020	150,703	250,169	277,335	485,881	585,020	0%	4%	4%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2021 Feb	166,850	272,010	301,385	528,227	637,988	166,850	272,010	301,385	528,227	637,988	0%	4%	3%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2021 Mar	226,054	352,025	389,635	684,006	832,715	226,054	352,025	389,635	684,006	832,715	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Apr	545,042	784,491	866,784	1,527,000	1,885,000	545,042	784,491	866,784	1,527,000	1,885,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 May	1,884,000	2,602,000	2,872,000	5,066,000	6,305,000	1,884,000	2,602,000	2,872,000	5,066,000	6,305,000	0%	3%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Jun	2,102,000	3,195,000	3,462,000	5,671,000	7,055,000	2,102,000	3,195,000	3,462,000	5,671,000	7,055,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Jul	979,569	1,512,000	1,639,000	2,688,000	3,332,000	979,569	1,512,000	1,639,000	2,688,000	3,332,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Aug	452,109	722,284	784,041	1,287,000	1,584,000	452,109	722,284	784,041	1,287,000	1,584,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Sep	389,316	629,591	683,503	1,121,000	1,378,000	389,316	629,591	683,503	1,121,000	1,378,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Oct	301,406	498,786	541,783	888,677	1,087,000	301,406	498,786	541,783	888,677	1,087,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Nov	311,453	514,773	558,943	916,205	1,121,000	311,453	514,773	558,943	916,205	1,121,000	0%	4%	3%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2021 Dec	226,054	386,593	420,208	689,170	837,939	226,054	386,593	420,208	689,170	837,939	0%	4%	4%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Jan	150,703	216,580	233,733	381,474	480,654	150,703	216,580	233,733	381,474	480,654	0%	10%	8%	4%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Feb	166,850	262,658	284,501	465,486	575,292	166,850	262,658	284,501	465,486	575,292	0%	11%	8%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Mar	226,054	386,735	420,214	689,132	837,901	226,054	386,735	420,214	689,132	837,901	0%	12%	9%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Apr	545,042	868,596	940,961	1,540,000	1,899,000	545,042	868,596	940,961	1,540,000	1,899,000	0%	11%	8%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 May	1,884,000	2,896,000	3,132,000	5,122,000	6,362,000	1,884,000	2,896,000	3,132,000	5,122,000	6,362,000	0%	11%	8%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Jun	2,102,000	3,230,000	3,491,000	5,709,000	7,092,000	2,102,000	3,230,000	3,491,000	5,709,000	7,092,000	0%	11%	8%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Jul	979,569	1,528,000	1,653,000	2,705,000	3,350,000	979,569	1,528,000	1,653,000	2,705,000	3,350,000	0%	11%	8%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Aug	452,109	729,680	790,330	1,295,000	1,592,000	452,109	729,680	790,330	1,295,000	1,592,000	0%	11%	9%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Sep	389,316	635,960	688,919	1,128,000	1,385,000	389,316	635,960	688,919	1,128,000	1,385,000	0%	12%	9%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Oct	301,406	503,717	545,975	894,117	1,092,000	301,406	503,717	545,975	894,117	1,092,000	0%	12%	9%	5%	4%	0%	0%	-1%	-5%	-3%
Impacted	2022 Nov	311,453	519,868	563,276	921,849	1,127,000	311,453	519,868	563,276	921,849	1,127,000	0%	12%	9%	5%	4%	0%	0%	-1%	-5%	-3%
Impacted	2022 Dec	226,054	390,291	423,353	693,284	842,053	226,054	390,291	423,353	693,284	842,053	0%	12%	9%	5%	4%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jan	150,703	215,486	231,819	377,280	476,460	150,703	215,486	231,819	377,280	476,460	0%	10%	7%	4%	4%	0%	0%	-1%	-5%	-3%
Impacted	2023 Feb	166,850	238,339	256,348	417,164	526,970	166,850	238,339	256,348	417,164	526,970	0%	10%	7%	4%	4%	0%	0%	-1%	-5%	-3%
Impacted	2023 Mar	226,054	350,935	378,858	618,366	767,136	226,054	350,935	378,858	618,366	767,136	0%	11%	8%	5%	4%	0%	0%	-1%	-5%	-3%
Impacted	2023 Apr	545,042	877,515	948,544	1,549,000	1,908,000	545,042	877,515	948,544	1,549,000	1,908,000	0%	11%	8%	5%	4%	0%	0%	-1%	-5%	-3%
Impacted	2023 May	1,884,000	2,921,000	3,151,000	5,137,000	6,377,000	1,884,000	2,921,000	3,151,000	5,137,000	6,377,000	0%	11%	8%	5%	4%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jun	2,102,000	3,239,000	3,492,000	5,690,000	7,073,000	2,102,000	3,239,000	3,492,000	5,690,000	7,073,000	0%	11%	8%	5%	4%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jul	979,569	1,551,000	1,674,000	2,731,000	3,376,000	979,569	1,551,000	1,674,000	2,731,000	3,376,000	0%	11%	8%	5%	4%	0%	0%	-1%	-5%	-3%
Impacted	2023 Aug	452,109	739,945	799,851	1,306,000	1,604,000	452,109	739,945	799,851	1,306,000	1,604,000	0%	12%	9%	5%	4%	0%	0%	-1%	-5%	-3%
Impacted	2023 Sep	389,316	644,893	697,222	1,138,000	1,395,000	389,316	644,893	697,222	1,138,000	1,395,000	0%	12%	9%	5%	4%	0%	0%	-1%	-5%	-3%
Impacted	2023 Oct	301,406	510,705	552,485	902,005	1,100,000	301,406	510,705	552,485	902,005	1,100,000	0%	12%	9%	5%	4%	0%	0%	-1%	-5%	-3%
Impacted	2023 Nov	311,453	527,153	570,075	930,128	1,135,000	311,453	527,153	570,075	930,128	1,135,000	0%	12%	9%	5%	4%	0%	0%	-1%	-5%	-3%
Impacted	2023 Dec	226,054	393,476	425,918	695,251	844,020	226,054	393,476	425,918	695,251	844,020	0%	12%	9%	5%	4%	0%	0%	-1%	-5%	-3%
Impacted	2024 Jan	150,703	234,378	252,463	410,100	509,279	150,703	234,378	252,463	410,100	509,279	0%	11%	8%	5%	4%	0%	0%	-1%	-5%	-3%
Impacted	2024 Feb	161,096	294,691	319,651	522,355	628,375	161,096	294,691	319,651	522,355	628,375	0%	13%	9%	6%	4%	0%	0%	-1%	-5%	-3%
Impacted	2024 Mar	226,054	394,109	426,762	697,442	846,211	226,054	394,109	426,762	697,442	846,211	0%	12%	9%	5%	4%	0%	0%	-1%	-6%	-3%
Impacted	2024 Apr	545,042	884,977	955,451	1,560,000	1,919,000	545,042	884,977	955,451	1,560,000	1,919,000	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 May	1,884,000	2,948,000	3,178,000	5,184,000	6,424,000	1,884,000	2,948,000	3,178,000	5,184,000	6,424,000	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jun	2,102,000	3,360,000	3,625,000	5,921,000	7,304,000	2,102,000	3,360,000	3,625,000	5,921,000	7,304,000	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jul	979,569	1,588,000	1,714,000	2,805,000	3,449,000	979,569	1,588,000	1,714,000	2,805,000	3,449,000	0%	11%	8%	5%	4%	0%	0%	-1%	-6%	-3%
Impacted	2024 Aug	452,109	738,220	797,588	1,306,000	1,604,000	452,109	738,220	797,588	1,306,000	1,604,000	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Sep	389,316	642,359	694,291	1,137,000	1,394,000	389,316	642,359	694,291	1,137,000	1,394,000	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%

		Runoff coefficient 0.51																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2024 Oct	301,406	507,932	549,455	900,534	1,099,000	301,406	507,932	549,455	900,534	1,099,000	0%	12%	9%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Nov	311,453	523,448	566,157	928,075	1,133,000	311,453	523,448	566,157	928,075	1,133,000	0%	12%	9%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Dec	226,054	392,282	424,874	697,172	845,942	226,054	392,282	424,874	697,172	845,942	0%	12%	9%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jan	150,703	276,602	300,271	494,103	593,282	150,703	276,602	300,271	494,103	593,282	0%	13%	9%	6%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Feb	166,850	300,917	326,487	537,444	647,250	166,850	300,917	326,487	537,444	647,250	0%	12%	9%	6%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Mar	226,054	390,522	423,078	696,533	845,303	226,054	390,522	423,078	696,533	845,303	0%	12%	9%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Apr	545,042	876,329	946,568	1,557,000	1,915,000	545,042	876,329	946,568	1,557,000	1,915,000	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2025 May	1,884,000	2,919,000	3,147,000	5,171,000	6,411,000	1,884,000	2,919,000	3,147,000	5,171,000	6,411,000	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jun	2,102,000	3,401,000	3,675,000	6,048,000	7,431,000	2,102,000	3,401,000	3,675,000	6,048,000	7,431,000	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jul	979,569	1,579,000	1,706,000	2,810,000	3,455,000	979,569	1,579,000	1,706,000	2,810,000	3,455,000	0%	11%	8%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Aug	452,109	731,047	790,220	1,304,000	1,601,000	452,109	731,047	790,220	1,304,000	1,601,000	0%	11%	8%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Sep	389,316	636,182	687,946	1,135,000	1,391,000	389,316	636,182	687,946	1,135,000	1,391,000	0%	11%	8%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Oct	301,406	503,150	544,542	899,078	1,097,000	301,406	503,150	544,542	899,078	1,097,000	0%	11%	9%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Nov	311,453	518,507	561,081	926,546	1,132,000	311,453	518,507	561,081	926,546	1,132,000	0%	11%	9%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Dec	226,054	388,695	421,190	696,264	845,033	226,054	388,695	421,190	696,264	845,033	0%	12%	9%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jan	150,703	274,212	297,815	493,110	592,290	150,703	274,212	297,815	493,110	592,290	0%	27%	24%	21%	17%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Feb	166,850	298,271	323,768	536,316	646,122	166,850	298,271	323,768	536,316	646,122	0%	24%	22%	19%	16%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Mar	226,054	386,937	419,394	694,974	843,743	226,054	386,937	419,394	694,974	843,743	0%	19%	16%	14%	11%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Apr	545,042	867,685	937,688	1,553,000	1,912,000	545,042	867,685	937,688	1,553,000	1,912,000	0%	11%	8%	6%	5%	0%	-1%	-2%	-6%	-4%
Impacted	2026 May	1,884,000	2,918,000	3,150,000	5,214,000	6,454,000	1,884,000	2,918,000	3,150,000	5,214,000	6,454,000	0%	8%	5%	3%	2%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jun	2,102,000	3,373,000	3,646,000	6,043,000	7,426,000	2,102,000	3,373,000	3,646,000	6,043,000	7,426,000	0%	12%	9%	7%	5%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jul	979,569	1,563,000	1,690,000	2,803,000	3,448,000	979,569	1,563,000	1,690,000	2,803,000	3,448,000	0%	11%	8%	6%	5%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Aug	452,109	723,876	782,854	1,300,000	1,598,000	452,109	723,876	782,854	1,300,000	1,598,000	0%	11%	9%	7%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Sep	389,316	630,008	681,603	1,133,000	1,389,000	389,316	630,008	681,603	1,133,000	1,389,000	0%	13%	10%	8%	7%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Oct	301,406	498,369	539,631	896,972	1,095,000	301,406	498,369	539,631	896,972	1,095,000	0%	15%	12%	11%	9%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Nov	311,453	513,567	556,007	924,367	1,129,000	311,453	513,567	556,007	924,367	1,129,000	0%	15%	12%	10%	8%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Dec	226,054	382,704	414,796	690,155	838,924	226,054	382,704	414,796	690,155	838,924	0%	18%	15%	13%	11%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jan	150,703	201,176	215,776	358,189	457,369	150,703	201,176	215,776	358,189	457,369	0%	9%	7%	6%	5%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Feb	166,850	222,328	238,492	396,168	505,974	166,850	222,328	238,492	396,168	505,974	0%	9%	7%	6%	5%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Mar	226,054	300,403	322,303	535,986	684,756	226,054	300,403	322,303	535,986	684,756	0%	9%	7%	6%	5%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Apr	545,042	723,920	776,722	1,292,000	1,651,000	545,042	723,920	776,722	1,292,000	1,651,000	0%	9%	7%	6%	5%	0%	-1%	-2%	-7%	-4%
Impacted	2027 May	1,884,000	2,770,000	2,986,000	4,971,000	6,210,000	1,884,000	2,770,000	2,986,000	4,971,000	6,210,000	0%	10%	8%	7%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jun	2,102,000	3,341,000	3,615,000	6,024,000	7,408,000	2,102,000	3,341,000	3,615,000	6,024,000	7,408,000	0%	11%	8%	7%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jul	979,569	1,547,000	1,674,000	2,792,000	3,437,000	979,569	1,547,000	1,674,000	2,792,000	3,437,000	0%	11%	8%	7%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Aug	452,109	718,929	778,247	1,299,000	1,597,000	452,109	718,929	778,247	1,299,000	1,597,000	0%	11%	8%	7%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Sep	389,316	626,004	677,954	1,132,000	1,388,000	389,316	626,004	677,954	1,132,000	1,388,000	0%	11%	8%	8%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Oct	301,406	495,468	537,053	896,632	1,095,000	301,406	495,468	537,053	896,632	1,095,000	0%	11%	9%	8%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Nov	311,453	510,774	553,597	924,246	1,129,000	311,453	510,774	553,597	924,246	1,129,000	0%	11%	9%	8%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Dec	226,054	383,232	415,942	694,727	843,497	226,054	383,232	415,942	694,727	843,497	0%	11%	9%	8%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jan	150,703	270,670	294,442	492,160	591,339	150,703	270,670	294,442	492,160	591,339	0%	12%	9%	8%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Feb	161,096	285,892	310,916	519,966	625,986	161,096	285,892	310,916	519,966	625,986	0%	11%	9%	8%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Mar	226,054	381,908	414,688	693,915	842,684	226,054	381,908	414,688	693,915	842,684	0%	11%	8%	8%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Apr	545,042	855,919	926,785	1,551,000	1,910,000	545,042	855,919	926,785	1,551,000	1,910,000	0%	10%	8%	7%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2028 May	1,884,000	2,849,000	3,080,000	5,153,000	6,393,000	1,884,000	2,849,000	3,080,000	5,153,000	6,393,000	0%	10%	7%	7%	5%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jun	2,102,000	3,420,000	3,708,000	6,200,000	7,584,000	2,102,000	3,420,000	3,708,000	6,200,000	7,584,000	0%	11%	8%	7%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jul	979,569	1,582,000	1,715,000	2,870,000	3,515,000	979,569	1,582,000	1,715,000	2,870,000	3,515,000	0%	10%	8%	7%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Aug	452,109	729,581	791,206	1,326,000	1,623,000	452,109	729,581	791,206	1,326,000	1,623,000	0%	10%	8%	7%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Sep	389,316	633,195	686,904	1,151,000	1,407,000	389,316	633,195	686,904	1,151,000	1,407,000	0%	11%	8%	7%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Oct	301,406	498,370	541,010	906,720	1,105,000	301,406	498,370	541,010	906,720	1,105,000	0%	11%	8%	7%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Nov	311,453	514,412	558,398	935,820	1,141,000	311,453	514,412	558,398	935,820	1,141,000	0%	11%	8%	7%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Dec	226,054	382,589	415,765	697,210	845,979	226,054	382,589	415,765	697,210	845,979	0%	11%	8%	8%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Jan	150,703	269,464	293,457	492,094	591,274	150,703	269,464	293,457	492,094	591,274	0%	12%	9%	8%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Feb	166,850	293,121	319,075	535,363	645,169	166,850	293,121	319,075	535,363	645,169	0%	11%	9%	8%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Mar	226,054	380,104	413,214	693,928	842,698	226,054	380,104	413,214	693,928	842,698	0%	11%	8%	7%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Apr	545,042	869,309	943,016	1,583,000	1,942,000	545,042	869,309	943,016	1,583,000	1,942,000	0%	10%	8%	7%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2029 May	1,884,000	2,943,000	3,189,000	5,353,000	6,592,000	1,884,000	2,943,000	3,189,000	5,353,000	6,592,000	0%	10%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jun	2,102,000	3,387,000	3,675,000	6,171,000	7,554,000	2,102,000	3,387,000	3,675,000	6,171,000	7,554,000	0%	10%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jul	979,569	1,575,000	1,710,000	2,872,000	3,517,000	979,569	1,575,000	1,710,000	2,872,000	3,517,000	0%	10%	8%	7%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Aug	452,109	728,913	791,538	1,331,000	1,629,000	452,109	728,913	791,538	1,331,000	1,629,000	0%	10%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Sep	389,316	632,891	687,492	1,156,000	1,413,000	389,316	632,891	687,492	1,156,000	1,413,000	0%	10%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Oct	301,406	498,099	541,425	910,693	1,109,000	301,406	498,099	541,425	910,693	1,109,000	0%	11%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Nov	311,453	514,107	558,799	939,893	1,145,000	311,453	514,107	558,799	939,893	1,145,000	0%	11%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Dec	226,054	382,621	416,340	700,557	849,327	226,054	382,621	416,340	700,557	849,327	0%	11%	8%	8%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jan	150,703	268,262	292,475	492,653	591,832	150,703	268,262	292,475	492,653	591,832	0%	12%	9%	8%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Feb	166,850	291,789	317,988	535,972	645,778	166,850	291,789	317,988	535,972	645,778	0%	11%	9%	8%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Mar	226,054	378,299	411,741	694,609	843,378	226,054	378,299	411,741	694,609	843,378	0%	11%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Apr	545,042	847,218	919,680	1,552,000	1,911,000	545,042	847,218	919,680	1,552,000	1,911,000	0%	10%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 May	1,884,000	2,928,000	3,177,000	5,356,000	6,595,000	1,884,000	2,928,000	3,177,000	5,356,000	6,595,000	0%	10%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jun	2,102,000	3,359,000	3,649,000	6,151,000	7,535,000	2,102,000	3,359,000	3,649,000	6,151,000	7,535,000	0%	10%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jul	979,569	1,567,000	1,703,000	2,874,000	3,518,000	979,569	1,567,000	1,703,000	2,874,000	3,518,000	0%	10%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Aug	452,109	720,373	783,092	1,323,000	1,621,000	452,109	720,373	783,092	1,323,000	1,621,000	0%	10%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Sep	389,316	625,118	679,751	1,149,000	1,405,000	389,316	625,118	679,751	1,149,000	1,405,000	0%	10%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Oct	301,406	490,410	533,568	901,905	1,100,000	301,406	490,410	533,568	901,905	1,100,000	0%	11%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Nov	311,453	505,642	550,101	929,857	1,135,000	311,453	505,642	550,101	929,857	1,135,000	0%	11%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Dec	226,054	377,815	411,518	695,792	844,562	226,054	377,815	411,518	695,792	844,562	0%	11%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Jan	150,703	267,050	291,485	492,863	592,042	150,703	267,050	291,485	492,863	592,042	0%	23%	21%	21%	17%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Feb	166,850	290,431	316,875	536,186	645,992	166,850	290,431	316,875	536,186	645,992	0%	21%	19%	19%	16%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Mar	226,054	376,436	410,211	694,902	843,671	226,054	376,436	410,211	694,902	843,671	0%	16%	14%	14%	11%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Apr	545,042	842,667	915,936	1,553,000	1,912,000	545,042	842,667	915,936	1,553,000	1,912,000	0%	8%	5%	6%	5%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 May	1,884,000	2,883,000	3,131,000	5,304,000	6,544,000	1,884,000	2,883,000	3,131,000	5,304,000	6,544,000	0%	6%	4%	5%	4%	-1%	-2%	-3%	-7%	-4%
Impacted	2031 Jun	2,102,000	3,344,000	3,637,000	6,160,000	7,543,000	2,102,000	3,344,000	3,637,000	6,160,000	7,543,000	0%	11%	9%	9%	7%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Jul	979,569	1,554,000	1,691,000	2,867,000	3,512,000	979,569	1,554,000	1,691,000	2,867,000	3,512,000	0%	10%	8%	9%	7%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Aug	452,109	709,679	772,303	1,312,000	1,609,000	452,109	709,679	772,303	1,312,000	1,609,000	0%	9%	7%	8%	6%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Sep	389,316	615,347	669,841	1,138,000	1,394,000	389,316	615,347	669,841	1,138,000	1,394,000	0%	10%	8%	9%	7%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Oct	301,406	485,561	528,929	898,449	1,097,000	301,406	485,561	528,929	898,449	1,097,000	0%	12%	10%	11%	9%	-1%	-3%	-3%	-8%	-5%
Impacted	2031 Nov	311,453	500,513	545,182	926,137	1,131,000	311,453	500,513	545,182	926,137	1,131,000	0%	12%	10%	11%	8%	-1%	-3%	-3%	-8%	-5%
Impacted	2031 Dec	226,054	375,767	409,820	696,173	844,942	226,054	375,767	409,820	696,173	844,942	0%	16%	14%	14%	12%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Jan	150,703	265,683	290,351	493,126	592,305	150,703	265,683	290,351	493,126	592,305	0%	11%	9%	11%	8%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Feb	161,096	280,549	306,533	520,997	627,017	161,096	280,549	306,533	520,997	627,017	0%	11%	9%	10%	8%	-1%	-3%	-3%	-8%	-4%
Impacted	2032 Mar	226,054	374,394	408,521	695,323	844,093	226,054	374,394	408,521	695,323	844,093	0%	10%	8%	10%	8%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Apr	545,042	837,759	911,881	1,554,000	1,913,000	545,042	837,759	911,881	1,554,000	1,913,000	0%	10%	8%	9%	7%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 May	1,884,000	2,867,000	3,118,000	5,308,000	6,548,000	1,884,000	2,867,000	3,118,000	5,308,000	6,548,000	0%	9%	8%	9%	7%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Jun	2,102,000	2,593,000	2,796,000	4,777,000	6,161,000	2,102,000	2,593,000	2,796,000	4,777,000	6,161,000	0%	8%	6%	7%	6%	-1%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2032 Jul	979,569	1,203,000	1,297,000	2,220,000	2,865,000	979,569	1,203,000	1,297,000	2,220,000	2,865,000	0%	8%	6%	7%	6%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Aug	452,109	551,769	595,539	1,021,000	1,319,000	452,109	551,769	595,539	1,021,000	1,319,000	0%	8%	6%	7%	6%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Sep	389,316	474,826	512,517	879,119	1,135,000	389,316	474,826	512,517	879,119	1,135,000	0%	8%	6%	7%	6%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Oct	301,406	383,658	414,939	711,443	909,803	301,406	383,658	414,939	711,443	909,803	0%	8%	6%	8%	6%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Nov	311,453	498,891	544,183	928,879	1,134,000	311,453	498,891	544,183	928,879	1,134,000	0%	10%	8%	10%	8%	-1%	-4%	-4%	-8%	-5%
Impacted	2032 Dec	226,054	373,755	408,164	696,651	845,421	226,054	373,755	408,164	696,651	845,421	0%	10%	8%	10%	8%	-1%	-4%	-4%	-8%	-5%
Impacted	2033 Jan	150,703	264,341	289,247	493,445	592,625	150,703	264,341	289,247	493,445	592,625	0%	9%	8%	9%	7%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Feb	166,850	287,436	314,402	536,840	646,647	166,850	287,436	314,402	536,840	646,647	0%	9%	7%	9%	7%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Mar	226,054	372,386	406,869	695,801	844,571	226,054	372,386	406,869	695,801	844,571	0%	9%	7%	9%	7%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Apr	545,042	842,541	918,629	1,573,000	1,931,000	545,042	842,541	918,629	1,573,000	1,931,000	0%	8%	7%	8%	6%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 May	1,884,000	2,922,000	3,185,000	5,444,000	6,684,000	1,884,000	2,922,000	3,185,000	5,444,000	6,684,000	0%	8%	7%	8%	6%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jun	2,102,000	3,380,000	3,689,000	6,305,000	7,688,000	2,102,000	3,380,000	3,689,000	6,305,000	7,688,000	0%	9%	7%	8%	7%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jul	979,569	1,592,000	1,739,000	2,975,000	3,619,000	979,569	1,592,000	1,739,000	2,975,000	3,619,000	0%	9%	7%	8%	7%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Aug	452,109	717,150	782,985	1,342,000	1,639,000	452,109	717,150	782,985	1,342,000	1,639,000	0%	9%	7%	8%	7%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Sep	389,316	622,273	679,590	1,165,000	1,421,000	389,316	622,273	679,590	1,165,000	1,421,000	0%	9%	7%	8%	7%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Oct	301,406	488,015	533,233	913,878	1,112,000	301,406	488,015	533,233	913,878	1,112,000	0%	9%	7%	8%	7%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Nov	311,453	504,132	550,838	944,041	1,149,000	311,453	504,132	550,838	944,041	1,149,000	0%	9%	7%	8%	7%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Dec	226,054	372,640	407,509	698,750	847,520	226,054	372,640	407,509	698,750	847,520	0%	9%	7%	9%	7%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Jan	150,703	263,760	288,976	495,038	594,217	150,703	263,760	288,976	495,038	594,217	0%	9%	7%	9%	7%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Feb	166,850	288,308	315,764	541,146	650,952	166,850	288,308	315,764	541,146	650,952	0%	9%	7%	9%	7%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Mar	226,054	378,748	414,453	710,743	859,513	226,054	378,748	414,453	710,743	859,513	0%	9%	7%	8%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Apr	545,042	867,445	947,481	1,625,000	1,984,000	545,042	867,445	947,481	1,625,000	1,984,000	0%	8%	7%	8%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 May	1,884,000	3,017,000	3,296,000	5,648,000	6,888,000	1,884,000	3,017,000	3,296,000	5,648,000	6,888,000	0%	8%	7%	8%	7%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Jun	2,102,000	3,456,000	3,778,000	6,472,000	7,856,000	2,102,000	3,456,000	3,778,000	6,472,000	7,856,000	0%	9%	7%	8%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jul	979,569	1,595,000	1,743,000	2,988,000	3,633,000	979,569	1,595,000	1,743,000	2,988,000	3,633,000	0%	9%	7%	8%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Aug	452,109	723,668	790,830	1,358,000	1,655,000	452,109	723,668	790,830	1,358,000	1,655,000	0%	8%	7%	8%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Sep	389,316	628,374	686,821	1,179,000	1,435,000	389,316	628,374	686,821	1,179,000	1,435,000	0%	8%	7%	8%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Oct	301,406	494,275	540,494	927,170	1,126,000	301,406	494,275	540,494	927,170	1,126,000	0%	9%	7%	8%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Nov	311,453	510,330	557,983	956,905	1,162,000	311,453	510,330	557,983	956,905	1,162,000	0%	9%	7%	8%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Dec	226,054	379,563	415,359	712,199	860,969	226,054	379,563	415,359	712,199	860,969	0%	9%	7%	9%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Jan	150,703	263,255	288,488	494,647	593,827	150,703	263,255	288,488	494,647	593,827	0%	9%	7%	9%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Feb	166,850	288,318	315,858	541,746	651,552	166,850	288,318	315,858	541,746	651,552	0%	9%	7%	9%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Mar	226,054	378,159	413,908	710,469	859,238	226,054	378,159	413,908	710,469	859,238	0%	9%	7%	8%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Apr	545,042	867,199	947,480	1,627,000	1,986,000	545,042	867,199	947,480	1,627,000	1,986,000	0%	8%	7%	8%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 May	1,884,000	3,024,000	3,304,000	5,668,000	6,907,000	1,884,000	3,024,000	3,304,000	5,668,000	6,907,000	0%	8%	7%	8%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jun	2,102,000	3,453,000	3,775,000	6,473,000	7,856,000	2,102,000	3,453,000	3,775,000	6,473,000	7,856,000	0%	9%	7%	8%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jul	979,569	1,594,000	1,743,000	2,991,000	3,636,000	979,569	1,594,000	1,743,000	2,991,000	3,636,000	0%	9%	7%	8%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Aug	452,109	723,909	791,328	1,360,000	1,657,000	452,109	723,909	791,328	1,360,000	1,657,000	0%	8%	7%	8%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Sep	389,316	628,352	686,993	1,180,000	1,436,000	389,316	628,352	686,993	1,180,000	1,436,000	0%	8%	7%	8%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Oct	301,406	493,864	540,187	927,491	1,126,000	301,406	493,864	540,187	927,491	1,126,000	0%	9%	7%	8%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Nov	311,453	510,648	558,494	958,580	1,164,000	311,453	510,648	558,494	958,580	1,164,000	0%	9%	7%	8%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Dec	226,054	378,774	414,593	711,569	860,339	226,054	378,774	414,593	711,569	860,339	0%	9%	7%	9%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Jan	150,703	262,752	288,002	494,268	593,448	150,703	262,752	288,002	494,268	593,448	0%	21%	20%	22%	18%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Feb	161,096	277,526	304,117	522,224	628,244	161,096	277,526	304,117	522,224	628,244	0%	20%	18%	20%	16%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Mar	226,054	375,538	411,100	706,525	855,294	226,054	375,538	411,100	706,525	855,294	0%	16%	14%	16%	13%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Apr	545,042	865,585	945,954	1,626,000	1,985,000	545,042	865,585	945,954	1,626,000	1,985,000	0%	10%	9%	11%	9%	-3%	-7%	-5%	-9%	-5%
Impacted	2036 May	1,884,000	2,983,000	3,259,000	5,597,000	6,837,000	1,884,000	2,983,000	3,259,000	5,597,000	6,837,000	0%	10%	9%	10%	8%	-3%	-7%	-5%	-9%	-5%
Impacted	2036 Jun	2,102,000	3,450,000	3,773,000	6,475,000	7,858,000	2,102,000	3,450,000	3,773,000	6,475,000	7,858,000	0%	14%	13%	14%	12%	-3%	-7%	-5%	-9%	-5%
Impacted	2036 Jul	979,569	1,587,000	1,736,000	2,982,000	3,627,000	979,569	1,587,000	1,736,000	2,982,000	3,627,000	0%	13%	11%	13%	11%	-3%	-7%	-5%	-9%	-6%
Impacted	2036 Aug	452,109	721,402	788,758	1,357,000	1,654,000	452,109	721,402	788,758	1,357,000	1,654,000	0%	11%	10%	12%	9%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Sep	389,316	626,066	684,639	1,177,000	1,434,000	389,316	626,066	684,639	1,177,000	1,434,000	0%	12%	10%	12%	10%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Oct	301,406	492,427	538,737	925,959	1,124,000	301,406	492,427	538,737	925,959	1,124,000	0%	14%	12%	14%	11%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Nov	311,453	508,352	556,090	955,527	1,160,000	311,453	508,352	556,090	955,527	1,160,000	0%	14%	12%	14%	11%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Dec	226,054	377,489	413,273	710,043	858,812	226,054	377,489	413,273	710,043	858,812	0%	16%	15%	17%	13%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jan	150,703	262,669	287,985	494,650	593,830	150,703	262,669	287,985	494,650	593,830	0%	21%	20%	22%	18%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Feb	166,850	285,697	313,102	538,180	647,986	166,850	285,697	313,102	538,180	647,986	0%	19%	18%	20%	16%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Mar	226,054	374,892	410,493	706,153	854,923	226,054	374,892	410,493	706,153	854,923	0%	15%	14%	16%	13%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Apr	545,042	864,651	945,187	1,626,000	1,985,000	545,042	864,651	945,187	1,626,000	1,985,000	0%	10%	9%	11%	9%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 May	1,884,000	2,993,000	3,270,000	5,622,000	6,861,000	1,884,000	2,993,000	3,270,000	5,622,000	6,861,000	0%	11%	9%	11%	9%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jun	2,102,000	3,460,000	3,786,000	6,502,000	7,886,000	2,102,000	3,460,000	3,786,000	6,502,000	7,886,000	0%	14%	13%	15%	12%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Jul	979,569	1,595,000	1,744,000	2,999,000	3,644,000	979,569	1,595,000	1,744,000	2,999,000	3,644,000	0%	13%	12%	14%	11%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Aug	452,109	723,421	791,265	1,362,000	1,660,000	452,109	723,421	791,265	1,362,000	1,660,000	0%	11%	10%	12%	10%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Sep	389,316	626,426	685,238	1,179,000	1,436,000	389,316	626,426	685,238	1,179,000	1,436,000	0%	12%	11%	13%	10%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Oct	301,406	492,073	538,493	926,381	1,125,000	301,406	492,073	538,493	926,381	1,125,000	0%	14%	12%	14%	11%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Nov	311,453	507,313	555,089	954,747	1,160,000	311,453	507,313	555,089	954,747	1,160,000	0%	13%	12%	14%	11%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Dec	226,054	376,892	412,721	709,762	858,531	226,054	376,892	412,721	709,762	858,531	0%	16%	15%	17%	13%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jan	150,703	200,139	217,458	375,834	475,013	150,703	200,139	217,458	375,834	475,013	0%	11%	9%	11%	9%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Feb	166,850	219,178	238,070	411,741	521,547	166,850	219,178	238,070	411,741	521,547	0%	10%	9%	11%	9%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Mar	226,054	299,579	325,573	563,220	711,990	226,054	299,579	325,573	563,220	711,990	0%	10%	9%	11%	9%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Apr	545,042	720,227	782,581	1,354,000	1,712,000	545,042	720,227	782,581	1,354,000	1,712,000	0%	10%	9%	11%	9%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 May	1,884,000	2,503,000	2,719,000	4,701,000	5,940,000	1,884,000	2,503,000	2,719,000	4,701,000	5,940,000	0%	11%	9%	11%	9%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jun	2,102,000	3,058,000	3,333,000	5,747,000	7,131,000	2,102,000	3,058,000	3,333,000	5,747,000	7,131,000	0%	12%	10%	12%	10%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jul	979,569	1,610,000	1,762,000	3,031,000	3,675,000	979,569	1,610,000	1,762,000	3,031,000	3,675,000	0%	13%	11%	14%	11%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Aug	452,109	739,010	808,885	1,392,000	1,690,000	452,109	739,010	808,885	1,392,000	1,690,000	0%	13%	11%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Sep	389,316	641,538	702,294	1,208,000	1,464,000	389,316	641,538	702,294	1,208,000	1,464,000	0%	13%	11%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Oct	301,406	506,819	555,089	954,145	1,153,000	301,406	506,819	555,089	954,145	1,153,000	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Nov	311,453	522,685	572,386	983,677	1,189,000	311,453	522,685	572,386	983,677	1,189,000	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Dec	226,054	391,842	429,506	737,626	886,395	226,054	391,842	429,506	737,626	886,395	0%	14%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jan	150,703	276,983	304,095	521,606	620,786	150,703	276,983	304,095	521,606	620,786	0%	13%	11%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Feb	166,850	301,506	330,889	567,905	677,711	166,850	301,506	330,889	567,905	677,711	0%	13%	11%	13%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Mar	226,054	391,528	429,246	737,697	886,466	226,054	391,528	429,246	737,697	886,466	0%	12%	11%	13%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Apr	545,042	879,269	961,952	1,656,000	2,014,000	545,042	879,269	961,952	1,656,000	2,014,000	0%	11%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 May	1,884,000	3,056,000	3,343,000	5,752,000	6,991,000	1,884,000	3,056,000	3,343,000	5,752,000	6,991,000	0%	11%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jun	2,102,000	3,470,000	3,798,000	6,532,000	7,915,000	2,102,000	3,470,000	3,798,000	6,532,000	7,915,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jul	979,569	1,609,000	1,761,000	3,029,000	3,674,000	979,569	1,609,000	1,761,000	3,029,000	3,674,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Aug	452,109	738,656	808,571	1,392,000	1,690,000	452,109	738,656	808,571	1,392,000	1,690,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Sep	389,316	641,141	701,902	1,208,000	1,464,000	389,316	641,141	701,902	1,208,000	1,464,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Oct	301,406	506,492	554,749	953,731	1,152,000	301,406	506,492	554,749	953,731	1,152,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Nov	311,453	522,256	571,920	982,989	1,188,000	311,453	522,256	571,920	982,989	1,188,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Dec	226,054	391,630	429,269	737,237	886,007	226,054	391,630	429,269	737,237	886,007	0%	12%	11%	13%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jan	150,703	276,313	303,345	520,368	619,548	150,703	276,313	303,345	520,368	619,548	0%	13%	11%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Feb	161,096	291,970	320,452	549,979	655,999	161,096	291,970	320,452	549,979	655,999	0%	13%	11%	13%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Mar	226,054	390,500	428,095	735,797	884,567	226,054	390,500	428,095	735,797	884,567	0%	12%	11%	13%	10%	-4%	-9%	-6%	-10%	-6%

		Runoff coefficient 0.51																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2040 Apr	545,042	876,792	959,176	1,651,000	2,010,000	545,042	876,792	959,176	1,651,000	2,010,000	0%	11%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 May	1,884,000	3,048,000	3,334,000	5,736,000	6,976,000	1,884,000	3,048,000	3,334,000	5,736,000	6,976,000	0%	11%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jun	2,102,000	3,461,000	3,788,000	6,515,000	7,898,000	2,102,000	3,461,000	3,788,000	6,515,000	7,898,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jul	979,569	1,604,000	1,756,000	3,022,000	3,666,000	979,569	1,604,000	1,756,000	3,022,000	3,666,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Aug	452,109	736,848	806,546	1,389,000	1,686,000	452,109	736,848	806,546	1,389,000	1,686,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Sep	389,316	639,654	700,238	1,205,000	1,461,000	389,316	639,654	700,238	1,205,000	1,461,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Oct	301,406	505,122	553,213	951,196	1,150,000	301,406	505,122	553,213	951,196	1,150,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Nov	311,453	520,839	570,333	980,369	1,185,000	311,453	520,839	570,333	980,369	1,185,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Dec	226,054	390,603	428,118	735,337	884,107	226,054	390,603	428,118	735,337	884,107	0%	12%	11%	13%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jan	150,703	275,621	302,569	519,088	618,267	150,703	275,621	302,569	519,088	618,267	0%	13%	11%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Feb	166,850	299,969	329,165	565,060	674,866	166,850	299,969	329,165	565,060	674,866	0%	13%	11%	13%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Mar	226,054	389,424	426,888	733,804	882,574	226,054	389,424	426,888	733,804	882,574	0%	12%	11%	13%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Apr	545,042	874,146	956,209	1,646,000	2,005,000	545,042	874,146	956,209	1,646,000	2,005,000	0%	11%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 May	1,884,000	3,045,000	3,331,000	5,731,000	6,971,000	1,884,000	3,045,000	3,331,000	5,731,000	6,971,000	0%	11%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jun	2,102,000	3,451,000	3,777,000	6,497,000	7,880,000	2,102,000	3,451,000	3,777,000	6,497,000	7,880,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jul	979,569	1,600,000	1,751,000	3,014,000	3,659,000	979,569	1,600,000	1,751,000	3,014,000	3,659,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Aug	452,109	735,477	805,014	1,386,000	1,684,000	452,109	735,477	805,014	1,386,000	1,684,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Sep	389,316	638,567	699,024	1,203,000	1,459,000	389,316	638,567	699,024	1,203,000	1,459,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Oct	301,406	503,489	551,382	948,165	1,147,000	301,406	503,489	551,382	948,165	1,147,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Nov	311,453	519,123	568,408	977,182	1,182,000	311,453	519,123	568,408	977,182	1,182,000	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Dec	226,054	389,336	426,696	732,983	881,753	226,054	389,336	426,696	732,983	881,753	0%	12%	11%	13%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jan	150,703	274,736	301,576	517,441	616,621	150,703	274,736	301,576	517,441	616,621	0%	27%	25%	27%	22%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Feb	166,850	298,921	327,989	563,107	672,913	166,850	298,921	327,989	563,107	672,913	0%	25%	23%	25%	20%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Mar	226,054	387,913	425,191	730,981	879,750	226,054	387,913	425,191	730,981	879,750	0%	19%	18%	20%	16%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Apr	545,042	870,274	951,858	1,639,000	1,998,000	545,042	870,274	951,858	1,639,000	1,998,000	0%	11%	10%	12%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 May	1,884,000	3,034,000	3,318,000	5,710,000	6,950,000	1,884,000	3,034,000	3,318,000	5,710,000	6,950,000	0%	12%	11%	13%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jun	2,102,000	3,434,000	3,758,000	6,465,000	7,849,000	2,102,000	3,434,000	3,758,000	6,465,000	7,849,000	0%	14%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jul	979,569	1,592,000	1,742,000	2,999,000	3,643,000	979,569	1,592,000	1,742,000	2,999,000	3,643,000	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Aug	452,109	731,492	800,529	1,379,000	1,676,000	452,109	731,492	800,529	1,379,000	1,676,000	0%	13%	11%	13%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Sep	389,316	634,971	694,975	1,196,000	1,452,000	389,316	634,971	694,975	1,196,000	1,452,000	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Oct	301,406	500,588	548,116	942,693	1,141,000	301,406	500,588	548,116	942,693	1,141,000	0%	16%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Nov	311,453	515,995	564,886	971,276	1,176,000	311,453	515,995	564,886	971,276	1,176,000	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Dec	226,054	386,971	424,032	728,514	877,283	226,054	386,971	424,032	728,514	877,283	0%	19%	18%	20%	16%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jan	150,703	256,223	280,609	483,227	582,480	150,703	256,223	280,609	483,227	582,480	0%	8%	6%	9%	7%	-4%	-7%	-6%	-10%	-6%
Impacted	2043 Feb	166,850	275,053	300,960	518,696	628,582	166,850	275,053	300,960	518,696	628,582	0%	8%	6%	9%	7%	-4%	-7%	-6%	-10%	-6%
Impacted	2043 Mar	226,054	344,098	375,583	648,747	797,626	226,054	344,098	375,583	648,747	797,626	0%	7%	5%	8%	6%	-4%	-8%	-6%	-10%	-6%
Impacted	2043 Apr	545,042	716,105	777,640	1,349,000	1,708,000	545,042	716,105	777,640	1,349,000	1,708,000	0%	6%	5%	7%	6%	-4%	-8%	-6%	-10%	-6%
Impacted	2043 May	1,884,000	2,277,000	2,465,000	4,290,000	5,531,000	1,884,000	2,277,000	2,465,000	4,290,000	5,531,000	0%	6%	4%	6%	5%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jun	2,102,000	2,862,000	3,111,000	5,393,000	6,778,000	2,102,000	2,862,000	3,111,000	5,393,000	6,778,000	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	7%	6%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	7%	6%	8%	6%	-4%	-5%	-4%	-9%	-5%
Impacted	2043 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2043 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2043 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	7%	5%	7%	6%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Feb	161,096	253,291	276,750	477,591	583,688	161,096	253,291	276,750	477,591	583,688	0%	7%	5%	7%	6%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	7%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	7%	5%	7%	6%	-4%	-5%	-4%	-9%	-5%
Impacted	2044 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	7%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	7%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	7%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	7%	5%	7%	6%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	7%	5%	7%	6%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	7%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	7%	5%	7%	6%	-4%	-5%	-4%	-9%	-5%
Impacted	2045 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	7%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	7%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	7%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	7%	5%	7%	6%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	7%	5%	7%	6%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	7%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	7%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	7%	5%	7%	6%	-4%	-5%	-4%	-9%	-5%
Impacted	2046 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	7%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	7%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	7%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2047 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2048 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2048 Feb	161,096	253,291	276,750	477,591	583,688	161,096	253,291	276,750	477,591	583,688	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2048 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2048 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2049 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2050 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2051 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Feb	161,096	253,291	276,750	477,591	583,688	161,096	253,291	276,750	477,591	583,688	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2052 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2053 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2054 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%

		Runoff coefficient 0.51																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2055 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Feb	161,096	253,291	276,750	477,591	583,688	161,096	253,291	276,750	477,591	583,688	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2056 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2057 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2058 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2059 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Feb	161,096	253,291	276,750	477,591	583,688	161,096	253,291	276,750	477,591	583,688	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2060 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2061 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2062 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%

		Runoff coefficient 0.51																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2063 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2063 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Feb	161,096	253,291	276,750	477,591	583,688	161,096	253,291	276,750	477,591	583,688	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2064 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2065 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2066 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2067 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Feb	161,096	253,291	276,750	477,591	583,688	161,096	253,291	276,750	477,591	583,688	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2068 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2069 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2070 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2071 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2071 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2071 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2071 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Feb	161,096	253,291	276,750	477,591	583,688	161,096	253,291	276,750	477,591	583,688	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2072 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2073 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 May	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	1,884,000	2,973,000	3,249,000	5,606,000	6,847,000	0%	10%	8%	11%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Jun	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	2,102,000	3,317,000	3,624,000	6,254,000	7,639,000	0%	10%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Jul	979,569	1,536,000	1,678,000	2,897,000	3,542,000	979,569	1,536,000	1,678,000	2,897,000	3,542,000	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Aug	452,109	702,881	767,709	1,325,000	1,623,000	452,109	702,881	767,709	1,325,000	1,623,000	0%	8%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Sep	389,316	608,853	665,132	1,148,000	1,404,000	389,316	608,853	665,132	1,148,000	1,404,000	0%	9%	7%	10%	8%	-4%	-5%	-4%	-9%	-5%
Impacted	2074 Oct	301,406	474,152	518,076	894,035	1,093,000	301,406	474,152	518,076	894,035	1,093,000	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Nov	311,453	492,441	538,143	928,533	1,134,000	311,453	492,441	538,143	928,533	1,134,000	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Dec	226,054	357,448	390,623	673,995	822,873	226,054	357,448	390,623	673,995	822,873	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Jan	150,703	237,835	259,893	448,453	547,705	150,703	237,835	259,893	448,453	547,705	0%	10%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Feb	166,850	262,337	286,634	494,647	604,534	166,850	262,337	286,634	494,647	604,534	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Mar	226,054	353,401	386,063	666,340	815,219	226,054	353,401	386,063	666,340	815,219	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Apr	545,042	854,746	933,835	1,612,000	1,971,000	545,042	854,746	933,835	1,612,000	1,971,000	0%	9%	7%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 May	1,884,000	2,978,000	3,255,000	5,616,000	6,856,000	1,884,000	2,978,000	3,255,000	5,616,000	6,856,000	0%	10%	8%	11%	9%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2075 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Feb	161,096	257,995	282,050	486,488	592,585	161,096	257,995	282,050	486,488	592,585	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2076 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2077 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2077 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2077 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2078 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2078 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2078 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2079 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2079 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Feb	161,096	257,995	282,050	486,488	592,585	161,096	257,995	282,050	486,488	592,585	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2080 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2081 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2082 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2083 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 Feb	161,096	257,995	282,050	486,488	592,585	161,096	257,995	282,050	486,488	592,585	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2084 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2085 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%

		Runoff coefficient 0.51																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2086 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2087 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Feb	161,096	257,995	282,050	486,488	592,585	161,096	257,995	282,050	486,488	592,585	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2088 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2089 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2090 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2091 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Feb	161,096	257,995	282,050	486,488	592,585	161,096	257,995	282,050	486,488	592,585	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2092 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2093 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%

		Runoff coefficient 0.51																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2094 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2094 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2095 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Feb	161,096	257,995	282,050	486,488	592,585	161,096	257,995	282,050	486,488	592,585	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2096 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2097 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2098 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Jan	150,703	243,676	266,474	459,500	558,752	150,703	243,676	266,474	459,500	558,752	0%	12%	11%	13%	11%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Feb	166,850	267,267	292,188	503,971	613,857	166,850	267,267	292,188	503,971	613,857	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Mar	226,054	357,122	390,255	673,377	822,255	226,054	357,122	390,255	673,377	822,255	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Apr	545,042	870,623	951,723	1,642,000	2,001,000	545,042	870,623	951,723	1,642,000	2,001,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 May	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	1,884,000	3,065,000	3,353,000	5,780,000	7,021,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Jun	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	2,102,000	3,417,000	3,738,000	6,444,000	7,829,000	0%	13%	12%	14%	11%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Jul	979,569	1,566,000	1,712,000	2,953,000	3,598,000	979,569	1,566,000	1,712,000	2,953,000	3,598,000	0%	11%	10%	12%	10%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Aug	452,109	705,093	770,202	1,329,000	1,627,000	452,109	705,093	770,202	1,329,000	1,627,000	0%	9%	7%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Sep	389,316	616,803	674,089	1,163,000	1,419,000	389,316	616,803	674,089	1,163,000	1,419,000	0%	10%	9%	11%	9%	-4%	-5%	-4%	-9%	-5%
Impacted	2099 Oct	301,406	484,797	530,068	914,166	1,113,000	301,406	484,797	530,068	914,166	1,113,000	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Nov	311,453	507,825	555,475	957,627	1,163,000	311,453	507,825	555,475	957,627	1,163,000	0%	13%	12%	14%	12%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Dec	226,054	368,228	402,768	694,382	843,260	226,054	368,228	402,768	694,382	843,260	0%	13%	12%	14%	11%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Baseline	2017 Jan	110,083	158,225	175,556	296,510	368,927	28,276	115,235	249,966	276,833	477,691	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Feb	121,877	175,177	194,331	328,244	408,421	31,306	127,581	276,748	306,493	528,873	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Mar	165,124	237,337	263,241	444,672	553,298	42,414	172,852	374,948	415,249	716,537	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Apr	398,132	572,246	634,588	1,072,000	1,334,000	102,266	416,765	904,042	1,001,000	1,728,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 May	1,376,000	1,978,000	2,193,000	3,705,000	4,610,000	353,454	1,440,000	3,125,000	3,460,000	5,971,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jun	1,536,000	2,207,000	2,447,000	4,134,000	5,144,000	394,454	1,608,000	3,487,000	3,862,000	6,664,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jul	715,537	1,028,000	1,140,000	1,926,000	2,397,000	183,796	749,025	1,625,000	1,799,000	3,105,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Aug	330,248	474,674	526,000	888,861	1,106,000	84,829	345,704	749,897	830,498	1,433,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Sep	284,380	408,747	452,862	765,325	952,403	73,047	297,690	645,744	715,151	1,234,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Oct	220,165	316,449	350,539	592,446	737,281	56,553	230,469	499,931	553,666	955,383	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Nov	227,504	326,998	362,157	612,128	761,790	58,438	238,152	516,595	572,121	987,229	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Dec	165,124	237,337	262,808	444,238	552,864	42,414	172,852	374,948	415,249	716,537	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Impacted	2018 Jan	110,083	158,225	175,173	296,126	368,544	28,276	115,235	249,966	276,833	477,691	0%	0%	0%	0%	-38300%	0%	0%	0%	0%	0%
Impacted	2018 Feb	121,877	175,177	193,907	327,820	407,996	31,306	127,581	276,748	306,493	528,873	0%	0%	0%	0%	-42400%	0%	0%	0%	0%	0%
Impacted	2018 Mar	165,124	237,337	262,666	444,096	552,722	42,414	172,852	374,948	415,249	716,537	0%	0%	0%	0%	-57500%	0%	0%	0%	0%	0%
Impacted	2018 Apr	398,132	572,246	633,201	1,071,000	1,333,000	102,266	416,765	904,042	1,001,000	1,728,000	0%	0%	0%	0%	-138700%	0%	0%	0%	0%	0%
Impacted	2018 May	1,376,000	1,978,000	2,188,000	3,700,000	4,605,000	353,454	1,440,000	3,125,000	3,460,000	5,971,000	0%	0%	0%	0%	-500000%	0%	0%	0%	0%	0%
Impacted	2018 Jun	1,536,000	2,207,000	2,441,000	4,129,000	5,139,000	394,454	1,608,000	3,487,000	3,862,000	6,664,000	0%	0%	0%	0%	-600000%	0%	0%	0%	0%	0%
Impacted	2018 Jul	715,537	1,028,000	1,137,000	1,924,000	2,394,000	183,796	749,025	1,625,000	1,799,000	3,105,000	0%	0%	0%	0%	-300000%	0%	0%	0%	0%	0%
Impacted	2018 Aug	330,248	474,674	524,850	887,710	1,105,000	84,829	345,704	749,897	830,498	1,433,000	0%	0%	0%	0%	-115000%	0%	0%	0%	0%	0%
Impacted	2018 Sep	284,380	408,747	451,871	764,335	951,413	73,047	297,690	645,744	715,151	1,234,000	0%	0%	0%	0%	-99100%	0%	0%	0%	0%	0%
Impacted	2018 Oct	220,165	316,449	349,772	591,679	736,514	56,553	230,469	499,931	553,666	955,383	0%	0%	0%	0%	-76700%	0%	0%	0%	0%	0%
Impacted	2018 Nov	227,504	326,998	361,364	611,335	760,998	58,438	238,152	516,595	572,121	987,229	0%	0%	0%	0%	-79300%	0%	0%	0%	0%	0%
Impacted	2018 Dec	165,124	237,337	262,233	443,663	552,289	42,414	172,852	374,948	415,249	716,537	0%	0%	0%	0%	-57500%	0%	0%	0%	0%	0%
Impacted	2019 Jan	110,083	204,353	226,758	382,576	454,993	28,276	115,235	249,966	276,298	477,157	23%	0%	0%	4612800%	5120200%	0%	0%	0%	0%	0%
Impacted	2019 Feb	121,877	221,270	245,408	413,232	493,409	31,306	127,581	276,748	304,738	527,118	21%	0%	0%	4609300%	5107700%	0%	0%	0%	-1%	0%
Impacted	2019 Mar	165,124	283,364	313,939	527,564	636,191	42,414	172,852	374,948	411,295	712,583	15%	0%	0%	4602700%	5069800%	0%	0%	0%	-1%	-1%
Impacted	2019 Apr	398,132	617,989	683,327	1,146,000	1,407,000	102,266	416,765	904,042	987,749	1,714,000	5%	0%	0%	4574300%	4873900%	0%	0%	0%	-1%	-1%
Impacted	2019 May	1,376,000	2,022,000	2,233,000	3,733,000	4,639,000	353,454	1,440,000	3,125,000	3,400,000	5,911,000	1%	0%	0%	4400000%	4000000%	0%	0%	0%	-2%	-1%
Impacted	2019 Jun	1,536,000	2,252,000	2,486,000	4,146,000	5,156,000	394,454	1,608,000	3,487,000	3,780,000	6,582,000	0%	0%	0%	4500000%	3900000%	0%	0%	0%	-2%	-1%
Impacted	2019 Jul	715,537	1,093,000	1,208,000	2,010,000	2,480,000	183,796	749,025	1,625,000	1,754,000	3,060,000	3%	0%	0%	6500000%	6800000%	0%	0%	0%	-3%	-1%
Impacted	2019 Aug	330,248	530,013	586,005	972,799	1,190,000	84,829	345,704	749,897	806,240	1,409,000	8%	0%	0%	5533900%	6000500%	0%	0%	0%	-3%	-2%
Impacted	2019 Sep	284,380	464,561	513,722	850,908	1,038,000	73,047	297,690	645,744	691,455	1,210,000	9%	0%	0%	5581400%	6086000%	0%	0%	0%	-3%	-2%
Impacted	2019 Oct	220,165	371,436	410,920	679,325	824,160	56,553	230,469	499,931	533,147	934,864	12%	0%	0%	5498700%	6038100%	0%	0%	0%	-4%	-2%
Impacted	2019 Nov	227,504	383,622	424,328	699,829	849,492	58,438	238,152	516,595	548,674	963,781	12%	0%	0%	5662400%	6217100%	0%	0%	0%	-4%	-2%
Impacted	2019 Dec	165,124	291,797	322,982	531,923	640,549	42,414	172,852	374,948	396,601	697,889	16%	0%	0%	5446000%	6017400%	0%	0%	0%	-4%	-3%
Impacted	2020 Jan	110,083	209,084	231,727	382,729	455,147	28,276	115,235	249,966	263,866	464,725	23%	0%	0%	5085900%	5617100%	0%	0%	0%	-5%	-3%
Impacted	2020 Feb	117,675	218,563	242,192	401,807	479,218	30,226	123,182	267,205	282,064	496,775	22%	0%	66%	4942659%	5456207%	0%	0%	0%	-5%	-3%
Impacted	2020 Mar	165,124	286,025	316,639	527,585	636,211	42,414	172,852	374,948	395,800	697,087	15%	0%	0%	4868800%	5339800%	0%	0%	0%	-5%	-3%
Impacted	2020 Apr	398,132	620,619	685,869	1,149,000	1,410,000	102,266	416,765	904,042	954,317	1,681,000	6%	0%	0%	4837300%	5128100%	0%	0%	0%	-5%	-3%
Impacted	2020 May	1,376,000	2,020,000	2,230,000	3,757,000	4,662,000	353,454	1,440,000	3,125,000	3,298,000	5,809,000	1%	0%	0%	4200000%	3700000%	0%	0%	0%	-5%	-3%
Impacted	2020 Jun	1,536,000	2,232,000	2,464,000	4,177,000	5,188,000	394,454	1,608,000	3,487,000	3,681,000	6,483,000	1%	0%	0%	2500000%	1700000%	0%	0%	0%	-5%	-3%
Impacted	2020 Jul	715,537	1,055,000	1,166,000	1,988,000	2,459,000	183,796	749,025	1,625,000	1,715,000	3,021,000	3%	0%	0%	2700000%	2600000%	0%	0%	0%	-5%	-3%
Impacted	2020 Aug	330,248	507,405	561,185	961,934	1,179,000	84,829	345,704	749,897	791,599	1,394,000	7%	0%	0%	3273100%	3518500%	0%	0%	0%	-5%	-3%
Impacted	2020 Sep	284,380	440,806	487,735	840,641	1,028,000	73,047	297,690	645,744	681,655	1,201,000	8%	0%	0%	3205900%	3487300%	0%	0%	0%	-5%	-3%
Impacted	2020 Oct	220,165	349,727	387,228	670,671	815,506	56,553	230,469	499,931	527,733	929,450	11%	0%	0%	3327800%	3668900%	0%	0%	0%	-5%	-3%
Impacted	2020 Nov	227,504	357,760	396,153	690,158	839,820	58,438	238,152	516,595	545,324	960,432	10%	0%	0%	3076200%	3399600%	0%	0%	0%	-5%	-3%
Impacted	2020 Dec	165,124	270,537	299,853	524,375	633,001	42,414	172,852	374,948	395,800	697,087	14%	0%	0%	3320000%	3704500%	0%	0%	0%	-5%	-3%
Impacted	2021 Jan	110,083	195,130	216,543	378,352	450,770	28,276	115,227	249,935	263,836	464,694	22%	0%	0%	3690500%	4098700%	0%	0%	0%	-5%	-3%
Impacted	2021 Feb	121,877	211,040	234,060	409,200	489,376	31,306	127,557	276,651	292,041	514,420	20%	0%	0%	3586300%	3972900%	0%	0%	0%	-5%	-3%
Impacted	2021 Mar	165,124	269,374	298,395	522,774	631,400	42,414	172,797	374,732	395,584	696,871	14%	0%	0%	3203700%	3515400%	0%	0%	0%	-5%	-3%
Impacted	2021 Apr	398,132	585,091	646,729	1,138,000	1,400,000	102,266	416,580	903,309	953,584	1,680,000	5%	0%	0%	1284500%	1214100%	0%	0%	0%	-5%	-3%
Impacted	2021 May	1,376,000	1,913,000	2,111,000	3,723,000	4,628,000	353,454	1,440,000	3,121,000	3,295,000	5,806,000	0%	0%	0%	-6500000%	-8200000%	0%	0%	0%	-5%	-3%
Impacted	2021 Jun	1,536,000	2,345,000	2,542,000	4,165,000	5,176,000	394,454	1,606,000	3,483,000	3,676,000	6,478,000	1%	0%	0%	13800000%	9500000%	0%	0%	0%	-5%	-3%
Impacted	2021 Jul	715,537	1,116,000	1,211,000	1,986,000	2,457,000	183,796	748,402	1,622,000	1,713,000	3,018,000	3%	0%	0%	8800000%	7100000%	0%	0%	0%	-5%	-3%
Impacted	2021 Aug	330,248	539,318	586,005	962,761	1,180,000	84,829	345,371	748,583	790,286	1,393,000	7%	0%	0%	6464400%	6000500%	0%	0%	0%	-5%	-3%
Impacted	2021 Sep	284,380	471,894	512,850	842,161	1,029,000	73,047	297,365	644,462	680,373	1,199,000	8%	0%	0%	6314700%	5998800%	0%	0%	0%	-5%	-3%
Impacted	2021 Oct	220,165	376,587	409,569	672,472	817,366	56,553	230,188	498,821	526,623	928,340	11%	0%	0%	6013800%	5903000%	0%	0%	0%	-5%	-3%
Impacted	2021 Nov	227,504	388,385	422,225	692,700	842,424	58,438	237,830	515,328	544,056	959,164	11%	0%	0%	6138700%	6006800%	0%	0%	0%	-5%	-3%
Impacted	2021 Dec	165,124	294,777	320,906	526,882	635,552	42,414	172,596	373,940	394,792	696,079	15%	0%	0%	5744000%	5809800%	0%	0%	0%	-5%	-3%
Impacted	2022 Jan	110,083	158,143	170,672	278,591	351,038	28,276	115,049	249,234	263,135	463,993	-5%	0%	0%	-8200%	-488400%	0%	0%	0%	-5%	-3%
Impacted	2022 Feb	121,877	191,578	207,518	339,621	419,830	31,306	127,360	275,875	291,265	513,644	3%	0%	0%	1640100%	1318700%	0%	0%	0%	-5%	-3%
Impacted	2022 Mar	165,124	294,673	320,703	526,647	635,317	42,414	172,531	373,681	394,532	695,820	15%	0%	0%	5733600%	5746200%	0%	0%	0%	-5%	-3%
Impacted	2022 Apr	398,132	646,424	700,859	1,148,000	1,410,000	102,266	415,937	900,775	951,049	1,677,000	6%	0%	0%	7417800%	6627100%	0%	0%	0%	-5%	-3%
Impacted	2022 May	1,376,000	2,126,000	2,300,000	3,757,000	4,663,000	353,454	1,437,000	3,113,000	3,286,000	5,797,000	1%	0%	0%	14800000%	10700000%	0%	0%	0%	-5%	-3%
Impacted	2022 Jun	1,536,000	2,369,000	2,562,000	4,184,000	5,195,000	394,454	1,604,000	3,473,000	3,667,000	6,469,000	1%	0%	0%	16200000%	11500000%	0%	0%	0%	-5%	-3%
Impacted	2022 Jul	715,537	1,128,000	1,221,000	1,995,000	2,466,000	183,796	747,247	1,618,000	1,708,000	3,014,000	3%	0%	0%	10000000%	8100000%	0%	0%	0%	-5%	-3%
Impacted	2022 Aug	330,248	544,721	590,598	967,956	1,185,000	84,829	344,838	746,480	788,183	1,391,000	7%	0%	0%	7004700%	6459800%	0%	0%	0%	-5%	-3%
Impacted	2022 Sep	284,380	476,546	516,805	847,272	1,034,000	73,047	296,906	642,651	678,562	1,197,000	9%	0%	0%	6779900%	6394300%	0%	0%	0%	-5%	-3%
Impacted	2022 Oct	220,165	380,189	412,632	676,446	821,339	56,553	229,833	497,419	525,221	926,938	11%	0%	0%	6374000%	6209300%	0%	0%	-1%	-5%	-3%
Impacted	2022 Nov	227,504	392,107	425,390	696,824	846,547	58,438	237,463	513,879	542,608	957,715	11%	0%	0%	6510900%	6323300%	0%	0%	-1%	-5%	-3%
Impacted	2022 Dec	165,124	297,478	323,203	529,887	638,557	42,414	172,330	372,889	393,740	695,028	15%	0%	0%	6014100%	6039500%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jan	110,083	157,344	169,274	275,469	347,915	28,276	114,871	248,533	262,433	463,292	-6%	0%	0%	-88100%	-628200%	0%	0%	-1%	-5%	-3%
Impacted	2023 Feb	121,877	173,944	187,099	304,507	384,716	31,306	127,163	275,098	290,489	512,868	-6%	0%	0%	-123300%	-723200%	0%	0%	-1%	-5%	-3%
Impacted	2023 Mar	165,124	250,215	269,868	440,270	548,941	42,414	172,264	372,629	393,480	694,768	-1%	0%	0%	1287800%	662700%	0%	0%	-1%	-5%	-3%
Impacted	2023 Apr	398,132	652,939	706,398	1,155,000	1,417,000	102,266	415,294	898,239	948,514	1,675,000	6%	0%	0%	8069300%	7181000%	0%	0%	-1%	-5%	-3%
Impacted	2023 May	1,376,000	2,143,000	2,313,000	3,772,000	4,678,000	353,454	1,435,000	3,104,000	3,278,000	5,788,000	1%	0%	0%	16500000%	12000000%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jun	1,536,000	2,359,000	2,543,000	4,144,000	5,155,000	394,454	1,601,000	3,463,000	3,657,000	6,459,000	0%	0%	0%	15200000%	9600000%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jul	715,537	1,144,000	1,236,000	2,017,000	2,488,000	183,796	746,092	1,613,000	1,704,000	3,009,000	4%	0%	0%	11600000%	9600000%	0%	0%	-1%	-5%	-3%
Impacted	2023 Aug	330,248	552,122	597,443	976,850	1,194,000	84,829	344,305	744,377	786,080	1,389,000	8%	0%	0%	7744800%	7144300%	0%	0%	-1%	-5%	-3%
Impacted	2023 Sep	284,380	483,012	522,804	854,462	1,042,000	73,047	296,447	640,840	676,751	1,196,000	9%	0%	0%	7426500%	6994200%	0%	0%	-1%	-5%	-3%
Impacted	2023 Oct	220,165	385,268	417,357	682,093	826,986	56,553	229,477	496,017	523,819	925,536	12%	0%	0%	6881900%	6681800%	0%	0%	-1%	-5%	-3%
Impacted	2023 Nov	227,504	397,419	430,346	702,790	852,514	58,438	237,096	512,430	541,158	956,266	12%	0%	0%	7042100%	6818900%	0%	0%	-1%	-5%	-3%
Impacted	2023 Dec	165,124	299,534	324,773	530,753	639,423	42,414	172,063	371,837	392,688	693,976	16%	0%	0%	6219700%	6196500%	0%	0%	-1%	-5%	-3%
Impacted	2024 Jan	110,083	171,242	184,465	299,640	372,087	28,276	114,693	247,814	261,715	462,573	1%	0%	0%	1301700%	890900%	0%	0%	-1%	-5%	-3%
Impacted	2024 Feb	117,675	227,536	247,340	404,813	482,256	30,226	122,587	264,807	279,667	494,378	22%	0%	66%	5839959%	5971007%	0%	0%	-1%	-5%	-3%
Impacted	2024 Mar	165,124	300,024	325,446	532,273	640,944	42,414	171,993	371,447	392,299	693,586	16%	0%	0%	6268700%	6220500%	0%	0%	-1%	-6%	-3%
Impacted	2024 Apr	398,132	658,323	711,368	1,162,000	1,424,000	102,266	414,638	895,265	945,540	1,672,000	7%	0%	0%	8607700%	7678000%	0%	-1%	-1%	-6%	-3%
Impacted	2024 May	1,376,000	2,164,000	2,333,000	3,808,000	4,714,000	353,454	1,433,000	3,093,000	3,267,000	5,778,000	2%	0%	0%	18600000%	14000000%	0%	0%	-1%	-6%	-3%
Impacted	2024 Jun	1,536,000	2,408,000	2,596,000	4,239,000	5,249,000	394,454	1,599,000	3,451,000	3,644,000	6,446,000	2%	0%	0%	20100000%	14900000%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jul	715,537	1,144,000	1,234,000	2,018,000	2,489,000	183,796	744,892	1,607,000	1,698,000	3,003,000	4%	0%	0%	11600000%	9400000%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Aug	330,248	550,861	595,790	976,474	1,194,000	84,829	343,748	741,497	783,200	1,386,000	8%	0%	0%	7618700%	6979000%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Sep	284,380	481,161	520,663	853,544	1,041,000	73,047	295,964	638,272	674,182	1,193,000	9%	0%	0%	7241400%	6780100%	0%	-1%	-1%	-6%	-3%

		Runoff coefficient 0.51																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2024 Oct	220,165	383,241	415,143	680,857	825,751	56,553	229,102	493,960	521,762	923,479	12%	0%	0%	6679200%	6460400%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Nov	227,504	394,713	427,484	701,127	850,850	58,438	236,706	510,234	538,962	954,070	12%	0%	0%	6771500%	6532700%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Dec	165,124	298,926	324,307	532,489	641,159	42,414	171,779	370,192	391,043	692,331	16%	0%	0%	6158900%	6149900%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jan	110,083	214,416	233,279	384,337	456,783	28,276	114,503	246,700	260,600	461,459	24%	0%	0%	5619100%	5772300%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Feb	121,877	232,077	252,328	415,894	496,103	31,306	126,754	273,032	288,423	510,802	21%	0%	0%	5690000%	5799700%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Mar	165,124	297,405	322,755	531,958	640,629	42,414	171,709	369,780	390,631	691,919	16%	0%	0%	6006800%	5951400%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Apr	398,132	652,007	704,880	1,160,000	1,422,000	102,266	413,952	891,246	941,521	1,668,000	7%	0%	0%	7976100%	7029200%	0%	-1%	-1%	-6%	-3%
Impacted	2025 May	1,376,000	2,142,000	2,311,000	3,799,000	4,704,000	353,454	1,431,000	3,079,000	3,253,000	5,764,000	2%	0%	0%	16400000%	11800000%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jun	1,536,000	2,383,000	2,570,000	4,228,000	5,239,000	394,454	1,596,000	3,435,000	3,629,000	6,431,000	2%	0%	0%	17600000%	12300000%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jul	715,537	1,132,000	1,222,000	2,014,000	2,485,000	183,796	743,659	1,600,000	1,690,000	2,996,000	4%	0%	0%	10400000%	8200000%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Aug	330,248	545,621	590,407	974,809	1,192,000	84,829	343,179	738,163	779,866	1,382,000	8%	0%	0%	7094700%	6440700%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Sep	284,380	476,649	516,028	852,211	1,039,000	73,047	295,474	635,401	671,311	1,190,000	9%	0%	0%	6790200%	6316600%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Oct	220,165	379,748	411,555	679,991	824,885	56,553	228,723	491,737	519,539	921,256	12%	0%	0%	6329900%	6101600%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Nov	227,504	391,103	423,776	700,207	849,931	58,438	236,314	507,937	536,665	951,773	12%	0%	0%	6410500%	6161900%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Dec	165,124	296,306	321,616	532,022	640,692	42,414	171,494	368,524	389,376	690,663	16%	0%	0%	5896900%	5880800%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jan	110,083	212,670	231,486	383,639	456,086	28,276	114,314	245,589	259,489	460,348	24%	0%	0%	5444500%	5593000%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Feb	121,877	230,144	250,342	415,092	495,301	31,306	126,544	271,802	287,192	509,572	21%	0%	0%	5496700%	5601100%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Mar	165,124	294,785	320,065	530,842	639,512	42,414	171,424	368,113	388,965	690,253	16%	0%	0%	5744800%	5682400%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Apr	398,132	645,692	698,393	1,157,000	1,419,000	102,266	413,266	887,227	937,502	1,664,000	6%	0%	0%	7344600%	6380500%	0%	-1%	-2%	-6%	-4%
Impacted	2026 May	1,376,000	2,121,000	2,288,000	3,789,000	4,695,000	353,454	1,428,000	3,065,000	3,239,000	5,750,000	2%	0%	0%	14300000%	9500000%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jun	1,536,000	2,359,000	2,545,000	4,217,000	5,228,000	394,454	1,594,000	3,420,000	3,613,000	6,415,000	2%	0%	0%	15200000%	9800000%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jul	715,537	1,121,000	1,211,000	2,009,000	2,480,000	183,796	742,427	1,593,000	1,683,000	2,989,000	3%	0%	0%	9300000%	7100000%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Aug	330,248	540,383	585,027	972,492	1,190,000	84,829	342,610	734,830	776,532	1,379,000	8%	0%	0%	6570900%	5902700%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Sep	284,380	472,138	511,394	850,229	1,037,000	73,047	294,984	632,530	668,441	1,187,000	9%	0%	0%	6339100%	5853200%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Oct	220,165	376,256	407,968	678,475	823,369	56,553	228,343	489,515	517,317	919,034	12%	0%	0%	5980700%	5742900%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Nov	227,504	387,494	420,069	698,638	848,362	58,438	235,922	505,640	534,369	949,476	11%	0%	0%	6049600%	5791200%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Dec	165,124	291,568	316,539	526,900	635,571	42,414	171,210	366,858	387,709	688,997	15%	0%	0%	5423100%	5373100%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jan	110,083	146,891	157,556	261,532	333,979	28,275	114,120	244,503	258,404	459,263	-9%	0%	0%	-1133400%	-1800000%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Feb	121,877	162,249	174,056	289,172	369,381	31,303	126,323	270,653	286,044	508,423	-10%	0%	0%	-1292800%	-2027500%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Mar	165,124	219,174	235,171	391,200	499,870	42,407	171,115	366,629	387,480	688,768	-10%	0%	0%	-1816300%	-2807000%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Apr	398,132	528,305	566,875	943,336	1,205,000	102,241	412,497	883,826	934,101	1,661,000	-10%	0%	0%	-4394100%	-6771300%	0%	-1%	-2%	-7%	-4%
Impacted	2027 May	1,376,000	1,943,000	2,091,000	3,481,000	4,387,000	353,343	1,425,000	3,054,000	3,228,000	5,739,000	-5%	0%	0%	-3500000%	-10200000%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jun	1,536,000	2,340,000	2,527,000	4,212,000	5,222,000	394,303	1,590,000	3,408,000	3,602,000	6,404,000	2%	0%	0%	13300000%	8000000%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jul	715,537	1,113,000	1,203,000	2,007,000	2,478,000	183,713	740,917	1,588,000	1,678,000	2,984,000	3%	0%	0%	8500000%	6300000%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Aug	330,248	536,770	581,662	971,683	1,189,000	84,784	341,894	732,604	774,306	1,377,000	8%	0%	0%	6209600%	5566200%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Sep	284,380	469,214	508,729	849,697	1,037,000	73,004	294,351	630,741	666,652	1,186,000	9%	0%	0%	6046700%	5586700%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Oct	220,165	374,137	406,084	678,178	823,071	56,515	227,839	488,229	516,030	917,747	12%	0%	0%	5768800%	5554500%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Nov	227,504	385,454	418,308	698,496	848,219	58,395	235,388	504,413	533,142	948,249	11%	0%	0%	5845600%	5615100%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Dec	165,124	292,315	317,782	530,873	639,543	42,380	170,812	366,041	386,893	688,180	16%	0%	0%	5497800%	5497400%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jan	110,083	210,083	229,021	382,921	455,368	28,252	113,852	243,983	257,884	458,743	23%	0%	0%	5185800%	5346500%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Feb	117,675	221,108	240,960	403,100	480,543	30,198	121,680	260,764	275,624	490,335	22%	0%	66%	5197159%	5333007%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Mar	165,124	291,112	316,626	530,036	638,706	42,371	170,712	365,847	386,698	687,986	15%	0%	0%	5377500%	5338500%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Apr	398,132	637,097	690,428	1,156,000	1,418,000	102,155	411,525	881,941	932,216	1,659,000	6%	0%	0%	6485100%	5584000%	0%	-1%	-2%	-7%	-4%
Impacted	2028 May	1,376,000	2,092,000	2,262,000	3,785,000	4,691,000	353,046	1,422,000	3,048,000	3,221,000	5,732,000	2%	0%	0%	11400000%	6900000%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jun	1,536,000	2,328,000	2,517,000	4,214,000	5,224,000	393,972	1,587,000	3,401,000	3,594,000	6,396,000	2%	0%	0%	12100000%	7000000%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jul	715,537	1,107,000	1,198,000	2,008,000	2,479,000	183,558	739,170	1,584,000	1,675,000	2,980,000	3%	0%	0%	7900000%	5800000%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Aug	330,248	534,126	579,503	972,175	1,190,000	84,713	341,087	731,040	772,742	1,375,000	8%	0%	0%	5945200%	5350300%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Sep	284,380	466,939	506,871	850,140	1,037,000	72,942	293,656	629,395	665,305	1,184,000	9%	0%	0%	5819200%	5400900%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Oct	220,165	372,375	404,646	678,538	823,431	56,467	227,302	487,186	514,988	916,705	12%	0%	0%	5592600%	5410700%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Nov	227,504	383,634	416,822	698,869	848,592	58,346	234,832	503,336	532,065	947,172	11%	0%	0%	5663600%	5466500%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Dec	165,124	290,993	316,703	531,163	639,833	42,345	170,409	365,259	386,111	687,398	16%	0%	0%	5365600%	5389500%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Jan	110,083	209,202	228,302	382,787	455,234	28,228	113,583	243,462	257,363	458,221	23%	0%	0%	5097700%	5274600%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Feb	121,877	226,382	246,914	414,269	494,478	31,250	125,729	269,501	284,891	507,270	21%	0%	0%	5120500%	5258300%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Mar	165,124	289,794	315,550	529,980	638,650	42,336	170,310	365,067	385,918	687,206	15%	0%	0%	5245700%	5230900%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Apr	398,132	633,920	687,834	1,156,000	1,418,000	102,069	410,555	880,061	930,336	1,657,000	6%	0%	0%	6167400%	5324600%	0%	-1%	-3%	-7%	-4%
Impacted	2029 May	1,376,000	2,081,000	2,253,000	3,786,000	4,692,000	352,750	1,419,000	3,041,000	3,215,000	5,726,000	2%	0%	0%	10300000%	6000000%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Jun	1,536,000	2,316,000	2,507,000	4,215,000	5,226,000	393,641	1,583,000	3,393,000	3,587,000	6,389,000	2%	0%	0%	10900000%	6000000%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jul	715,537	1,102,000	1,195,000	2,010,000	2,481,000	183,404	737,427	1,581,000	1,671,000	2,977,000	4%	0%	0%	7400000%	5500000%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Aug	330,248	540,391	587,275	988,426	1,206,000	84,642	340,282	729,480	771,183	1,374,000	9%	0%	0%	6571700%	6127500%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Sep	284,380	470,801	511,856	861,330	1,048,000	72,881	292,963	628,051	663,961	1,183,000	10%	0%	0%	6205400%	5899400%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Oct	220,165	372,862	405,713	682,619	827,513	56,420	226,765	486,146	513,948	915,665	12%	0%	0%	5641300%	5517400%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Nov	227,504	384,216	418,013	703,221	852,945	58,297	234,278	502,262	530,990	946,098	12%	0%	0%	5721800%	5585600%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Dec	165,124	289,676	315,627	531,103	639,774	42,309	170,007	364,480	385,331	686,619	16%	0%	0%	5233900%	5281900%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jan	110,083	208,324	227,585	383,311	455,758	28,204	113,315	242,942	256,843	457,702	24%	0%	0%	5009900%	5202900%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Feb	121,877	225,410	246,119	414,820	495,029	31,224	125,432	268,925	284,315	506,695	21%	0%	0%	5023300%	5178800%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Mar	165,124	288,476	314,474	530,581	639,251	42,300	169,908	364,288	385,139	686,427	16%	0%	0%	5113900%	5123300%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Apr	398,132	630,742	685,238	1,157,000	1,419,000	101,984	409,586	878,181	928,455	1,655,000	6%	0%	0%	5849600%	5065000%	0%	-2%	-3%	-7%	-4%
Impacted	2030 May	1,376,000	2,122,000	2,302,000	3,883,000	4,788,000	352,453	1,415,000	3,035,000	3,208,000	5,719,000	4%	0%	0%	14400000%	10900000%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jun	1,536,000	2,393,000	2,597,000	4,380,000	5,390,000	393,310	1,579,000	3,386,000	3,580,000	6,382,000	5%	0%	0%	18600000%	15000000%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jul	715,537	1,126,000	1,223,000	2,066,000	2,537,000	183,250	735,684	1,577,000	1,668,000	2,973,000	6%	0%	0%	9800000%	8300000%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Aug	330,248	532,746	579,537	980,176	1,198,000	84,571	339,478	727,920	769,623	1,372,000	8%	0%	0%	5807200%	5353700%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Sep	284,380	462,792	503,601	851,695	1,039,000	72,820	292,271	626,708	662,619	1,182,000	9%	0%	0%	5404500%	5073900%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Oct	220,165	368,861	401,776	679,221	824,114	56,373	226,229	485,107	512,909	914,626	12%	0%	0%	5241200%	5123700%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Nov	227,504	380,003	413,856	699,570	849,294	58,248	233,724	501,187	529,916	945,023	11%	0%	0%	5300500%	5169900%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Dec	165,124	288,358	314,551	531,706	640,377	42,273	169,605	363,700	384,551	685,839	16%	0%	0%	5102100%	5174300%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Jan	110,083	207,439	226,861	383,462	455,909	28,174	113,013	242,393	256,293	457,152	24%	0%	0%	4921400%	5130500%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Feb	121,877	224,418	245,306	414,977	495,186	31,178	125,029	268,257	283,647	506,026	21%	0%	0%	4924100%	5097500%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Mar	165,124	287,115	313,356	530,795	639,465	42,221	169,269	363,301	384,152	685,440	16%	0%	0%	4977800%	5011500%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Apr	398,132	627,417	682,504	1,157,000	1,419,000	101,749	407,817	875,599	925,874	1,652,000	6%	0%	0%	5517100%	4791600%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 May	1,376,000	2,065,000	2,242,000	3,803,000	4,708,000	351,497	1,408,000	3,025,000	3,199,000	5,710,000	2%	0%	0%	8700000%	4900000%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Jun	1,536,000	2,381,000	2,587,000	4,384,000	5,395,000	392,077	1,571,000	3,375,000	3,568,000	6,370,000	5%	0%	0%	17400000%	14000000%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Jul	715,537	1,115,000	1,213,000	2,058,000	2,529,000	182,598	731,262	1,572,000	1,662,000	2,968,000	6%	0%	0%	8700000%	7300000%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Aug	330,248	525,964	572,804	973,592	1,191,000	84,234	337,242	725,106	766,808	1,369,000	8%	0%	0%	5129000%	4680400%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Sep	284,380	459,888	501,083	851,401	1,039,000	72,499	290,181	624,140	660,051	1,179,000	9%	0%	0%	5114100%	4822100%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Oct	220,165	366,900	400,150	679,560	824,454	56,101	224,484	483,006	510,808	912,525	12%	0%	0%	5045100%	4961100%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Nov	227,504	377,959	412,161	699,937	849,660	57,942	231,788	498,901	527,630	942,737	12%	0%	0%	5096100%	5000400%	-1%	-3%	-3%	-8%	-5%
Impacted	2031 Dec	165,124	286,863	313,311	531,984	640,654	42,034	168,106	361,958	382,809	684,097	16%	0%	0%	4952600%	5050300%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Jan	110,083	206,441	226,033	383,654	456,101	28,009	111,983	241,205	255,105	455,964	24%	0%	0%	4821600%	5047700%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Feb	117,675	217,205	237,758	403,889	481,332	29,926	119,615	257,735	272,594	487,305	22%	0%	66%	4806859%	5012807%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Mar	165,124	285,623	312,122	531,103	639,773	41,972	167,720	361,514	382,365	683,653	16%	0%	0%	4828600%	4888100%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Apr	398,132	623,832	679,542	1,158,000	1,420,000	101,150	404,080	871,290	921,565	1,648,000	6%	0%	0%	5158600%	4495400%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 May	1,376,000	2,035,000	2,212,000	3,773,000	4,678,000	349,424	1,396,000	3,010,000	3,184,000	5,695,000	1%	0%	0%	5700000%	1900000%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Jun	1,536,000	1,891,000	2,040,000	3,486,000	4,496,000	389,764	1,556,000	3,358,000	3,552,000	6,354,000	-13%	0%	0%	-31600000%	-40700000%	-1%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2032 Jul	715,537	876,891	946,165	1,620,000	2,091,000	181,520	724,540	1,564,000	1,654,000	2,960,000	-13%	0%	0%	-15110900%	-19383500%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Aug	330,248	401,692	433,664	744,647	961,987	83,736	334,141	721,529	763,231	1,366,000	-13%	0%	0%	-7298200%	-9233600%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Sep	284,380	345,903	373,435	641,224	828,378	72,071	287,512	621,063	656,973	1,176,000	-13%	0%	0%	-6284400%	-7942700%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Oct	220,165	267,933	289,249	496,567	641,461	55,769	222,418	480,624	508,426	910,143	-13%	0%	0%	-4851600%	-6129000%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Nov	227,504	276,932	298,957	513,185	662,908	57,600	229,654	496,439	525,168	940,276	-13%	0%	0%	-5006600%	-6320000%	-1%	-4%	-4%	-8%	-5%
Impacted	2032 Dec	165,124	200,711	216,697	372,184	480,854	41,786	166,555	360,170	381,021	682,309	-13%	0%	0%	-3662600%	-4611100%	-1%	-4%	-4%	-8%	-5%
Impacted	2033 Jan	110,083	133,520	144,177	247,834	320,281	27,843	110,949	240,012	253,913	454,772	-13%	0%	0%	-2470500%	-3137900%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Feb	121,877	147,429	159,228	273,991	354,200	30,811	122,744	265,622	281,012	503,391	-13%	0%	0%	-2774800%	-3510300%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Mar	165,124	199,073	215,059	370,543	479,213	41,724	166,174	359,730	380,582	681,869	-13%	0%	0%	-3826400%	-4818200%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Apr	398,132	607,803	662,558	1,135,000	1,397,000	100,552	400,352	866,990	917,265	1,644,000	5%	0%	0%	3555700%	2797000%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 May	1,376,000	2,102,000	2,291,000	3,920,000	4,826,000	347,358	1,383,000	2,995,000	3,169,000	5,680,000	5%	0%	0%	12400000%	9800000%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jun	1,536,000	2,384,000	2,599,000	4,446,000	5,456,000	387,458	1,542,000	3,341,000	3,535,000	6,337,000	6%	0%	0%	17700000%	15200000%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jul	715,537	1,122,000	1,224,000	2,097,000	2,568,000	180,446	717,842	1,556,000	1,647,000	2,952,000	7%	0%	0%	9400000%	8400000%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Aug	330,248	530,670	579,770	994,147	1,211,000	83,241	331,050	717,963	759,666	1,362,000	9%	0%	0%	5599600%	5377000%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Sep	284,380	460,546	503,295	862,953	1,050,000	71,644	284,849	617,991	653,901	1,173,000	10%	0%	0%	5179900%	5043300%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Oct	220,165	363,109	397,068	680,717	825,611	55,439	220,356	478,246	506,048	907,765	12%	0%	0%	4666000%	4652900%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Nov	227,504	374,868	409,898	702,629	852,352	57,258	227,523	493,982	522,711	937,818	12%	0%	0%	4787000%	4774100%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Dec	165,124	283,926	310,894	532,683	641,353	41,538	165,009	358,387	379,238	680,526	16%	0%	0%	4658900%	4808600%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Jan	110,083	204,509	224,441	384,097	456,544	27,680	109,920	238,832	252,733	453,591	24%	0%	0%	4628400%	4888500%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Feb	121,877	221,232	242,672	415,639	495,848	30,636	121,609	264,333	279,723	502,102	21%	0%	0%	4605500%	4834100%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Mar	165,124	282,878	309,847	531,637	640,307	41,494	164,640	358,008	378,859	680,147	16%	0%	0%	4554100%	4660600%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Apr	398,132	633,663	692,327	1,189,000	1,451,000	100,013	396,663	862,895	913,170	1,640,000	9%	0%	0%	6141700%	5773900%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 May	1,376,000	2,143,000	2,339,000	4,012,000	4,918,000	345,551	1,370,000	2,981,000	3,155,000	5,666,000	7%	0%	0%	16500000%	14600000%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jun	1,536,000	2,388,000	2,606,000	4,470,000	5,480,000	385,508	1,528,000	3,326,000	3,520,000	6,322,000	7%	0%	0%	18100000%	15900000%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jul	715,537	1,128,000	1,231,000	2,114,000	2,585,000	179,568	711,282	1,549,000	1,640,000	2,945,000	8%	0%	0%	10000000%	9100000%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Aug	330,248	536,216	586,375	1,007,000	1,224,000	82,850	328,032	714,769	756,471	1,359,000	11%	0%	0%	6154200%	6037500%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Sep	284,380	467,719	511,609	878,141	1,065,000	71,319	282,258	615,281	651,192	1,170,000	12%	0%	0%	5897200%	5874700%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Oct	220,165	369,392	404,279	693,528	838,421	55,196	218,356	476,181	503,982	905,699	14%	0%	0%	5294300%	5374000%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Nov	227,504	381,192	417,120	715,280	865,004	57,017	225,464	491,882	520,611	935,718	14%	0%	0%	5419400%	5496300%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Dec	165,124	285,705	312,973	536,574	645,245	41,370	163,519	356,887	377,738	679,026	17%	0%	0%	4836800%	5016500%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Jan	110,083	204,361	224,330	384,211	456,658	27,571	108,929	237,841	251,742	452,601	24%	0%	0%	4613600%	4877400%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Feb	121,877	221,095	242,580	415,816	496,025	30,515	120,511	263,235	278,626	501,005	21%	0%	0%	4591800%	4824900%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Mar	165,124	282,730	309,764	531,948	640,618	41,329	163,153	356,521	377,373	678,661	16%	0%	0%	4539300%	4652300%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Apr	398,132	638,891	698,357	1,200,000	1,462,000	99,617	393,080	859,312	909,587	1,636,000	10%	0%	0%	6664500%	6376900%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 May	1,376,000	2,142,000	2,339,000	4,015,000	4,921,000	344,183	1,358,000	2,969,000	3,143,000	5,653,000	7%	0%	0%	16400000%	14600000%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jun	1,536,000	2,387,000	2,605,000	4,474,000	5,484,000	383,981	1,514,000	3,312,000	3,506,000	6,308,000	7%	0%	0%	18000000%	15800000%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jul	715,537	1,127,000	1,231,000	2,115,000	2,586,000	178,856	704,843	1,543,000	1,633,000	2,939,000	8%	0%	0%	9900000%	9100000%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Aug	330,248	536,813	587,207	1,009,000	1,227,000	82,521	325,060	711,796	753,498	1,356,000	11%	0%	0%	6213900%	6120700%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Sep	284,380	467,112	511,074	878,046	1,065,000	71,036	279,698	612,721	648,632	1,168,000	12%	0%	0%	5836500%	5821200%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Oct	220,165	369,180	404,153	693,921	838,815	54,977	216,375	474,199	502,001	903,718	14%	0%	0%	5273100%	5361400%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Nov	227,504	381,438	417,509	716,530	866,253	56,791	223,416	489,835	518,563	933,671	14%	0%	0%	5444000%	5535200%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Dec	165,124	285,456	312,779	536,707	645,377	41,206	162,033	355,401	376,252	677,540	17%	0%	0%	4811900%	4997100%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Jan	110,083	204,300	224,318	384,489	456,936	27,461	107,938	236,850	250,751	451,610	24%	0%	0%	4607500%	4876200%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Feb	117,675	214,997	235,994	404,785	482,228	29,345	115,295	253,098	267,957	482,668	22%	0%	66%	4586059%	4836407%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Mar	165,124	282,638	309,744	532,366	641,036	41,165	161,663	355,031	375,882	677,170	16%	0%	0%	4530100%	4650300%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Apr	398,132	631,508	690,324	1,188,000	1,450,000	99,220	389,486	855,718	905,993	1,632,000	9%	0%	0%	5926200%	5573600%	-3%	-7%	-5%	-9%	-6%
Impacted	2036 May	1,376,000	2,140,000	2,337,000	4,016,000	4,921,000	342,811	1,345,000	2,957,000	3,130,000	5,641,000	7%	0%	0%	16200000%	14400000%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Jun	1,536,000	2,384,000	2,603,000	4,474,000	5,485,000	382,450	1,500,000	3,298,000	3,492,000	6,294,000	7%	0%	0%	17700000%	15600000%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Jul	715,537	1,125,000	1,230,000	2,115,000	2,585,000	178,143	698,383	1,536,000	1,627,000	2,932,000	8%	0%	0%	9700000%	9000000%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Aug	330,248	534,618	584,926	1,007,000	1,224,000	82,192	322,078	708,814	750,517	1,353,000	11%	0%	0%	5994400%	5892600%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Sep	284,380	464,895	508,745	875,040	1,062,000	70,753	277,131	610,154	646,065	1,165,000	12%	0%	0%	5614800%	5588300%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Oct	220,165	368,180	403,149	692,891	837,784	54,758	214,387	472,211	500,013	901,730	14%	0%	0%	5173100%	5261000%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Nov	227,504	379,509	415,472	713,843	863,567	56,564	221,363	487,781	516,510	931,617	13%	0%	0%	5251100%	5331500%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Dec	165,124	283,443	310,618	533,648	642,319	41,041	160,543	353,911	374,762	676,050	16%	0%	0%	4610600%	4781000%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jan	110,083	204,238	224,305	384,768	457,215	27,351	106,945	235,857	249,757	450,616	24%	0%	0%	4601300%	4874900%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Feb	121,877	220,960	242,551	416,433	496,642	30,272	118,314	261,038	276,429	498,808	22%	0%	0%	4578300%	4822000%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Mar	165,124	282,546	309,725	532,783	641,454	41,001	160,177	353,545	374,396	675,684	16%	0%	0%	4520900%	4648400%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Apr	398,132	630,247	689,118	1,187,000	1,449,000	98,824	385,902	852,134	902,409	1,629,000	9%	0%	0%	5800100%	5453000%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 May	1,376,000	2,139,000	2,336,000	4,018,000	4,924,000	341,443	1,333,000	2,944,000	3,118,000	5,629,000	7%	0%	0%	16100000%	14300000%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jun	1,536,000	2,384,000	2,603,000	4,479,000	5,490,000	380,923	1,486,000	3,284,000	3,478,000	6,280,000	7%	0%	0%	17700000%	15600000%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Jul	715,537	1,124,000	1,229,000	2,115,000	2,586,000	177,432	691,945	1,530,000	1,620,000	2,926,000	8%	0%	0%	9600000%	8900000%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Aug	330,248	533,999	584,402	1,007,000	1,224,000	81,864	319,107	705,843	747,546	1,350,000	11%	0%	0%	5932500%	5840200%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Sep	284,380	464,805	508,787	875,881	1,063,000	70,470	274,573	607,596	643,506	1,162,000	12%	0%	0%	5605800%	5592500%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Oct	220,165	367,282	402,258	692,042	836,936	54,539	212,407	470,231	498,033	899,750	14%	0%	0%	5083300%	5171900%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Nov	227,504	379,041	415,065	713,799	863,523	56,338	219,316	485,734	514,993	930,100	13%	0%	0%	5204300%	5290800%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Dec	165,124	283,418	310,672	534,186	642,856	40,877	159,057	352,425	373,911	675,199	16%	0%	0%	4608100%	4786400%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jan	110,083	151,266	164,574	284,226	356,673	27,242	105,953	234,866	249,189	450,048	-3%	0%	0%	-695900%	-1098200%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Feb	121,877	165,756	180,294	311,585	391,794	30,151	117,217	259,941	275,799	498,178	-4%	0%	0%	-942100%	-1403700%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Mar	165,124	227,299	247,394	427,673	536,343	40,836	158,690	352,058	373,543	674,831	-3%	0%	0%	-1003800%	-1584700%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Apr	398,132	545,994	594,125	1,027,000	1,289,000	98,428	382,320	848,552	900,353	1,627,000	-3%	0%	0%	-2625200%	-4046300%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 May	1,376,000	1,899,000	2,067,000	3,569,000	4,475,000	340,075	1,320,000	2,932,000	3,111,000	5,622,000	-3%	0%	0%	-7900000%	-12600000%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jun	1,536,000	2,109,000	2,295,000	3,964,000	4,974,000	379,396	1,472,000	3,271,000	3,470,000	6,272,000	-3%	0%	0%	-9800000%	-15200000%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jul	715,537	985,163	1,072,000	1,853,000	2,324,000	176,720	685,502	1,523,000	1,617,000	2,922,000	-3%	0%	0%	-4283700%	-6800000%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Aug	330,248	453,371	493,560	854,117	1,071,000	81,535	316,133	702,869	745,834	1,348,000	-3%	0%	0%	-2130300%	-3244000%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Sep	284,380	389,176	423,555	732,657	919,811	70,187	272,011	605,034	642,031	1,161,000	-3%	0%	0%	-1957100%	-2930700%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Oct	220,165	303,133	329,926	570,297	715,191	54,320	210,424	468,248	496,890	898,607	-3%	0%	0%	-1331600%	-2061300%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Nov	227,504	312,194	339,697	586,978	736,702	56,112	217,267	483,685	513,281	928,389	-3%	0%	0%	-1480400%	-2246000%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Dec	165,124	273,647	299,576	515,085	623,756	40,713	157,569	350,938	372,418	673,706	13%	0%	0%	3631000%	3676800%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jan	110,083	214,688	236,065	404,446	476,893	27,137	105,006	233,918	248,238	449,097	29%	0%	0%	5646300%	6050900%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Feb	121,877	232,508	255,543	438,146	518,355	30,045	116,255	258,979	274,834	497,213	27%	0%	0%	5733100%	6121200%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Mar	165,124	298,139	327,261	562,055	670,725	40,706	157,506	350,874	372,354	673,642	21%	0%	0%	6080200%	6402000%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Apr	398,132	654,154	716,117	1,232,000	1,494,000	98,147	379,761	845,993	897,784	1,624,000	12%	0%	0%	8190800%	8152900%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 May	1,376,000	2,151,000	2,351,000	4,049,000	4,954,000	339,217	1,313,000	2,924,000	3,103,000	5,614,000	7%	0%	0%	17300000%	15800000%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jun	1,536,000	2,394,000	2,617,000	4,507,000	5,517,000	378,566	1,465,000	3,263,000	3,463,000	6,265,000	7%	0%	0%	18700000%	17000000%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jul	715,537	1,138,000	1,245,000	2,144,000	2,615,000	176,393	682,501	1,520,000	1,614,000	2,919,000	9%	0%	0%	11000000%	10500000%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Aug	330,248	548,658	600,972	1,035,000	1,252,000	81,412	314,998	701,734	744,695	1,347,000	13%	0%	0%	7398400%	7497200%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Sep	284,380	479,534	525,392	903,810	1,091,000	70,105	271,246	604,269	641,263	1,160,000	15%	0%	0%	7078700%	7253000%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Oct	220,165	382,189	419,011	719,941	864,834	54,275	209,995	467,819	496,460	898,177	17%	0%	0%	6574000%	6847200%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Nov	227,504	393,841	431,693	741,464	891,188	56,084	216,993	483,411	513,006	928,114	17%	0%	0%	6684300%	6953600%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Dec	165,124	298,449	327,517	561,980	670,650	40,706	157,493	350,862	372,342	673,630	21%	0%	0%	6111200%	6470900%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jan	110,083	214,205	235,525	403,554	476,000	27,137	104,995	233,907	248,227	449,086	29%	0%	0%	5598000%	5996900%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Feb	117,675	225,547	247,926	425,059	502,502	29,009	112,235	250,037	265,345	480,056	27%	0%	66%	5641059%	6029607%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Mar	165,124	297,388	326,420	560,667	669,337	40,706	157,489	350,858	372,338	673,626	21%	0%	0%	6005100%	6317900%	-4%	-9%	-6%	-10%	-6%

		Runoff coefficient 0.51																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2040 Apr	398,132	652,345	714,089	1,229,000	1,491,000	98,147	379,721	845,953	897,745	1,624,000	12%	0%	0%	8009900%	7950100%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 May	1,376,000	2,145,000	2,344,000	4,037,000	4,943,000	339,217	1,312,000	2,924,000	3,103,000	5,614,000	7%	0%	0%	16700000%	15100000%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jun	1,536,000	2,387,000	2,609,000	4,494,000	5,504,000	378,566	1,465,000	3,263,000	3,463,000	6,265,000	7%	0%	0%	18000000%	16200000%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jul	715,537	1,135,000	1,241,000	2,138,000	2,609,000	176,393	682,430	1,520,000	1,613,000	2,919,000	9%	0%	0%	10700000%	10100000%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Aug	330,248	547,157	599,289	1,032,000	1,249,000	81,412	314,965	701,701	744,662	1,347,000	13%	0%	0%	7248300%	7328900%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Sep	284,380	478,240	523,942	901,418	1,089,000	70,105	271,218	604,240	641,234	1,160,000	14%	0%	0%	6949300%	7108000%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Oct	220,165	381,189	417,889	718,090	862,984	54,275	209,973	467,797	496,438	898,155	17%	0%	0%	6474000%	6735000%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Nov	227,504	392,808	430,534	739,552	889,276	56,084	216,970	483,389	512,984	928,091	17%	0%	0%	6581000%	6837700%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Dec	165,124	297,699	326,676	560,592	669,262	40,706	157,477	350,845	372,326	673,613	21%	0%	0%	6036200%	6386800%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jan	110,083	213,700	234,958	402,618	475,065	27,137	104,983	233,895	248,215	449,074	29%	0%	0%	5547500%	5940200%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Feb	121,877	231,385	254,285	436,068	516,277	30,045	116,228	258,952	274,806	497,185	26%	0%	0%	5620800%	5995400%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Mar	165,124	296,602	325,539	559,211	667,882	40,706	157,465	350,833	372,314	673,601	21%	0%	0%	5926500%	6229800%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Apr	398,132	650,412	711,922	1,225,000	1,487,000	98,147	379,655	845,887	897,678	1,624,000	11%	0%	0%	7816600%	7733400%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 May	1,376,000	2,138,000	2,336,000	4,024,000	4,930,000	339,217	1,312,000	2,924,000	3,103,000	5,613,000	7%	0%	0%	16000000%	14300000%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jun	1,536,000	2,411,000	2,635,000	4,538,000	5,548,000	378,566	1,464,000	3,263,000	3,462,000	6,264,000	8%	0%	0%	20400000%	18800000%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jul	715,537	1,166,000	1,276,000	2,196,000	2,667,000	176,393	682,269	1,520,000	1,613,000	2,919,000	11%	0%	0%	13800000%	13600000%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Aug	330,248	545,430	597,352	1,029,000	1,246,000	81,412	314,884	701,621	744,581	1,347,000	13%	0%	0%	7075600%	7135200%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Sep	284,380	476,727	522,245	898,609	1,086,000	70,105	271,143	604,165	641,159	1,160,000	14%	0%	0%	6798000%	6938300%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Oct	220,165	379,996	416,551	715,876	860,769	54,275	209,911	467,735	496,375	898,092	17%	0%	0%	6354700%	6601200%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Nov	227,504	391,553	429,128	737,223	886,947	56,084	216,901	483,320	512,915	928,023	16%	0%	0%	6455500%	6697100%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Dec	165,124	296,773	325,638	558,873	667,543	40,706	157,424	350,792	372,272	673,560	21%	0%	0%	5943600%	6283000%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jan	110,083	213,053	234,232	401,416	473,862	27,137	104,948	233,860	248,180	449,039	28%	0%	0%	5482800%	5867600%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Feb	121,877	230,619	253,425	434,641	514,850	30,045	116,192	258,916	274,771	497,150	26%	0%	0%	5544200%	5909400%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Mar	165,124	295,499	324,299	557,149	665,819	40,706	157,422	350,790	372,270	673,558	20%	0%	0%	5816200%	6105800%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Apr	398,132	647,584	708,744	1,220,000	1,482,000	98,147	379,561	845,793	897,584	1,624,000	11%	0%	0%	7533800%	7415600%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 May	1,376,000	2,128,000	2,325,000	4,005,000	4,911,000	339,217	1,312,000	2,923,000	3,102,000	5,613,000	7%	0%	0%	15000000%	13200000%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jun	1,536,000	2,492,000	2,726,000	4,692,000	5,702,000	378,566	1,464,000	3,262,000	3,462,000	6,264,000	11%	0%	0%	28500000%	27900000%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jul	715,537	1,160,000	1,269,000	2,185,000	2,656,000	176,393	682,160	1,520,000	1,613,000	2,919,000	11%	0%	0%	13200000%	12900000%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Aug	330,248	542,528	594,087	1,023,000	1,241,000	81,412	314,843	701,579	744,540	1,347,000	12%	0%	0%	6785400%	6808700%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Sep	284,380	474,109	519,298	893,676	1,081,000	70,105	271,115	604,138	641,131	1,160,000	14%	0%	0%	6536200%	6643600%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Oct	220,165	377,877	414,166	711,878	856,772	54,275	209,895	467,720	496,360	898,077	16%	0%	0%	6142800%	6362700%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Nov	227,504	389,269	426,554	732,909	882,633	56,084	216,892	483,310	512,905	928,012	16%	0%	0%	6227100%	6439700%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Dec	165,124	295,046	323,692	555,608	664,278	40,706	157,422	350,790	372,270	673,557	20%	0%	0%	5770900%	6088400%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jan	110,083	208,851	229,410	393,999	466,499	27,137	107,992	236,904	251,224	452,082	26%	0%	0%	5062600%	5385400%	-4%	-6%	-5%	-9%	-5%
Impacted	2043 Feb	121,877	222,606	244,276	419,907	500,175	30,045	119,236	261,960	277,814	500,193	22%	0%	0%	4742900%	4994500%	-4%	-7%	-5%	-9%	-5%
Impacted	2043 Mar	165,124	273,041	298,785	514,905	623,655	40,706	160,465	353,834	375,313	676,601	13%	0%	0%	3570400%	3554400%	-4%	-7%	-6%	-10%	-6%
Impacted	2043 Apr	398,132	544,777	592,472	1,027,000	1,289,000	98,147	382,605	848,837	900,627	1,627,000	-3%	0%	0%	-2746900%	-4211600%	-4%	-8%	-6%	-10%	-6%
Impacted	2043 May	1,376,000	1,685,000	1,825,000	3,175,000	4,081,000	339,217	1,315,000	2,926,000	3,105,000	5,616,000	-11%	0%	0%	-29300000%	-36800000%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jun	1,536,000	1,871,000	2,026,000	3,525,000	4,537,000	378,566	1,498,000	3,297,000	3,496,000	6,298,000	-12%	0%	0%	-33600000%	-42100000%	-4%	-7%	-5%	-9%	-5%
Impacted	2043 Jul	715,537	931,732	1,011,000	1,756,000	2,227,000	176,393	711,673	1,550,000	1,643,000	2,948,000	-7%	0%	0%	-9626800%	-12900000%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2043 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2043 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2043 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2044 Feb	117,675	184,436	201,498	347,759	425,258	29,009	119,700	257,502	272,810	487,520	8%	0%	66%	1529959%	1386807%	-4%	-3%	-4%	-8%	-4%
Impacted	2044 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2044 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2045 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2045 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2046 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2046 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2047 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2047 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2048 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2048 Feb	117,675	184,436	201,498	347,759	425,258	29,009	119,700	257,502	272,810	487,520	8%	0%	66%	1529959%	1386807%	-4%	-3%	-4%	-8%	-4%
Impacted	2048 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2048 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2049 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2049 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2050 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2050 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2051 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2051 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2052 Feb	117,675	184,436	201,498	347,759	425,258	29,009	119,700	257,502	272,810	487,520	8%	0%	66%	1529959%	1386807%	-4%	-3%	-4%	-8%	-4%
Impacted	2052 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2052 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2053 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2053 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2054 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2054 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2055 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2055 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2055 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2056 Feb	117,675	184,436	201,498	347,759	425,258	29,009	119,700	257,502	272,810	487,520	8%	0%	66%	1529959%	1386807%	-4%	-3%	-4%	-8%	-4%
Impacted	2056 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2056 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2057 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2057 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2058 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2058 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2059 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2059 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2060 Feb	117,675	184,436	201,498	347,759	425,258	29,009	119,700	257,502	272,810	487,520	8%	0%	66%	1529959%	1386807%	-4%	-3%	-4%	-8%	-4%
Impacted	2060 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2060 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2061 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2061 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2062 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2062 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2063 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2063 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%

		Runoff coefficient 0.51																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2063 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2064 Feb	117,675	184,436	201,498	347,759	425,258	29,009	119,700	257,502	272,810	487,520	8%	0%	66%	1529959%	1386807%	-4%	-3%	-4%	-8%	-4%
Impacted	2064 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2064 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2065 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2065 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2066 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2066 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2067 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2067 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2068 Feb	117,675	184,436	201,498	347,759	425,258	29,009	119,700	257,502	272,810	487,520	8%	0%	66%	1529959%	1386807%	-4%	-3%	-4%	-8%	-4%
Impacted	2068 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2068 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2069 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2069 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2070 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2070 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2071 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2071 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2071 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2071 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2071 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2072 Feb	117,675	184,436	201,498	347,759	425,258	29,009	119,700	257,502	272,810	487,520	8%	0%	66%	1529959%	1386807%	-4%	-3%	-4%	-8%	-4%
Impacted	2072 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2072 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2073 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2073 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2074 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2074 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2075 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2075 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2076 Feb	117,675	184,436	201,498	347,759	425,258	29,009	119,700	257,502	272,810	487,520	8%	0%	66%	1529959%	1386807%	-4%	-3%	-4%	-8%	-4%
Impacted	2076 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2076 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2077 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2077 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2077 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2077 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2078 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2078 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2078 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2078 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2079 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2079 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2079 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2080 Feb	117,675	184,436	201,498	347,759	425,258	29,009	119,700	257,502	272,810	487,520	8%	0%	66%	1529959%	1386807%	-4%	-3%	-4%	-8%	-4%
Impacted	2080 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2080 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2081 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2081 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2082 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2082 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2083 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2083 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2084 Feb	117,675	184,436	201,498	347,759	425,258	29,009	119,700	257,502	272,810	487,520	8%	0%	66%	1529959%	1386807%	-4%	-3%	-4%	-8%	-4%
Impacted	2084 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2084 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2085 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2085 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2086 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2086 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2086 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2087 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2087 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2088 Feb	117,675	184,436	201,498	347,759	425,258	29,009	119,700	257,502	272,810	487,520	8%	0%	66%	1529959%	1386807%	-4%	-3%	-4%	-8%	-4%
Impacted	2088 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2088 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2089 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2089 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2090 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2090 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2091 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2091 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2092 Feb	117,675	184,436	201,498	347,759	425,258	29,009	119,700	257,502	272,810	487,520	8%	0%	66%	1529959%	1386807%	-4%	-3%	-4%	-8%	-4%
Impacted	2092 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2092 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2093 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2093 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Jun	1,536,000	2,418,000	2,642,000	4,560,000	5,571,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	8%	0%	0%	21100000%	19500000%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Jul	715,537	1,118,000	1,221,000	2,107,000	2,578,000	176,393	711,673	1,550,000	1,643,000	2,948,000	8%	0%	0%	9000000%	8100000%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Oct	220,165	345,327	377,282	651,123	796,123	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	2887800%	2674300%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Nov	227,504	359,321	392,656	677,524	827,357	56,084	229,077	495,495	525,090	940,198	9%	0%	0%	3232300%	3049900%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Dec	165,124	260,829	285,028	491,811	600,561	40,706	167,106	360,474	381,954	683,242	9%	0%	0%	2349200%	2222000%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Jan	110,083	173,422	189,496	326,997	399,497	27,137	112,334	241,246	255,566	456,425	8%	0%	0%	1519700%	1394000%	-4%	-3%	-3%	-8%	-4%
Impacted	2094 Feb	121,877	191,023	208,695	360,178	440,446	30,045	123,866	266,590	282,444	504,823	8%	0%	0%	1584600%	1436400%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Apr	398,132	621,787	679,233	1,172,000	1,435,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	4954100%	4464500%	-4%	-5%	-4%	-9%	-5%
Impacted	2094 May	1,376,000	2,168,000	2,369,000	4,088,000	4,994,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	8%	0%	0%	19000000%	17600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Jun	1,536,000	2,477,000	2,709,000	4,671,000	5,683,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	10%	0%	0%	27000000%	26200000%	-4%	-5%	-5%	-9%	-5%

		Runoff coefficient 0.51																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2094 Jul	715,537	1,131,000	1,236,000	2,133,000	2,604,000	176,393	711,673	1,550,000	1,643,000	2,948,000	9%	0%	0%	10300000%	9600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Oct	220,165	346,810	378,953	653,928	798,928	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	3036100%	2841400%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Nov	227,504	369,449	404,066	696,678	846,511	56,084	229,077	495,495	525,090	940,198	11%	0%	0%	4245100%	4190900%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Dec	165,124	267,794	292,874	504,983	613,733	40,706	167,106	360,474	381,954	683,242	11%	0%	0%	3045700%	3006600%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Jan	110,083	176,720	193,211	333,234	405,734	27,137	112,334	241,246	255,566	456,425	10%	0%	0%	1849500%	1765500%	-4%	-3%	-3%	-8%	-4%
Impacted	2095 Feb	121,877	193,137	211,076	364,177	444,444	30,045	123,866	266,590	282,444	504,823	9%	0%	0%	1796000%	1674500%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Apr	398,132	628,368	686,648	1,185,000	1,447,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	5612200%	5206000%	-4%	-5%	-4%	-9%	-5%
Impacted	2095 May	1,376,000	2,228,000	2,437,000	4,202,000	5,108,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	11%	0%	0%	25000000%	24400000%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Jun	1,536,000	2,483,000	2,716,000	4,683,000	5,694,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	11%	0%	0%	27600000%	26900000%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Jul	715,537	1,131,000	1,236,000	2,133,000	2,604,000	176,393	711,673	1,550,000	1,643,000	2,948,000	9%	0%	0%	10300000%	9600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Oct	220,165	346,810	378,953	653,928	798,928	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	3036100%	2841400%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Nov	227,504	369,449	404,066	696,678	846,511	56,084	229,077	495,495	525,090	940,198	11%	0%	0%	4245100%	4190900%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Dec	165,124	267,794	292,874	504,983	613,733	40,706	167,106	360,474	381,954	683,242	11%	0%	0%	3045700%	3006600%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Jan	110,083	176,720	193,211	333,234	405,734	27,137	112,334	241,246	255,566	456,425	10%	0%	0%	1849500%	1765500%	-4%	-3%	-3%	-8%	-4%
Impacted	2096 Feb	117,675	186,422	203,735	351,514	429,014	29,009	119,700	257,502	272,810	487,520	9%	0%	66%	1728559%	1610507%	-4%	-3%	-4%	-8%	-4%
Impacted	2096 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Apr	398,132	628,368	686,648	1,185,000	1,447,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	5612200%	5206000%	-4%	-5%	-4%	-9%	-5%
Impacted	2096 May	1,376,000	2,228,000	2,437,000	4,202,000	5,108,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	11%	0%	0%	25000000%	24400000%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Jun	1,536,000	2,483,000	2,716,000	4,683,000	5,694,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	11%	0%	0%	27600000%	26900000%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Jul	715,537	1,131,000	1,236,000	2,133,000	2,604,000	176,393	711,673	1,550,000	1,643,000	2,948,000	9%	0%	0%	10300000%	9600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Oct	220,165	346,810	378,953	653,928	798,928	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	3036100%	2841400%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Nov	227,504	369,449	404,066	696,678	846,511	56,084	229,077	495,495	525,090	940,198	11%	0%	0%	4245100%	4190900%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Dec	165,124	267,794	292,874	504,983	613,733	40,706	167,106	360,474	381,954	683,242	11%	0%	0%	3045700%	3006600%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Jan	110,083	176,720	193,211	333,234	405,734	27,137	112,334	241,246	255,566	456,425	10%	0%	0%	1849500%	1765500%	-4%	-3%	-3%	-8%	-4%
Impacted	2097 Feb	121,877	193,137	211,076	364,177	444,444	30,045	123,866	266,590	282,444	504,823	9%	0%	0%	1796000%	1674500%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Apr	398,132	628,368	686,648	1,185,000	1,447,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	5612200%	5206000%	-4%	-5%	-4%	-9%	-5%
Impacted	2097 May	1,376,000	2,228,000	2,437,000	4,202,000	5,108,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	11%	0%	0%	25000000%	24400000%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Jun	1,536,000	2,483,000	2,716,000	4,683,000	5,694,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	11%	0%	0%	27600000%	26900000%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Jul	715,537	1,131,000	1,236,000	2,133,000	2,604,000	176,393	711,673	1,550,000	1,643,000	2,948,000	9%	0%	0%	10300000%	9600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Oct	220,165	346,810	378,953	653,928	798,928	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	3036100%	2841400%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Nov	227,504	369,449	404,066	696,678	846,511	56,084	229,077	495,495	525,090	940,198	11%	0%	0%	4245100%	4190900%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Dec	165,124	267,794	292,874	504,983	613,733	40,706	167,106	360,474	381,954	683,242	11%	0%	0%	3045700%	3006600%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Jan	110,083	176,720	193,211	333,234	405,734	27,137	112,334	241,246	255,566	456,425	10%	0%	0%	1849500%	1765500%	-4%	-3%	-3%	-8%	-4%
Impacted	2098 Feb	121,877	193,137	211,076	364,177	444,444	30,045	123,866	266,590	282,444	504,823	9%	0%	0%	1796000%	1674500%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Apr	398,132	628,368	686,648	1,185,000	1,447,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	5612200%	5206000%	-4%	-5%	-4%	-9%	-5%
Impacted	2098 May	1,376,000	2,228,000	2,437,000	4,202,000	5,108,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	11%	0%	0%	25000000%	24400000%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Jun	1,536,000	2,483,000	2,716,000	4,683,000	5,694,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	11%	0%	0%	27600000%	26900000%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Jul	715,537	1,131,000	1,236,000	2,133,000	2,604,000	176,393	711,673	1,550,000	1,643,000	2,948,000	9%	0%	0%	10300000%	9600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Oct	220,165	346,810	378,953	653,928	798,928	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	3036100%	2841400%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Nov	227,504	369,449	404,066	696,678	846,511	56,084	229,077	495,495	525,090	940,198	11%	0%	0%	4245100%	4190900%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Dec	165,124	267,794	292,874	504,983	613,733	40,706	167,106	360,474	381,954	683,242	11%	0%	0%	3045700%	3006600%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Jan	110,083	176,720	193,211	333,234	405,734	27,137	112,334	241,246	255,566	456,425	10%	0%	0%	1849500%	1765500%	-4%	-3%	-3%	-8%	-4%
Impacted	2099 Feb	121,877	193,137	211,076	364,177	444,444	30,045	123,866	266,590	282,444	504,823	9%	0%	0%	1796000%	1674500%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Mar	165,124	256,782	280,468	484,156	592,906	40,706	166,370	359,738	381,218	682,506	7%	0%	0%	1944500%	1722700%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Apr	398,132	628,368	686,648	1,185,000	1,447,000	98,147	397,325	863,557	915,347	1,642,000	8%	0%	0%	5612200%	5206000%	-4%	-5%	-4%	-9%	-5%
Impacted	2099 May	1,376,000	2,228,000	2,437,000	4,202,000	5,108,000	339,217	1,369,000	2,981,000	3,160,000	5,670,000	11%	0%	0%	25000000%	24400000%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Jun	1,536,000	2,483,000	2,716,000	4,683,000	5,694,000	378,566	1,527,000	3,326,000	3,526,000	6,328,000	11%	0%	0%	27600000%	26900000%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Jul	715,537	1,131,000	1,236,000	2,133,000	2,604,000	176,393	711,673	1,550,000	1,643,000	2,948,000	9%	0%	0%	10300000%	9600000%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Aug	330,248	509,643	556,518	960,898	1,178,000	81,412	328,984	715,720	758,680	1,361,000	7%	0%	0%	3496900%	3051800%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Sep	284,380	442,453	483,273	834,237	1,022,000	70,105	284,368	617,391	654,384	1,173,000	7%	0%	0%	3370600%	3041100%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Oct	220,165	346,810	378,953	653,928	798,928	54,275	221,349	479,173	507,813	909,530	8%	0%	0%	3036100%	2841400%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Nov	227,504	369,449	404,066	696,678	846,511	56,084	229,077	495,495	525,090	940,198	11%	0%	0%	4245100%	4190900%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Dec	165,124	267,794	292,874	504,983	613,733	40,706	167,106	360,474	381,954	683,242	11%	0%	0%	3045700%	3006600%	-4%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Baseline	2017 Jan	8.05E+04	1.16E+05	1.28E+05	2.17E+05	2.70E+05	20674	84252	182759	202403	349259	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Feb	8.91E+04	1.28E+05	1.42E+05	2.40E+05	2.99E+05	22889	93280	202341	224089	386679	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Mar	1.21E+05	1.74E+05	1.92E+05	3.25E+05	4.05E+05	31011	126379	274139	303605	523888	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Apr	2.91E+05	4.18E+05	4.64E+05	7.84E+05	9.75E+05	74771	304713	6.61E+05	7.32E+05	1.26E+06	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 May	1.01E+06	1.45E+06	1.60E+06	2.71E+06	3.37E+06	2.58E+05	1.05E+06	2.28E+06	2.53E+06	4.37E+06	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jun	1.12E+06	1.61E+06	1.79E+06	3.02E+06	3.76E+06	2.88E+05	1.18E+06	2.55E+06	2.82E+06	4.87E+06	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jul	5.23E+05	7.52E+05	8.33E+05	1.41E+06	1.75E+06	134380	5.48E+05	1.19E+06	1.32E+06	2.27E+06	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Aug	2.41E+05	3.47E+05	3.85E+05	6.50E+05	8.09E+05	62022	252758	5.48E+05	6.07E+05	1.05E+06	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Sep	2.08E+05	2.99E+05	3.31E+05	5.60E+05	6.96E+05	53408	217652	472129	522875	9.02E+05	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Oct	1.61E+05	2.31E+05	2.56E+05	4.33E+05	5.39E+05	41348	168505	365519	404806	6.99E+05	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Nov	1.66E+05	2.39E+05	2.65E+05	4.48E+05	5.57E+05	42726	174122	377703	418300	7.22E+05	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Dec	1.21E+05	1.74E+05	1.92E+05	3.25E+05	4.04E+05	31011	126379	274139	303605	523888	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Impacted	2018 Jan	8.05E+04	1.16E+05	1.28E+05	2.17E+05	2.69E+05	20674	84252	182759	202403	349259	0%	7%	6%	6%	5%	0%	0%	0%	0%	0%
Impacted	2018 Feb	8.91E+04	1.28E+05	1.42E+05	2.40E+05	2.98E+05	22889	93280	202341	224089	386679	0%	7%	6%	6%	5%	0%	0%	0%	0%	0%
Impacted	2018 Mar	1.21E+05	1.74E+05	1.92E+05	3.25E+05	4.04E+05	31011	126379	274139	303605	523888	0%	7%	6%	6%	5%	0%	0%	0%	0%	0%
Impacted	2018 Apr	2.91E+05	4.18E+05	4.63E+05	7.83E+05	9.74E+05	74771	304713	6.61E+05	7.32E+05	1.26E+06	0%	7%	6%	6%	5%	0%	0%	0%	0%	0%
Impacted	2018 May	1.01E+06	1.45E+06	1.60E+06	2.71E+06	3.37E+06	2.58E+05	1.05E+06	2.28E+06	2.53E+06	4.37E+06	0%	7%	6%	6%	5%	0%	0%	0%	0%	0%
Impacted	2018 Jun	1.12E+06	1.61E+06	1.79E+06	3.02E+06	3.76E+06	2.88E+05	1.18E+06	2.55E+06	2.82E+06	4.87E+06	0%	7%	6%	6%	5%	0%	0%	0%	0%	0%
Impacted	2018 Jul	5.23E+05	7.52E+05	8.32E+05	1.41E+06	1.75E+06	134380	5.48E+05	1.19E+06	1.32E+06	2.27E+06	0%	7%	6%	6%	5%	0%	0%	0%	0%	0%
Impacted	2018 Aug	2.41E+05	3.47E+05	3.84E+05	6.49E+05	8.08E+05	62022	252758	5.48E+05	6.07E+05	1.05E+06	0%	7%	6%	6%	5%	0%	0%	0%	0%	0%
Impacted	2018 Sep	2.08E+05	2.99E+05	3.30E+05	5.59E+05	6.96E+05	53408	217652	472129	522875	9.02E+05	0%	7%	6%	6%	5%	0%	0%	0%	0%	0%
Impacted	2018 Oct	1.61E+05	2.31E+05	2.56E+05	4.33E+05	5.38E+05	41348	168505	365519	404806	6.99E+05	0%	7%	6%	6%	5%	0%	0%	0%	0%	0%
Impacted	2018 Nov	1.66E+05	2.39E+05	2.64E+05	4.47E+05	5.56E+05	42726	174122	377703	418300	7.22E+05	0%	7%	6%	6%	5%	0%	0%	0%	0%	0%
Impacted	2018 Dec	1.21E+05	1.74E+05	1.92E+05	3.24E+05	4.04E+05	31011	126379	274139	303605	523888	0%	7%	6%	6%	5%	0%	0%	0%	0%	0%
Impacted	2019 Jan	8.05E+04	1.62E+05	1.80E+05	3.03E+05	3.56E+05	20674	84252	182759	202012	348868	0%	9%	8%	8%	6%	0%	0%	0%	0%	0%
Impacted	2019 Feb	8.91E+04	1.74E+05	1.93E+05	3.26E+05	3.84E+05	22889	93280	202341	222806	385396	0%	8%	8%	7%	6%	0%	0%	0%	-1%	0%
Impacted	2019 Mar	1.21E+05	2.20E+05	2.44E+05	4.09E+05	4.89E+05	31011	126379	274139	300714	520997	0%	8%	7%	7%	5%	0%	0%	0%	-1%	-1%
Impacted	2019 Apr	2.91E+05	4.64E+05	5.14E+05	8.61E+05	1.05E+06	74771	304713	6.61E+05	7.22E+05	1.25E+06	0%	7%	6%	6%	5%	0%	0%	0%	-1%	-1%
Impacted	2019 May	1.01E+06	1.49E+06	1.65E+06	2.75E+06	3.42E+06	2.58E+05	1.05E+06	2.28E+06	2.49E+06	4.32E+06	0%	6%	6%	6%	5%	0%	0%	0%	-2%	-1%
Impacted	2019 Jun	1.12E+06	1.66E+06	1.83E+06	3.05E+06	3.79E+06	2.88E+05	1.18E+06	2.55E+06	2.76E+06	4.81E+06	0%	6%	6%	6%	5%	0%	0%	0%	-2%	-1%
Impacted	2019 Jul	5.23E+05	7.97E+05	8.81E+05	1.47E+06	1.81E+06	134380	5.48E+05	1.19E+06	1.28E+06	2.24E+06	0%	7%	6%	6%	5%	0%	0%	0%	-3%	-1%
Impacted	2019 Aug	2.41E+05	3.93E+05	4.34E+05	7.21E+05	8.80E+05	62022	252758	5.48E+05	5.89E+05	1.03E+06	0%	7%	6%	6%	5%	0%	0%	0%	-3%	-2%
Impacted	2019 Sep	2.08E+05	3.51E+05	3.89E+05	6.44E+05	7.81E+05	53408	217652	472129	505549	8.85E+05	0%	7%	7%	6%	5%	0%	0%	0%	-3%	-2%
Impacted	2019 Oct	1.61E+05	2.84E+05	3.14E+05	5.20E+05	6.26E+05	41348	168505	365519	389805	6.84E+05	0%	8%	7%	7%	5%	0%	0%	0%	-4%	-2%
Impacted	2019 Nov	1.66E+05	2.93E+05	3.24E+05	5.35E+05	6.44E+05	42726	174122	377703	401156	7.05E+05	0%	8%	7%	7%	5%	0%	0%	0%	-4%	-2%
Impacted	2019 Dec	1.21E+05	2.26E+05	2.50E+05	4.12E+05	4.92E+05	31011	126379	274139	289970	510253	0%	8%	7%	7%	5%	0%	0%	0%	-4%	-3%
Impacted	2020 Jan	8.05E+04	1.65E+05	1.83E+05	3.03E+05	3.56E+05	20674	84252	182759	192923	339778	0%	9%	8%	8%	6%	0%	0%	0%	-5%	-3%
Impacted	2020 Feb	8.60E+04	1.72E+05	1.91E+05	3.17E+05	3.74E+05	22100	90063	195364	206228	363211	0%	9%	8%	8%	6%	0%	0%	0%	-5%	-3%
Impacted	2020 Mar	1.21E+05	2.21E+05	2.45E+05	4.09E+05	4.88E+05	31011	126379	274139	289384	509667	0%	8%	7%	7%	5%	0%	0%	0%	-5%	-3%
Impacted	2020 Apr	2.91E+05	4.66E+05	5.15E+05	8.62E+05	1.05E+06	74771	304713	6.61E+05	6.98E+05	1.23E+06	0%	7%	6%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2020 May	1.01E+06	1.49E+06	1.64E+06	2.77E+06	3.43E+06	2.58E+05	1.05E+06	2.28E+06	2.41E+06	4.25E+06	0%	7%	6%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2020 Jun	1.12E+06	1.64E+06	1.82E+06	3.08E+06	3.82E+06	2.88E+05	1.18E+06	2.55E+06	2.69E+06	4.74E+06	0%	6%	6%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2020 Jul	5.23E+05	7.83E+05	8.66E+05	1.48E+06	1.82E+06	134380	5.48E+05	1.19E+06	1.25E+06	2.21E+06	0%	7%	6%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2020 Aug	2.41E+05	3.83E+05	4.24E+05	7.26E+05	8.85E+05	62022	252758	5.48E+05	5.79E+05	1.02E+06	0%	7%	6%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2020 Sep	2.08E+05	3.34E+05	3.70E+05	6.37E+05	7.74E+05	53408	217652	472129	498384	8.78E+05	0%	7%	7%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2020 Oct	1.61E+05	2.68E+05	2.97E+05	5.14E+05	6.19E+05	41348	168505	365519	385846	6.80E+05	0%	7%	7%	7%	5%	0%	0%	0%	-5%	-3%
Impacted	2020 Nov	1.66E+05	2.74E+05	3.04E+05	5.28E+05	6.37E+05	42726	174122	377703	398707	7.02E+05	0%	7%	7%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2020 Dec	1.21E+05	2.10E+05	2.33E+05	4.07E+05	4.86E+05	31011	126379	274139	289384	509667	0%	8%	7%	7%	5%	0%	0%	0%	-5%	-3%
Impacted	2021 Jan	8.05E+04	1.55E+05	1.72E+05	3.00E+05	3.53E+05	20674	84247	182737	192900	339756	0%	8%	8%	8%	6%	0%	0%	0%	-5%	-3%
Impacted	2021 Feb	8.91E+04	1.67E+05	1.85E+05	3.22E+05	3.81E+05	22889	93262	202270	213523	376112	0%	8%	8%	7%	6%	0%	0%	0%	-5%	-3%
Impacted	2021 Mar	1.21E+05	2.09E+05	2.32E+05	4.05E+05	4.85E+05	31011	126339	273981	289226	509510	0%	8%	7%	7%	5%	0%	0%	0%	-5%	-3%
Impacted	2021 Apr	2.91E+05	4.40E+05	4.86E+05	8.55E+05	1.05E+06	74771	304577	6.60E+05	6.97E+05	1.23E+06	0%	7%	6%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2021 May	1.01E+06	1.41E+06	1.56E+06	2.74E+06	3.41E+06	2.58E+05	1.05E+06	2.28E+06	2.41E+06	4.25E+06	0%	6%	6%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2021 Jun	1.12E+06	1.73E+06	1.87E+06	3.07E+06	3.81E+06	2.88E+05	1.17E+06	2.55E+06	2.69E+06	4.74E+06	0%	7%	6%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2021 Jul	5.23E+05	8.28E+05	8.98E+05	1.48E+06	1.82E+06	134380	5.47E+05	1.19E+06	1.25E+06	2.21E+06	0%	7%	6%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2021 Aug	2.41E+05	4.06E+05	4.42E+05	7.27E+05	8.86E+05	62022	252514	547318	5.78E+05	1.02E+06	0%	7%	7%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2021 Sep	2.08E+05	3.57E+05	3.89E+05	6.39E+05	7.76E+05	53408	217415	471191	497447	8.77E+05	0%	7%	7%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2021 Oct	1.61E+05	2.88E+05	3.13E+05	5.15E+05	6.21E+05	41348	168299	364707	385034	6.79E+05	0%	8%	7%	7%	5%	0%	0%	0%	-5%	-3%
Impacted	2021 Nov	1.66E+05	2.96E+05	3.23E+05	5.30E+05	6.39E+05	42726	173887	376776	397780	7.01E+05	0%	8%	7%	7%	5%	0%	0%	0%	-5%	-3%
Impacted	2021 Dec	1.21E+05	2.28E+05	2.49E+05	4.09E+05	4.88E+05	31011	126192	273402	288647	508930	0%	8%	8%	7%	5%	0%	0%	0%	-5%	-3%
Impacted	2022 Jan	8.05E+04	1.16E+05	1.25E+05	2.04E+05	2.57E+05	20674	84117	182225	192388	339243	0%	12%	10%	7%	6%	0%	0%	0%	-5%	-3%
Impacted	2022 Feb	8.91E+04	1.40E+05	1.51E+05	2.48E+05	3.07E+05	22889	93118	201703	212955	375545	0%	13%	11%	7%	6%	0%	0%	0%	-5%	-3%
Impacted	2022 Mar	1.21E+05	2.28E+05	2.48E+05	4.08E+05	4.88E+05	31011	126144	273213	288458	508741	0%	16%	13%	9%	7%	0%	0%	0%	-5%	-3%
Impacted	2022 Apr	2.91E+05	4.85E+05	5.26E+05	8.62E+05	1.05E+06	74771	304108	6.59E+05	6.95E+05	1.23E+06	0%	14%	11%	8%	6%	0%	0%	0%	-5%	-3%
Impacted	2022 May	1.01E+06	1.57E+06	1.70E+06	2.77E+06	3.43E+06	2.58E+05	1.05E+06	2.28E+06	2.40E+06	4.24E+06	0%	13%	11%	7%	6%	0%	0%	0%	-5%	-3%
Impacted	2022 Jun	1.12E+06	1.74E+06	1.89E+06	3.08E+06	3.82E+06	2.88E+05	1.17E+06	2.54E+06	2.68E+06	4.73E+06	0%	13%	11%	7%	6%	0%	0%	0%	-5%	-3%
Impacted	2022 Jul	5.23E+05	8.36E+05	9.06E+05	1.48E+06	1.83E+06	134380	5.46E+05	1.18E+06	1.25E+06	2.20E+06	0%	14%	11%	8%	6%	0%	0%	0%	-5%	-3%
Impacted	2022 Aug	2.41E+05	4.10E+05	4.45E+05	7.30E+05	8.89E+05	62022	252124	5.46E+05	5.76E+05	1.02E+06	0%	14%	12%	8%	6%	0%	0%	0%	-5%	-3%
Impacted	2022 Sep	2.08E+05	3.60E+05	3.91E+05	6.41E+05	7.78E+05	53408	217079	469867	496123	8.75E+05	0%	15%	12%	8%	7%	0%	0%	0%	-5%	-3%
Impacted	2022 Oct	1.61E+05	2.90E+05	3.15E+05	5.17E+05	6.23E+05	41348	168040	363683	384009	6.78E+05	0%	15%	12%	9%	7%	0%	0%	-1%	-5%	-3%
Impacted	2022 Nov	1.66E+05	2.99E+05	3.25E+05	5.32E+05	6.42E+05	42726	173618	375717	396721	7.00E+05	0%	15%	12%	9%	7%	0%	0%	-1%	-5%	-3%
Impacted	2022 Dec	1.21E+05	2.30E+05	2.50E+05	4.10E+05	4.90E+05	31011	125997	272633	287879	508162	0%	16%	13%	9%	7%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jan	8.05E+04	1.15E+05	1.24E+05	2.01E+05	2.54E+05	20674	83987	181712	191876	338731	0%	12%	10%	7%	6%	0%	0%	-1%	-5%	-3%
Impacted	2023 Feb	8.91E+04	1.27E+05	1.37E+05	2.22E+05	2.81E+05	22889	92974	201135	212388	374978	0%	12%	10%	7%	6%	0%	0%	-1%	-5%	-3%
Impacted	2023 Mar	1.21E+05	1.77E+05	1.90E+05	3.10E+05	3.90E+05	31011	125949	272444	287689	507972	0%	13%	10%	7%	6%	0%	0%	-1%	-5%	-3%
Impacted	2023 Apr	2.91E+05	4.89E+05	5.30E+05	8.66E+05	1.06E+06	74771	303638	6.57E+05	6.93E+05	1.23E+06	0%	14%	12%	8%	6%	0%	0%	-1%	-5%	-3%
Impacted	2023 May	1.01E+06	1.58E+06	1.71E+06	2.78E+06	3.45E+06	2.58E+05	1.05E+06	2.27E+06	2.40E+06	4.23E+06	0%	14%	11%	7%	6%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jun	1.12E+06	1.71E+06	1.85E+06	3.01E+06	3.74E+06	2.88E+05	1.17E+06	2.53E+06	2.67E+06	4.72E+06	0%	13%	10%	7%	6%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jul	5.23E+05	8.47E+05	9.16E+05	1.50E+06	1.84E+06	134380	5.45E+05	1.18E+06	1.25E+06	2.20E+06	0%	14%	11%	8%	6%	0%	0%	-1%	-5%	-3%
Impacted	2023 Aug	2.41E+05	4.15E+05	4.50E+05	7.37E+05	8.96E+05	62022	251735	5.44E+05	5.75E+05	1.02E+06	0%	15%	12%	8%	7%	0%	0%	-1%	-5%	-3%
Impacted	2023 Sep	2.08E+05	3.65E+05	3.96E+05	6.48E+05	7.84E+05	53408	216743	468543	494798	8.74E+05	0%	15%	12%	8%	7%	0%	0%	-1%	-5%	-3%
Impacted	2023 Oct	1.61E+05	2.94E+05	3.19E+05	5.22E+05	6.28E+05	41348	167780	362657	382984	6.77E+05	0%	16%	13%	9%	7%	0%	0%	-1%	-5%	-3%
Impacted	2023 Nov	1.66E+05	3.03E+05	3.29E+05	5.37E+05	6.47E+05	42726	173350	374657	395662	6.99E+05	0%	16%	13%	9%	7%	0%	0%	-1%	-5%	-3%
Impacted	2023 Dec	1.21E+05	2.33E+05	2.53E+05	4.14E+05	4.93E+05	31011	125802	271864	287110	507393	0%	17%	13%	9%	7%	0%	0%	-1%	-5%	-3%
Impacted	2024 Jan	8.05E+04	1.24E+05	1.33E+05	2.16E+05	2.69E+05	20674	83857	181187	191350	338205	0%	13%	10%	7%	6%	0%	0%	-1%	-5%	-3%
Impacted	2024 Feb	8.60E+04	1.79E+05	1.95E+05	3.19E+05	3.76E+05	22100	89628	193611	204475	361459	0%	17%	14%	10%	8%	0%	0%	-1%	-5%	-3%
Impacted	2024 Mar	1.21E+05	2.31E+05	2.52E+05	4.12E+05	4.92E+05	31011	125751	271579	286825	507108	0%	16%	13%	9%	7%	0%	0%	-1%	-6%	-3%
Impacted	2024 Apr	2.91E+05	4.93E+05	5.34E+05	8.72E+05	1.06E+06	74771	303158	6.55E+05	6.91E+05	1.22E+06	0%	14%	11%	8%	6%	0%	-1%	-1%	-6%	-3%
Impacted	2024 May	1.01E+06	1.59E+06	1.72E+06	2.81E+06	3.47E+06	2.58E+05	1.05E+06	2.26E+06	2.39E+06	4.22E+06	0%	13%	11%	7%	6%	0%	0%	-1%	-6%	-3%
Impacted	2024 Jun	1.12E+06	1.77E+06	1.91E+06	3.12E+06	3.86E+06	2.88E+05	1.17E+06	2.52E+06	2.67E+06	4.71E+06	0%	13%	11%	7%	6%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jul	5.23E+05	8.48E+05	9.15E+05	1.50E+06	1.84E+06	134380	5.45E+05	1.18E+06	1.24E+06	2.20E+06	0%	14%	11%	8%	6%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Aug	2.41E+05	4.14E+05	4.49E+05	7.36E+05	8.95E+05	62022	251327	5.42E+05	5.73E+05	1.01E+06	0%	14%	12%	8%	6%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Sep	2.08E+05	3.64E+05	3.94E+05	6.47E+05	7.84E+05	53408	216391	466665	4.93E+05	8.72E+05	0%	15%	12%	8%	7%	0%	-1%	-1%	-6%	-3%

		Runoff coefficient 0.51																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2024 Oct	1.61E+05	2.92E+05	3.17E+05	5.21E+05	6.27E+05	41348	167505	361153	381480	6.75E+05	0%	15%	12%	9%	7%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Nov	1.66E+05	3.01E+05	3.26E+05	5.36E+05	6.45E+05	42726	173065	373051	394056	6.98E+05	0%	15%	12%	8%	7%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Dec	1.21E+05	2.31E+05	2.51E+05	4.13E+05	4.92E+05	31011	125594	270661	285907	506190	0%	16%	13%	9%	7%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jan	8.05E+04	1.69E+05	1.84E+05	3.04E+05	3.57E+05	20674	83718	180372	190535	337391	0%	18%	14%	10%	8%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Feb	8.91E+04	1.82E+05	1.98E+05	3.27E+05	3.86E+05	22889	92675	199624	210877	373467	0%	17%	14%	10%	7%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Mar	1.21E+05	2.30E+05	2.50E+05	4.12E+05	4.91E+05	31011	125543	270360	285606	505889	0%	16%	13%	9%	7%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Apr	2.91E+05	4.89E+05	5.29E+05	8.71E+05	1.06E+06	74771	302656	6.52E+05	6.88E+05	1.22E+06	0%	14%	11%	8%	6%	0%	-1%	-1%	-6%	-3%
Impacted	2025 May	1.01E+06	1.58E+06	1.70E+06	2.80E+06	3.46E+06	2.58E+05	1.05E+06	2.25E+06	2.38E+06	4.21E+06	0%	13%	11%	7%	6%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jun	1.12E+06	1.75E+06	1.89E+06	3.11E+06	3.85E+06	2.88E+05	1.17E+06	2.51E+06	2.65E+06	4.70E+06	0%	13%	10%	7%	6%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jul	5.23E+05	8.39E+05	9.07E+05	1.50E+06	1.84E+06	134380	5.44E+05	1.17E+06	1.24E+06	2.19E+06	0%	13%	11%	7%	6%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Aug	2.41E+05	4.11E+05	4.45E+05	7.35E+05	8.94E+05	62022	250911	539699	5.70E+05	1.01E+06	0%	14%	11%	8%	6%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Sep	2.08E+05	3.60E+05	3.91E+05	6.46E+05	7.83E+05	53408	216033	464566	490821	8.70E+05	0%	15%	12%	8%	6%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Oct	1.61E+05	2.90E+05	3.15E+05	5.20E+05	6.26E+05	41348	167228	359528	379855	6.74E+05	0%	15%	12%	8%	7%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Nov	1.66E+05	2.98E+05	3.24E+05	5.35E+05	6.45E+05	42726	172778	371372	392376	6.96E+05	0%	15%	12%	8%	7%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Dec	1.21E+05	2.29E+05	2.49E+05	4.12E+05	4.92E+05	31011	125386	269442	284687	504970	0%	16%	13%	9%	7%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jan	8.05E+04	1.68E+05	1.83E+05	3.04E+05	3.57E+05	20674	83579	179559	189723	336578	0%	45%	43%	40%	32%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Feb	8.91E+04	1.81E+05	1.97E+05	3.27E+05	3.85E+05	22889	92522	198725	209977	372567	0%	41%	39%	36%	29%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Mar	1.21E+05	2.28E+05	2.48E+05	4.11E+05	4.91E+05	31011	125335	269142	284387	504670	0%	31%	29%	26%	21%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Apr	2.91E+05	4.84E+05	5.24E+05	8.69E+05	1.06E+06	74771	302155	6.49E+05	6.85E+05	1.22E+06	0%	16%	13%	11%	9%	0%	-1%	-2%	-6%	-4%
Impacted	2026 May	1.01E+06	1.56E+06	1.69E+06	2.79E+06	3.46E+06	2.58E+05	1.04E+06	2.24E+06	2.37E+06	4.20E+06	0%	8%	5%	3%	2%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jun	1.12E+06	1.74E+06	1.87E+06	3.11E+06	3.85E+06	2.88E+05	1.17E+06	2.50E+06	2.64E+06	4.69E+06	0%	8%	5%	3%	2%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jul	5.23E+05	8.31E+05	8.98E+05	1.49E+06	1.84E+06	134380	5.43E+05	1.17E+06	1.23E+06	2.19E+06	0%	11%	8%	6%	5%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Aug	2.41E+05	4.07E+05	4.41E+05	7.34E+05	8.92E+05	62022	250495	537262	5.68E+05	1.01E+06	0%	17%	15%	13%	10%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Sep	2.08E+05	3.57E+05	3.87E+05	6.45E+05	7.81E+05	53408	215675	462467	488723	8.68E+05	0%	19%	17%	15%	12%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Oct	1.61E+05	2.87E+05	3.12E+05	5.19E+05	6.25E+05	41348	166951	357903	378230	6.72E+05	0%	24%	22%	20%	16%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Nov	1.66E+05	2.96E+05	3.21E+05	5.34E+05	6.44E+05	42726	172492	369693	390698	6.94E+05	0%	24%	21%	19%	16%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Dec	1.21E+05	2.25E+05	2.45E+05	4.08E+05	4.87E+05	31011	125178	268224	283469	503752	0%	30%	27%	26%	21%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jan	8.05E+04	1.07E+05	1.15E+05	1.91E+05	2.44E+05	20673	83438	178766	188929	335785	0%	9%	7%	6%	5%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Feb	8.91E+04	1.19E+05	1.27E+05	2.11E+05	2.70E+05	22887	92360	197885	209138	371728	0%	9%	7%	6%	5%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Mar	1.21E+05	1.60E+05	1.72E+05	2.86E+05	3.65E+05	31005	125109	268057	283302	503585	0%	9%	7%	6%	5%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Apr	2.91E+05	3.86E+05	4.14E+05	6.89E+05	8.81E+05	74752	301593	6.46E+05	6.83E+05	1.21E+06	0%	9%	7%	6%	5%	0%	-1%	-2%	-7%	-4%
Impacted	2027 May	1.01E+06	1.36E+06	1.46E+06	2.42E+06	3.08E+06	2.58E+05	1.04E+06	2.23E+06	2.36E+06	4.20E+06	0%	9%	7%	6%	5%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jun	1.12E+06	1.72E+06	1.86E+06	3.10E+06	3.84E+06	2.88E+05	1.16E+06	2.49E+06	2.63E+06	4.68E+06	0%	10%	8%	7%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jul	5.23E+05	8.25E+05	8.92E+05	1.49E+06	1.83E+06	134319	5.42E+05	1.16E+06	1.23E+06	2.18E+06	0%	11%	8%	7%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Aug	2.41E+05	4.04E+05	4.38E+05	7.33E+05	8.92E+05	61989	249972	5.36E+05	5.66E+05	1.01E+06	0%	11%	9%	8%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Sep	2.08E+05	3.55E+05	3.85E+05	6.44E+05	7.81E+05	53376	215211	461159	487415	8.67E+05	0%	12%	9%	8%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Oct	1.61E+05	2.86E+05	3.11E+05	5.19E+05	6.25E+05	41320	166582	356963	377290	6.71E+05	0%	12%	9%	8%	7%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Nov	1.66E+05	2.94E+05	3.20E+05	5.34E+05	6.43E+05	42695	172101	368796	389800	6.93E+05	0%	12%	9%	8%	7%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Dec	1.21E+05	2.26E+05	2.46E+05	4.11E+05	4.91E+05	30986	124888	267627	282872	503155	0%	13%	10%	9%	7%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jan	8.05E+04	1.66E+05	1.81E+05	3.03E+05	3.56E+05	20656	83242	178386	188549	335404	0%	13%	10%	9%	7%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Feb	8.60E+04	1.74E+05	1.90E+05	3.18E+05	3.75E+05	22079	88965	190655	201519	358502	0%	13%	10%	9%	7%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Mar	1.21E+05	2.25E+05	2.45E+05	4.11E+05	4.90E+05	30979	124814	267485	282730	503013	0%	12%	9%	8%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Apr	2.91E+05	4.78E+05	5.18E+05	8.68E+05	1.06E+06	74690	300882	6.45E+05	6.82E+05	1.21E+06	0%	10%	8%	7%	6%	0%	-1%	-2%	-7%	-4%
Impacted	2028 May	1.01E+06	1.54E+06	1.67E+06	2.79E+06	3.45E+06	2.58E+05	1.04E+06	2.23E+06	2.36E+06	4.19E+06	0%	10%	7%	7%	5%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jun	1.12E+06	1.71E+06	1.85E+06	3.10E+06	3.84E+06	2.88E+05	1.16E+06	2.49E+06	2.63E+06	4.68E+06	0%	10%	7%	7%	5%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jul	5.23E+05	8.21E+05	8.89E+05	1.49E+06	1.84E+06	134206	5.40E+05	1.16E+06	1.22E+06	2.18E+06	0%	10%	8%	7%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Aug	2.41E+05	4.02E+05	4.37E+05	7.33E+05	8.92E+05	61937	249382	534492	5.65E+05	1.01E+06	0%	11%	8%	7%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Sep	2.08E+05	3.53E+05	3.84E+05	6.44E+05	7.81E+05	53331	214703	460175	486430	8.66E+05	0%	11%	8%	8%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Oct	1.61E+05	2.84E+05	3.10E+05	5.19E+05	6.25E+05	41286	166189	356201	376528	6.70E+05	0%	11%	9%	8%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Nov	1.66E+05	2.93E+05	3.19E+05	5.34E+05	6.44E+05	42659	171695	368008	389013	6.93E+05	0%	11%	9%	8%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Dec	1.21E+05	2.25E+05	2.45E+05	4.12E+05	4.91E+05	30960	124593	267055	282300	502584	0%	12%	9%	8%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Jan	8.05E+04	1.65E+05	1.81E+05	3.03E+05	3.56E+05	20638	83045	178004	188168	335023	0%	13%	10%	9%	7%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Feb	8.91E+04	1.78E+05	1.94E+05	3.26E+05	3.85E+05	22848	91925	197042	208295	370885	0%	13%	10%	9%	7%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Mar	1.21E+05	2.24E+05	2.44E+05	4.11E+05	4.90E+05	30953	124520	266915	282160	502443	0%	12%	9%	8%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Apr	2.91E+05	4.75E+05	5.16E+05	8.68E+05	1.06E+06	74627	300173	6.43E+05	6.80E+05	1.21E+06	0%	10%	8%	7%	6%	0%	-1%	-3%	-7%	-4%
Impacted	2029 May	1.01E+06	1.53E+06	1.66E+06	2.79E+06	3.45E+06	2.58E+05	1.04E+06	2.22E+06	2.35E+06	4.19E+06	0%	10%	7%	7%	5%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jun	1.12E+06	1.70E+06	1.85E+06	3.10E+06	3.84E+06	2.88E+05	1.16E+06	2.48E+06	2.62E+06	4.67E+06	0%	10%	7%	7%	5%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jul	5.23E+05	8.16E+05	8.86E+05	1.49E+06	1.84E+06	134094	5.39E+05	1.16E+06	1.22E+06	2.18E+06	0%	10%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Aug	2.41E+05	4.00E+05	4.35E+05	7.33E+05	8.92E+05	61885	248794	533351	5.64E+05	1.00E+06	0%	11%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Sep	2.08E+05	3.52E+05	3.83E+05	6.44E+05	7.81E+05	53286	214197	459193	485448	8.65E+05	0%	11%	8%	8%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Oct	1.61E+05	2.83E+05	3.09E+05	5.19E+05	6.25E+05	41251	165797	355441	375767	6.69E+05	0%	11%	9%	8%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Nov	1.66E+05	2.91E+05	3.18E+05	5.34E+05	6.44E+05	42623	171290	367223	388227	6.92E+05	0%	11%	9%	8%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Dec	1.21E+05	2.24E+05	2.45E+05	4.12E+05	4.91E+05	30934	124299	266485	281730	502013	0%	12%	9%	8%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jan	8.05E+04	1.65E+05	1.80E+05	3.04E+05	3.57E+05	20621	82849	177625	187788	334644	0%	13%	10%	9%	7%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Feb	8.91E+04	1.77E+05	1.94E+05	3.27E+05	3.85E+05	22829	91708	196622	207874	370464	0%	13%	10%	9%	7%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Mar	1.21E+05	2.23E+05	2.44E+05	4.11E+05	4.91E+05	30927	124226	266345	281590	501873	0%	12%	9%	8%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Apr	2.91E+05	4.73E+05	5.14E+05	8.69E+05	1.06E+06	74564	299464	6.42E+05	6.79E+05	1.21E+06	0%	10%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 May	1.01E+06	1.53E+06	1.65E+06	2.79E+06	3.46E+06	2.58E+05	1.04E+06	2.22E+06	2.35E+06	4.18E+06	0%	10%	7%	7%	5%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jun	1.12E+06	1.70E+06	1.84E+06	3.11E+06	3.85E+06	2.88E+05	1.16E+06	2.48E+06	2.62E+06	4.67E+06	0%	10%	7%	7%	5%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jul	5.23E+05	8.12E+05	8.82E+05	1.49E+06	1.84E+06	133981	5.38E+05	1.15E+06	1.22E+06	2.17E+06	0%	10%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Aug	2.41E+05	3.98E+05	4.34E+05	7.34E+05	8.93E+05	61833	248206	532211	5.63E+05	1.00E+06	0%	11%	8%	7%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Sep	2.08E+05	3.50E+05	3.81E+05	6.45E+05	7.82E+05	53241	213690	458211	4.84E+05	8.64E+05	0%	11%	8%	8%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Oct	1.61E+05	2.82E+05	3.08E+05	5.20E+05	6.26E+05	41216	165405	354680	375007	6.69E+05	0%	11%	9%	8%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Nov	1.66E+05	2.90E+05	3.16E+05	5.35E+05	6.44E+05	42587	170885	366438	387442	6.91E+05	0%	11%	9%	8%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Dec	1.21E+05	2.23E+05	2.44E+05	4.12E+05	4.92E+05	30908	124005	265915	281160	501443	0%	12%	9%	8%	6%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Jan	8.05E+04	1.64E+05	1.80E+05	3.04E+05	3.57E+05	20599	82629	177223	187386	334242	0%	42%	40%	40%	32%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Feb	8.91E+04	1.76E+05	1.93E+05	3.27E+05	3.85E+05	22795	91414	196134	207386	369976	0%	38%	36%	36%	29%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Mar	1.21E+05	2.22E+05	2.43E+05	4.11E+05	4.91E+05	30869	123760	265624	280869	501152	0%	28%	26%	26%	21%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Apr	2.91E+05	4.71E+05	5.12E+05	8.69E+05	1.06E+06	74393	298170	6.40E+05	6.77E+05	1.21E+06	0%	12%	10%	11%	9%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 May	1.01E+06	1.52E+06	1.65E+06	2.79E+06	3.46E+06	2.57E+05	1.03E+06	2.21E+06	2.34E+06	4.17E+06	0%	5%	3%	3%	3%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Jun	1.12E+06	1.69E+06	1.83E+06	3.11E+06	3.85E+06	2.87E+05	1.15E+06	2.47E+06	2.61E+06	4.66E+06	0%	4%	2%	3%	2%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Jul	5.23E+05	8.08E+05	8.78E+05	1.49E+06	1.84E+06	133505	5.35E+05	1.15E+06	1.22E+06	2.17E+06	0%	7%	5%	6%	5%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Aug	2.41E+05	3.96E+05	4.32E+05	7.34E+05	8.93E+05	61587	246571	530152	5.61E+05	1.00E+06	0%	14%	12%	13%	10%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Sep	2.08E+05	3.48E+05	3.80E+05	6.45E+05	7.82E+05	53007	212162	456333	482588	8.62E+05	0%	16%	15%	15%	12%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Oct	1.61E+05	2.80E+05	3.06E+05	5.20E+05	6.26E+05	41018	164130	353146	373473	6.67E+05	0%	21%	20%	20%	16%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Nov	1.66E+05	2.89E+05	3.15E+05	5.35E+05	6.45E+05	42364	169471	364768	385772	6.89E+05	0%	21%	19%	20%	16%	-1%	-3%	-3%	-8%	-5%
Impacted	2031 Dec	1.21E+05	2.22E+05	2.43E+05	4.12E+05	4.92E+05	30733	122909	264642	279887	500170	0%	28%	26%	27%	22%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Jan	8.05E+04	1.63E+05	1.79E+05	3.04E+05	3.57E+05	20478	81875	176354	186517	333373	0%	7%	4%	6%	5%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Feb	8.60E+04	1.71E+05	1.88E+05	3.19E+05	3.75E+05	21880	87455	188440	199304	356288	0%	6%	4%	6%	5%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Mar	1.21E+05	2.21E+05	2.42E+05	4.11E+05	4.91E+05	30688	122627	264317	279562	499845	0%	6%	4%	6%	4%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Apr	2.91E+05	4.68E+05	5.10E+05	8.70E+05	1.06E+06	73955	295439	6.37E+05	6.74E+05	1.21E+06	0%	5%	3%	5%	4%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 May	1.01E+06	1.50E+06	1.63E+06	2.78E+06	3.44E+06	2.55E+05	1.02E+06	2.20E+06	2.33E+06	4.16E+06	0%	5%	3%	5%	4%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Jun	1.12E+06	1.38E+06	1.48E+06	2.54E+06	3.28E+06	2.85E+05	1.14E+06	2.46E+06	2.60E+06	4.65E+06	0%	4%	2%	4%	3%	-1%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2032 Jul	5.23E+05	6.38E+05	6.89E+05	1.18E+06	1.53E+06	132716	5.30E+05	1.14E+06	1.21E+06	2.16E+06	0%	4%	2%	4%	3%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Aug	2.41E+05	2.93E+05	3.16E+05	5.44E+05	7.02E+05	61223	244305	527540	5.58E+05	9.99E+05	0%	4%	2%	4%	3%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Sep	2.08E+05	2.52E+05	2.73E+05	4.68E+05	6.05E+05	52694	210211	454083	480338	8.60E+05	0%	4%	2%	4%	3%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Oct	1.61E+05	1.96E+05	2.11E+05	3.63E+05	4.69E+05	40775	162618	351403	371730	6.65E+05	0%	4%	2%	4%	3%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Nov	1.66E+05	2.02E+05	2.19E+05	3.75E+05	4.85E+05	42113	167909	362966	383971	6.87E+05	0%	4%	2%	4%	3%	-1%	-4%	-4%	-8%	-5%
Impacted	2032 Dec	1.21E+05	1.47E+05	1.58E+05	2.72E+05	3.52E+05	30551	121775	263334	278579	498863	0%	4%	2%	4%	3%	-1%	-4%	-4%	-8%	-5%
Impacted	2033 Jan	8.05E+04	9.76E+04	1.05E+05	1.81E+05	2.34E+05	20357	81119	175482	185646	332501	0%	4%	2%	4%	3%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Feb	8.91E+04	1.08E+05	1.16E+05	2.00E+05	2.59E+05	22527	89743	194206	205459	368049	0%	4%	2%	4%	3%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Mar	1.21E+05	1.45E+05	1.57E+05	2.71E+05	3.50E+05	30506	121496	263013	278258	498541	0%	4%	2%	4%	3%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Apr	2.91E+05	3.50E+05	3.78E+05	6.53E+05	8.44E+05	73518	292713	6.34E+05	6.71E+05	1.20E+06	0%	4%	2%	4%	3%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 May	1.01E+06	1.23E+06	1.33E+06	2.30E+06	2.96E+06	2.54E+05	1.01E+06	2.19E+06	2.32E+06	4.15E+06	0%	4%	2%	4%	3%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jun	1.12E+06	1.67E+06	1.81E+06	3.11E+06	3.85E+06	2.83E+05	1.13E+06	2.44E+06	2.59E+06	4.63E+06	0%	5%	3%	4%	4%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jul	5.23E+05	7.98E+05	8.71E+05	1.50E+06	1.84E+06	131932	5.25E+05	1.14E+06	1.20E+06	2.16E+06	0%	5%	3%	5%	4%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Aug	2.41E+05	3.92E+05	4.28E+05	7.35E+05	8.94E+05	60861	242044	524932	5.55E+05	9.96E+05	0%	5%	3%	5%	4%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Sep	2.08E+05	3.44E+05	3.77E+05	6.46E+05	7.83E+05	52382	208264	451837	4.78E+05	8.57E+05	0%	5%	3%	5%	4%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Oct	1.61E+05	2.78E+05	3.04E+05	5.21E+05	6.27E+05	40533	161111	349664	369991	6.64E+05	0%	5%	3%	5%	4%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Nov	1.66E+05	2.86E+05	3.13E+05	5.36E+05	6.45E+05	41864	166351	361170	382174	6.86E+05	0%	5%	3%	5%	4%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Dec	1.21E+05	2.20E+05	2.41E+05	4.13E+05	4.92E+05	30370	120644	262030	277275	497559	0%	6%	3%	5%	4%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Jan	8.05E+04	1.62E+05	1.78E+05	3.04E+05	3.57E+05	20238	80367	174619	184783	331638	0%	6%	3%	5%	4%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Feb	8.91E+04	1.74E+05	1.91E+05	3.27E+05	3.86E+05	22399	88913	193264	204516	367106	0%	5%	3%	5%	4%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Mar	1.21E+05	2.19E+05	2.40E+05	4.12E+05	4.91E+05	30338	120374	261753	276999	497282	0%	5%	3%	5%	4%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Apr	2.91E+05	4.63E+05	5.06E+05	8.70E+05	1.06E+06	73123	290017	6.31E+05	6.68E+05	1.20E+06	0%	4%	3%	4%	3%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 May	1.01E+06	1.49E+06	1.63E+06	2.80E+06	3.46E+06	2.53E+05	1.00E+06	2.18E+06	2.31E+06	4.14E+06	0%	4%	3%	4%	3%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jun	1.12E+06	1.67E+06	1.82E+06	3.13E+06	3.87E+06	2.82E+05	1.12E+06	2.43E+06	2.57E+06	4.62E+06	0%	4%	3%	4%	3%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jul	5.23E+05	8.32E+05	9.09E+05	1.56E+06	1.91E+06	131289	5.20E+05	1.13E+06	1.20E+06	2.15E+06	0%	4%	3%	4%	3%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Aug	2.41E+05	4.00E+05	4.38E+05	7.52E+05	9.11E+05	60574	239837	522594	5.53E+05	9.94E+05	0%	5%	3%	4%	4%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Sep	2.08E+05	3.50E+05	3.83E+05	6.58E+05	7.95E+05	52144	206369	449855	4.76E+05	8.55E+05	0%	5%	3%	5%	4%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Oct	1.61E+05	2.79E+05	3.05E+05	5.24E+05	6.29E+05	40356	159649	348154	368481	6.62E+05	0%	5%	3%	5%	4%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Nov	1.66E+05	2.87E+05	3.15E+05	5.40E+05	6.49E+05	41688	164846	359634	380639	6.84E+05	0%	5%	3%	5%	4%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Dec	1.21E+05	2.20E+05	2.41E+05	4.13E+05	4.92E+05	30247	119556	260935	276180	496463	0%	5%	3%	5%	4%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Jan	8.05E+04	1.62E+05	1.78E+05	3.04E+05	3.57E+05	20158	79642	173895	184058	330914	0%	5%	3%	5%	4%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Feb	8.91E+04	1.74E+05	1.91E+05	3.27E+05	3.86E+05	22311	88111	192462	203714	366304	0%	5%	3%	5%	4%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Mar	1.21E+05	2.19E+05	2.40E+05	4.12E+05	4.92E+05	30218	119288	260667	275912	496195	0%	5%	3%	5%	4%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Apr	2.91E+05	4.63E+05	5.06E+05	8.71E+05	1.06E+06	72834	287397	6.28E+05	6.65E+05	1.20E+06	0%	4%	3%	4%	3%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 May	1.01E+06	1.57E+06	1.72E+06	2.95E+06	3.61E+06	2.52E+05	9.93E+05	2.17E+06	2.30E+06	4.13E+06	0%	4%	3%	4%	3%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jun	1.12E+06	1.75E+06	1.91E+06	3.29E+06	4.03E+06	2.81E+05	1.11E+06	2.42E+06	2.56E+06	4.61E+06	0%	4%	3%	4%	3%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jul	5.23E+05	8.32E+05	9.09E+05	1.56E+06	1.91E+06	130769	5.15E+05	1.13E+06	1.19E+06	2.15E+06	0%	4%	3%	4%	3%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Aug	2.41E+05	4.00E+05	4.38E+05	7.53E+05	9.12E+05	60334	237663	520421	5.51E+05	9.91E+05	0%	5%	3%	4%	4%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Sep	2.08E+05	3.50E+05	3.83E+05	6.58E+05	7.95E+05	51937	204498	447984	4.74E+05	8.54E+05	0%	5%	3%	4%	4%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Oct	1.61E+05	2.79E+05	3.05E+05	5.24E+05	6.30E+05	40196	158200	346706	367032	6.61E+05	0%	5%	3%	5%	4%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Nov	1.66E+05	2.87E+05	3.15E+05	5.40E+05	6.50E+05	41522	163349	358137	379142	6.83E+05	0%	5%	3%	5%	4%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Dec	1.21E+05	2.20E+05	2.41E+05	4.13E+05	4.93E+05	30127	118469	259848	275093	495376	0%	5%	3%	5%	4%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Jan	8.05E+04	1.62E+05	1.78E+05	3.05E+05	3.57E+05	20078	78918	173170	183334	330189	0%	40%	39%	40%	33%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Feb	8.60E+04	1.69E+05	1.86E+05	3.19E+05	3.76E+05	21456	84297	185050	195914	352897	0%	37%	36%	38%	30%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Mar	1.21E+05	2.19E+05	2.40E+05	4.12E+05	4.92E+05	30097	118198	259577	274822	495105	0%	26%	25%	27%	22%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Apr	2.91E+05	4.63E+05	5.06E+05	8.72E+05	1.06E+06	72544	284770	6.26E+05	6.62E+05	1.19E+06	0%	11%	9%	11%	9%	-3%	-7%	-5%	-10%	-5%
Impacted	2036 May	1.01E+06	1.56E+06	1.71E+06	2.94E+06	3.60E+06	2.51E+05	9.83E+05	2.16E+06	2.29E+06	4.12E+06	0%	8%	7%	8%	7%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Jun	1.12E+06	1.75E+06	1.91E+06	3.29E+06	4.03E+06	2.80E+05	1.10E+06	2.41E+06	2.55E+06	4.60E+06	0%	8%	7%	9%	7%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Jul	5.23E+05	8.30E+05	9.08E+05	1.56E+06	1.91E+06	130247	5.11E+05	1.12E+06	1.19E+06	2.14E+06	0%	10%	9%	11%	9%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Aug	2.41E+05	3.98E+05	4.36E+05	7.51E+05	9.10E+05	60094	235484	518242	5.49E+05	9.89E+05	0%	15%	13%	16%	12%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Sep	2.08E+05	3.48E+05	3.81E+05	6.56E+05	7.93E+05	51730	202621	446107	4.72E+05	8.52E+05	0%	16%	15%	17%	14%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Oct	1.61E+05	2.77E+05	3.04E+05	5.22E+05	6.28E+05	40036	156747	345252	365579	6.59E+05	0%	20%	18%	20%	16%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Nov	1.66E+05	2.85E+05	3.13E+05	5.37E+05	6.47E+05	41356	161847	356635	377640	6.81E+05	0%	19%	18%	20%	16%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Dec	1.21E+05	2.20E+05	2.41E+05	4.14E+05	4.93E+05	30007	117379	258758	274003	494286	0%	27%	25%	27%	22%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jan	8.05E+04	1.62E+05	1.78E+05	3.05E+05	3.58E+05	19998	78191	172444	182607	329463	0%	40%	39%	41%	33%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Feb	8.91E+04	1.74E+05	1.91E+05	3.28E+05	3.86E+05	22133	86504	190855	202108	364698	0%	36%	35%	37%	29%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Mar	1.21E+05	2.19E+05	2.40E+05	4.13E+05	4.92E+05	29977	117111	258490	273735	494018	0%	26%	25%	27%	22%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Apr	2.91E+05	4.63E+05	5.06E+05	8.73E+05	1.06E+06	72254	282149	6.23E+05	6.60E+05	1.19E+06	0%	11%	9%	11%	9%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 May	1.01E+06	1.56E+06	1.70E+06	2.93E+06	3.60E+06	2.50E+05	9.74E+05	2.15E+06	2.28E+06	4.12E+06	0%	8%	6%	8%	7%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jun	1.12E+06	1.75E+06	1.91E+06	3.29E+06	4.03E+06	2.79E+05	1.09E+06	2.40E+06	2.54E+06	4.59E+06	0%	8%	7%	9%	7%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jul	5.23E+05	8.29E+05	9.07E+05	1.56E+06	1.91E+06	129727	5.06E+05	1.12E+06	1.19E+06	2.14E+06	0%	10%	9%	11%	9%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Aug	2.41E+05	3.98E+05	4.36E+05	7.51E+05	9.10E+05	59854	233311	516069	5.47E+05	9.87E+05	0%	15%	13%	16%	12%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Sep	2.08E+05	3.48E+05	3.81E+05	6.56E+05	7.93E+05	51523	200750	444236	4.70E+05	8.50E+05	0%	16%	15%	17%	14%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Oct	1.61E+05	2.77E+05	3.03E+05	5.22E+05	6.28E+05	39876	155299	343804	364131	6.58E+05	0%	20%	18%	21%	17%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Nov	1.66E+05	2.85E+05	3.12E+05	5.37E+05	6.47E+05	41191	160350	355139	376143	6.80E+05	0%	19%	18%	20%	16%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Dec	1.21E+05	2.20E+05	2.41E+05	4.14E+05	4.93E+05	29887	116292	257671	272917	493200	0%	27%	25%	27%	22%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jan	8.05E+04	1.16E+05	1.26E+05	2.18E+05	2.71E+05	19918	77467	171719	181883	328738	0%	9%	8%	10%	8%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Feb	8.91E+04	1.27E+05	1.38E+05	2.39E+05	2.97E+05	22045	85702	190053	201305	363895	0%	9%	8%	10%	8%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Mar	1.21E+05	1.75E+05	1.90E+05	3.29E+05	4.08E+05	29857	116024	257403	272648	492932	0%	9%	8%	10%	8%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Apr	2.91E+05	4.19E+05	4.57E+05	7.89E+05	9.80E+05	71965	279529	6.20E+05	6.57E+05	1.19E+06	0%	9%	8%	10%	8%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 May	1.01E+06	1.46E+06	1.59E+06	2.75E+06	3.41E+06	2.49E+05	9.65E+05	2.14E+06	2.27E+06	4.11E+06	0%	10%	8%	10%	8%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jun	1.12E+06	1.62E+06	1.77E+06	3.05E+06	3.79E+06	2.77E+05	1.08E+06	2.39E+06	2.53E+06	4.58E+06	0%	9%	8%	10%	8%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jul	5.23E+05	7.57E+05	8.26E+05	1.43E+06	1.77E+06	129207	5.01E+05	1.11E+06	1.18E+06	2.13E+06	0%	9%	8%	10%	8%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Aug	2.41E+05	3.48E+05	3.80E+05	6.57E+05	8.16E+05	59614	231137	513895	5.44E+05	9.85E+05	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Sep	2.08E+05	2.99E+05	3.26E+05	5.63E+05	7.00E+05	51317	198879	442364	4.69E+05	8.48E+05	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Oct	1.61E+05	2.33E+05	2.54E+05	4.39E+05	5.45E+05	39716	153849	342355	362682	6.56E+05	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Nov	1.66E+05	2.40E+05	2.61E+05	4.51E+05	5.61E+05	41026	158853	353641	374646	6.78E+05	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Dec	1.21E+05	1.75E+05	1.91E+05	3.29E+05	4.09E+05	29767	115205	256584	271830	492113	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jan	8.05E+04	1.17E+05	1.27E+05	2.19E+05	2.72E+05	19841	76774	171026	181190	328045	0%	9%	7%	9%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Feb	8.91E+04	1.27E+05	1.38E+05	2.38E+05	2.97E+05	21967	84999	189350	200602	363192	0%	9%	7%	9%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Mar	1.21E+05	1.74E+05	1.90E+05	3.29E+05	4.08E+05	29762	115159	256538	271783	492066	0%	9%	7%	9%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Apr	2.91E+05	4.18E+05	4.56E+05	7.88E+05	9.80E+05	71759	277658	6.19E+05	6.55E+05	1.19E+06	0%	9%	7%	9%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 May	1.01E+06	1.46E+06	1.59E+06	2.74E+06	3.41E+06	2.48E+05	9.60E+05	2.14E+06	2.27E+06	4.10E+06	0%	9%	7%	9%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jun	1.12E+06	1.63E+06	1.78E+06	3.07E+06	3.81E+06	2.77E+05	1.07E+06	2.39E+06	2.53E+06	4.58E+06	0%	9%	7%	9%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jul	5.23E+05	8.44E+05	9.23E+05	1.59E+06	1.93E+06	128968	4.99E+05	1.11E+06	1.18E+06	2.13E+06	0%	10%	8%	11%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Aug	2.41E+05	4.13E+05	4.53E+05	7.79E+05	9.38E+05	59524	230307	513065	5.44E+05	9.84E+05	0%	10%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Sep	2.08E+05	3.63E+05	3.98E+05	6.84E+05	8.21E+05	51256	198318	441804	4.68E+05	8.47E+05	0%	11%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Oct	1.61E+05	2.92E+05	3.20E+05	5.50E+05	6.56E+05	39682	153535	342041	362368	6.56E+05	0%	11%	9%	12%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Nov	1.66E+05	3.00E+05	3.30E+05	5.65E+05	6.75E+05	41005	158652	353441	374445	6.78E+05	0%	11%	9%	12%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Dec	1.21E+05	2.31E+05	2.53E+05	4.34E+05	5.14E+05	29762	115150	256528	271774	492057	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jan	8.05E+04	1.69E+05	1.86E+05	3.18E+05	3.71E+05	19841	76766	171018	181182	328037	0%	12%	10%	13%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Feb	8.60E+04	1.77E+05	1.95E+05	3.34E+05	3.91E+05	21210	82059	182812	193676	350660	0%	12%	10%	13%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Mar	1.21E+05	2.30E+05	2.52E+05	4.33E+05	5.13E+05	29762	115147	256525	271771	492054	0%	11%	9%	12%	9%	-4%	-9%	-6%	-10%	-6%

		Runoff coefficient 0.51																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2040 Apr	2.91E+05	4.89E+05	5.36E+05	9.21E+05	1.11E+06	71759	277629	6.19E+05	6.55E+05	1.19E+06	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 May	1.01E+06	1.58E+06	1.73E+06	2.97E+06	3.64E+06	2.48E+05	9.60E+05	2.14E+06	2.27E+06	4.10E+06	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jun	1.12E+06	1.76E+06	1.92E+06	3.31E+06	4.05E+06	2.77E+05	1.07E+06	2.39E+06	2.53E+06	4.58E+06	0%	9%	8%	10%	8%	-4%	-9%	-6%	-11%	-6%
Impacted	2040 Jul	5.23E+05	8.41E+05	9.20E+05	1.59E+06	1.93E+06	128968	4.99E+05	1.11E+06	1.18E+06	2.13E+06	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Aug	2.41E+05	4.12E+05	4.51E+05	7.77E+05	9.36E+05	59524	230283	513041	5.44E+05	9.84E+05	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Sep	2.08E+05	3.62E+05	3.97E+05	6.82E+05	8.19E+05	51256	198298	441783	4.68E+05	8.47E+05	0%	10%	8%	11%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Oct	1.61E+05	2.91E+05	3.19E+05	5.48E+05	6.54E+05	39682	153519	342025	362351	6.56E+05	0%	10%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Nov	1.66E+05	3.00E+05	3.29E+05	5.64E+05	6.74E+05	41005	158635	353424	374429	6.78E+05	0%	10%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Dec	1.21E+05	2.30E+05	2.53E+05	4.33E+05	5.13E+05	29762	115138	256516	271762	492045	0%	11%	9%	12%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jan	8.05E+04	1.69E+05	1.86E+05	3.18E+05	3.71E+05	19841	76757	171009	181173	328028	0%	12%	10%	13%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Feb	8.91E+04	1.81E+05	2.00E+05	3.42E+05	4.01E+05	21967	84978	189330	200582	363172	0%	12%	10%	12%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Mar	1.21E+05	2.29E+05	2.52E+05	4.32E+05	5.11E+05	29762	115129	256508	271753	492036	0%	11%	9%	12%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Apr	2.91E+05	4.87E+05	5.34E+05	9.19E+05	1.11E+06	71759	277580	6.18E+05	6.55E+05	1.19E+06	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 May	1.01E+06	1.58E+06	1.72E+06	2.97E+06	3.63E+06	2.48E+05	9.59E+05	2.14E+06	2.27E+06	4.10E+06	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jun	1.12E+06	1.75E+06	1.91E+06	3.30E+06	4.04E+06	2.77E+05	1.07E+06	2.39E+06	2.53E+06	4.58E+06	0%	9%	8%	10%	8%	-4%	-9%	-6%	-11%	-6%
Impacted	2041 Jul	5.23E+05	8.38E+05	9.17E+05	1.58E+06	1.93E+06	128968	4.99E+05	1.11E+06	1.18E+06	2.13E+06	0%	9%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Aug	2.41E+05	4.10E+05	4.50E+05	7.75E+05	9.34E+05	59524	230224	512982	5.43E+05	9.84E+05	0%	10%	8%	10%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Sep	2.08E+05	3.60E+05	3.95E+05	6.80E+05	8.17E+05	51256	198243	441729	4.68E+05	8.47E+05	0%	10%	8%	11%	8%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Oct	1.61E+05	2.90E+05	3.18E+05	5.47E+05	6.53E+05	39682	153474	341979	362306	6.56E+05	0%	10%	9%	11%	9%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Nov	1.66E+05	2.99E+05	3.28E+05	5.62E+05	6.72E+05	41005	158585	353374	374378	6.78E+05	0%	10%	9%	11%	9%	-4%	-9%	-6%	-11%	-6%
Impacted	2041 Dec	1.21E+05	2.29E+05	2.52E+05	4.32E+05	5.11E+05	29762	115099	256478	271723	492006	0%	11%	9%	12%	9%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Jan	8.05E+04	1.68E+05	1.85E+05	3.17E+05	3.70E+05	19841	76731	170984	181147	328003	0%	45%	44%	46%	37%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Feb	8.91E+04	1.81E+05	1.99E+05	3.41E+05	4.00E+05	21967	84953	189304	200556	363146	0%	41%	40%	42%	34%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Mar	1.21E+05	2.28E+05	2.51E+05	4.30E+05	5.10E+05	29762	115097	256476	271721	492004	0%	31%	30%	32%	26%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Apr	2.91E+05	4.85E+05	5.32E+05	9.15E+05	1.11E+06	71759	277512	6.18E+05	6.55E+05	1.19E+06	0%	16%	15%	17%	14%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 May	1.01E+06	1.57E+06	1.71E+06	2.95E+06	3.61E+06	2.48E+05	9.59E+05	2.14E+06	2.26E+06	4.10E+06	0%	8%	7%	9%	7%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Jun	1.12E+06	1.74E+06	1.90E+06	3.28E+06	4.02E+06	2.77E+05	1.07E+06	2.39E+06	2.53E+06	4.58E+06	0%	8%	6%	9%	7%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Jul	5.23E+05	8.34E+05	9.12E+05	1.57E+06	1.92E+06	128968	4.99E+05	1.11E+06	1.18E+06	2.13E+06	0%	11%	9%	12%	9%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Aug	2.41E+05	4.08E+05	4.48E+05	7.71E+05	9.30E+05	59524	230194	512952	5.43E+05	9.84E+05	0%	18%	16%	19%	15%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Sep	2.08E+05	3.59E+05	3.93E+05	6.76E+05	8.13E+05	51256	198223	441708	4.68E+05	8.47E+05	0%	20%	19%	21%	17%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Oct	1.61E+05	2.88E+05	3.17E+05	5.44E+05	6.50E+05	39682	153463	341968	362295	6.56E+05	0%	25%	24%	26%	21%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Nov	1.66E+05	2.97E+05	3.26E+05	5.59E+05	6.69E+05	41005	158578	353367	374371	6.78E+05	0%	24%	23%	25%	20%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Dec	1.21E+05	2.28E+05	2.51E+05	4.30E+05	5.09E+05	29762	115097	256476	271721	492004	0%	31%	30%	32%	26%	-4%	-9%	-6%	-11%	-6%
Impacted	2043 Jan	8.05E+04	1.74E+05	1.92E+05	3.29E+05	3.82E+05	19841	79775	174028	184191	331047	0%	7%	4%	8%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Feb	8.91E+04	1.84E+05	2.03E+05	3.48E+05	4.07E+05	21967	87996	192347	203600	366190	0%	6%	4%	7%	6%	-4%	-6%	-5%	-9%	-5%
Impacted	2043 Mar	1.21E+05	2.21E+05	2.43E+05	4.17E+05	4.97E+05	29762	118141	259520	274765	495048	0%	6%	4%	7%	5%	-4%	-7%	-5%	-9%	-6%
Impacted	2043 Apr	2.91E+05	4.20E+05	4.58E+05	7.92E+05	9.83E+05	71759	280555	6.21E+05	6.58E+05	1.19E+06	0%	4%	3%	5%	4%	-4%	-8%	-6%	-10%	-6%
Impacted	2043 May	1.01E+06	1.25E+06	1.36E+06	2.36E+06	3.03E+06	2.48E+05	9.62E+05	2.14E+06	2.27E+06	4.10E+06	0%	4%	2%	4%	4%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jun	1.12E+06	1.39E+06	1.51E+06	2.62E+06	3.36E+06	2.77E+05	1.07E+06	2.39E+06	2.53E+06	4.58E+06	0%	4%	2%	4%	4%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jul	5.23E+05	6.91E+05	7.50E+05	1.30E+06	1.65E+06	128968	5.10E+05	1.12E+06	1.19E+06	2.15E+06	0%	4%	2%	5%	4%	-4%	-7%	-6%	-10%	-6%
Impacted	2043 Aug	2.41E+05	3.62E+05	3.95E+05	6.83E+05	8.42E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	5%	3%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Sep	2.08E+05	3.23E+05	3.53E+05	6.09E+05	7.46E+05	51256	208315	451801	478848	8.58E+05	0%	5%	3%	6%	4%	-4%	-4%	-4%	-8%	-5%
Impacted	2043 Oct	1.61E+05	2.68E+05	2.94E+05	5.06E+05	6.12E+05	39682	162470	350975	371914	6.66E+05	0%	5%	3%	6%	5%	-4%	-4%	-4%	-8%	-5%
Impacted	2043 Nov	1.66E+05	2.74E+05	3.00E+05	5.18E+05	6.27E+05	41005	168235	363024	384662	6.88E+05	0%	5%	3%	6%	5%	-4%	-3%	-4%	-8%	-5%
Impacted	2043 Dec	1.21E+05	2.21E+05	2.43E+05	4.17E+05	4.97E+05	29762	122947	264325	280030	500313	0%	6%	4%	7%	5%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Jan	8.05E+04	1.74E+05	1.92E+05	3.29E+05	3.82E+05	19841	82895	177147	187617	334473	0%	6%	4%	7%	6%	-4%	-2%	-3%	-7%	-4%
Impacted	2044 Feb	8.60E+04	1.81E+05	1.99E+05	3.41E+05	3.98E+05	21210	88229	188982	200174	357158	0%	6%	4%	7%	5%	-4%	-2%	-3%	-7%	-4%
Impacted	2044 Mar	1.21E+05	2.21E+05	2.43E+05	4.17E+05	4.97E+05	29762	122211	263590	279294	499577	0%	5%	3%	6%	5%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Apr	2.91E+05	4.20E+05	4.58E+05	7.92E+05	9.83E+05	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	4%	3%	5%	4%	-4%	-5%	-4%	-9%	-5%
Impacted	2044 May	1.01E+06	1.25E+06	1.36E+06	2.36E+06	3.03E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	4%	2%	4%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Jun	1.12E+06	1.61E+06	1.76E+06	3.04E+06	3.78E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	4%	3%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	5%	3%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	4%	3%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2044 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	5%	3%	5%	4%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	5%	3%	5%	4%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	5%	3%	5%	4%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	5%	3%	5%	4%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	4%	3%	5%	4%	-4%	-2%	-3%	-7%	-4%
Impacted	2045 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	4%	3%	5%	4%	-4%	-2%	-3%	-8%	-4%
Impacted	2045 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	4%	3%	5%	4%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	4%	3%	5%	4%	-4%	-5%	-4%	-9%	-5%
Impacted	2045 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	4%	3%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	4%	3%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	4%	3%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	4%	3%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2045 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	4.79E+05	8.58E+05	0%	4%	3%	5%	4%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	4%	3%	5%	4%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	4%	3%	5%	4%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	4%	3%	5%	4%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	4%	3%	5%	4%	-4%	-2%	-3%	-7%	-4%
Impacted	2046 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	4%	3%	5%	4%	-4%	-2%	-3%	-8%	-4%
Impacted	2046 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	4%	3%	5%	4%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	4%	3%	5%	4%	-4%	-5%	-4%	-9%	-5%
Impacted	2046 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	4%	3%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	4%	3%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	4%	3%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	4%	3%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2046 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	4.79E+05	8.58E+05	0%	4%	3%	5%	4%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	4%	3%	5%	4%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	4%	3%	5%	4%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	4%	3%	5%	4%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2047 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2047 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2047 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2047 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2048 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2048 Feb	8.60E+04	1.34E+05	1.47E+05	2.53E+05	3.10E+05	21210	88229	188982	200174	357158	0%	9%	7%	9%	7%	-4%	-2%	-3%	-7%	-4%
Impacted	2048 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2048 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2048 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2048 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2048 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2049 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2049 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2049 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2049 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2050 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2050 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2050 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	5.23E+05	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2050 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	4.79E+05	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2051 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2051 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2051 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2051 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2052 Feb	8.60E+04	1.34E+05	1.47E+05	2.53E+05	3.10E+05	21210	88229	188982	200174	357158	0%	9%	7%	9%	7%	-4%	-2%	-3%	-7%	-4%
Impacted	2052 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2052 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2052 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2053 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2053 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2053 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2053 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2054 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2054 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2054 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2054 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2055 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2055 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2055 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	5.23E+05	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2055 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	4.79E+05	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2055 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2056 Feb	8.60E+04	1.34E+05	1.47E+05	2.53E+05	3.10E+05	21210	88229	188982	200174	357158	0%	9%	7%	9%	7%	-4%	-2%	-3%	-7%	-4%
Impacted	2056 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2056 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2056 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2057 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2057 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2057 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2057 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2058 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2058 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2058 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	5.23E+05	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2058 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	4.79E+05	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2059 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2059 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2059 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2059 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2060 Feb	8.60E+04	1.34E+05	1.47E+05	2.53E+05	3.10E+05	21210	88229	188982	200174	357158	0%	9%	7%	9%	7%	-4%	-2%	-3%	-7%	-4%
Impacted	2060 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2060 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2060 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2061 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2061 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2061 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2061 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2062 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2062 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2062 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2062 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2063 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2063 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2063 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%

		Runoff coefficient 0.51																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2063 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	5.23E+05	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2063 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2064 Feb	8.60E+04	1.34E+05	1.47E+05	2.53E+05	3.10E+05	21210	88229	188982	200174	357158	0%	9%	7%	9%	7%	-4%	-2%	-3%	-7%	-4%
Impacted	2064 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2064 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2064 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2065 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2065 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2065 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2065 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2066 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2066 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2066 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2066 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2067 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2067 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2067 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2067 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2068 Feb	8.60E+04	1.34E+05	1.47E+05	2.53E+05	3.10E+05	21210	88229	188982	200174	357158	0%	9%	7%	9%	7%	-4%	-2%	-3%	-7%	-4%
Impacted	2068 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2068 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2068 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2069 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2069 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2069 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2069 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2070 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2070 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2070 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2070 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2071 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2071 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2071 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2071 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2071 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2071 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	9%	8%	10%	8%	-4%	-5%	-5%	-8%	-5%
Impacted	2071 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2072 Feb	8.60E+04	1.34E+05	1.47E+05	2.53E+05	3.10E+05	21210	88229	188982	200174	357158	0%	9%	7%	9%	7%	-4%	-2%	-3%	-7%	-4%
Impacted	2072 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2072 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2072 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	9%	8%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2073 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2073 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2073 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	5.23E+05	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2073 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2074 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2074 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2074 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2074 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2075 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2075 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2075 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2075 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2076 Feb	8.60E+04	1.34E+05	1.47E+05	2.53E+05	3.10E+05	21210	88229	188982	200174	357158	0%	9%	7%	9%	7%	-4%	-2%	-3%	-7%	-4%
Impacted	2076 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2076 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2076 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2077 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2077 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2077 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2077 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2077 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	5.23E+05	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2077 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	4.79E+05	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2077 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2078 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2078 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2078 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2078 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2078 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2078 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2078 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2079 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2079 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2079 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2079 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2079 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2080 Feb	8.60E+04	1.34E+05	1.47E+05	2.53E+05	3.10E+05	21210	88229	188982	200174	357158	0%	9%	7%	9%	7%	-4%	-2%	-3%	-7%	-4%
Impacted	2080 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2080 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2080 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2081 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2081 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2081 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2081 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2082 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2082 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2082 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	5.23E+05	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2082 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2083 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2083 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2083 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2083 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2084 Feb	8.60E+04	1.34E+05	1.47E+05	2.53E+05	3.10E+05	21210	88229	188982	200174	357158	0%	9%	7%	9%	7%	-4%	-2%	-3%	-7%	-4%
Impacted	2084 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2084 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	5.23E+05	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2084 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	4.79E+05	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%	
Impacted	2084 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2085 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2085 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2085 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2085 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2086 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2086 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2086 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2086 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.51																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2086 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2087 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2087 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2087 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2087 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2088 Feb	8.60E+04	1.34E+05	1.47E+05	2.53E+05	3.10E+05	21210	88229	188982	200174	357158	0%	9%	7%	9%	7%	-4%	-2%	-3%	-7%	-4%
Impacted	2088 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2088 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2088 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2089 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2089 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2089 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	5.23E+05	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2089 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2090 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2090 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2090 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2090 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2091 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2091 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2091 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2091 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2092 Feb	8.60E+04	1.34E+05	1.47E+05	2.53E+05	3.10E+05	21210	88229	188982	200174	357158	0%	9%	7%	9%	7%	-4%	-2%	-3%	-7%	-4%
Impacted	2092 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2092 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2092 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2093 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2093 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2093 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	5.23E+05	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2093 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	4.79E+05	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2094 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2094 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2094 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%

		Runoff coefficient 0.51																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2094 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2094 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2095 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2095 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2095 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2095 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2096 Feb	8.60E+04	1.34E+05	1.47E+05	2.53E+05	3.10E+05	21210	88229	188982	200174	357158	0%	9%	7%	9%	7%	-4%	-2%	-3%	-7%	-4%
Impacted	2096 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2096 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	5.23E+05	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2096 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	4.79E+05	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2097 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2097 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2097 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2097 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2098 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2098 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2098 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2098 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Jan	8.05E+04	1.26E+05	1.38E+05	2.39E+05	2.92E+05	19841	82895	177147	187617	334473	0%	9%	8%	10%	8%	-4%	-2%	-3%	-7%	-4%
Impacted	2099 Feb	8.91E+04	1.39E+05	1.52E+05	2.62E+05	3.21E+05	21967	91272	195623	207215	369805	0%	9%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2099 Mar	1.21E+05	1.86E+05	2.04E+05	3.51E+05	4.31E+05	29762	122211	263590	279294	499577	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Apr	2.91E+05	4.52E+05	4.94E+05	8.52E+05	1.04E+06	71759	290852	6.32E+05	6.70E+05	1.20E+06	0%	8%	6%	9%	7%	-4%	-5%	-4%	-9%	-5%
Impacted	2099 May	1.01E+06	1.58E+06	1.73E+06	2.98E+06	3.64E+06	2.48E+05	1.00E+06	2.18E+06	2.31E+06	4.15E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Jun	1.12E+06	1.76E+06	1.93E+06	3.33E+06	4.07E+06	2.77E+05	1.12E+06	2.43E+06	2.58E+06	4.63E+06	0%	9%	8%	10%	8%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Jul	5.23E+05	8.13E+05	8.87E+05	1.53E+06	1.88E+06	128968	5.20E+05	1.13E+06	1.20E+06	2.16E+06	0%	8%	6%	9%	7%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Aug	2.41E+05	3.69E+05	4.03E+05	6.95E+05	8.54E+05	59524	240665	523422	5.55E+05	9.95E+05	0%	6%	5%	7%	6%	-4%	-5%	-5%	-9%	-5%
Impacted	2099 Sep	2.08E+05	3.21E+05	3.51E+05	6.06E+05	7.43E+05	51256	208315	451801	478848	8.58E+05	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Oct	1.61E+05	2.51E+05	2.75E+05	4.74E+05	5.80E+05	39682	162470	350975	371914	6.66E+05	0%	9%	7%	9%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Nov	1.66E+05	2.62E+05	2.87E+05	4.95E+05	6.04E+05	41005	168235	363024	384662	6.88E+05	0%	10%	8%	11%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Dec	1.21E+05	1.90E+05	2.08E+05	3.59E+05	4.39E+05	29762	122947	264325	280030	500313	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Baseline	2017 Jan	120,163	172,713	191,631	323,661	402,709	120,163	172,713	191,631	323,661	402,709	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Feb	133,037	191,218	212,126	358,301	445,819	133,037	191,218	212,126	358,301	445,819	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Mar	180,244	259,070	287,346	485,390	603,963	180,244	259,070	287,346	485,390	603,963	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Apr	434,589	624,646	692,696	1,170,200	1,456,090	434,589	624,646	692,696	1,170,200	1,456,090	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 May	1,502,030	2,158,910	2,393,670	4,044,040	5,032,150	1,502,030	2,158,910	2,393,670	4,044,040	5,032,150	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jun	1,676,270	2,409,350	2,670,850	4,512,660	5,615,390	1,676,270	2,409,350	2,670,850	4,512,660	5,615,390	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jul	781,058	1,122,640	1,244,260	2,102,450	2,616,260	781,058	1,122,640	1,244,260	2,102,450	2,616,260	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Aug	360,488	518,139	574,165	970,253	1,207,400	360,488	518,139	574,165	970,253	1,207,400	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Sep	310,420	446,175	494,330	835,405	1,039,610	310,420	446,175	494,330	835,405	1,039,610	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Oct	240,325	345,426	382,637	646,695	804,793	240,325	345,426	382,637	646,695	804,793	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Nov	248,336	356,940	395,319	668,180	831,547	248,336	356,940	395,319	668,180	831,547	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Dec	180,244	259,070	286,873	484,917	603,489	180,244	259,070	286,873	484,917	603,489	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Impacted	2018 Jan	120,163	172,713	191,213	323,242	402,291	120,163	172,713	191,213	323,242	402,291	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Feb	133,037	191,218	211,663	357,838	445,356	133,037	191,218	211,663	357,838	445,356	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Mar	180,244	259,070	286,718	484,762	603,335	180,244	259,070	286,718	484,762	603,335	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Apr	434,589	624,646	691,182	1,168,690	1,454,580	434,589	624,646	691,182	1,168,690	1,454,580	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 May	1,502,030	2,158,910	2,388,440	4,038,810	5,026,910	1,502,030	2,158,910	2,388,440	4,038,810	5,026,910	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Jun	1,676,270	2,409,350	2,665,010	4,506,820	5,609,550	1,676,270	2,409,350	2,665,010	4,506,820	5,609,550	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Jul	781,058	1,122,640	1,241,540	2,099,730	2,613,540	781,058	1,122,640	1,241,540	2,099,730	2,613,540	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Aug	360,488	518,139	572,909	968,997	1,206,140	360,488	518,139	572,909	968,997	1,206,140	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Sep	310,420	446,175	493,248	834,324	1,038,530	310,420	446,175	493,248	834,324	1,038,530	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Oct	240,325	345,426	381,800	645,858	803,955	240,325	345,426	381,800	645,858	803,955	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Nov	248,336	356,940	394,454	667,315	830,682	248,336	356,940	394,454	667,315	830,682	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2018 Dec	180,244	259,070	286,245	484,289	602,862	180,244	259,070	286,245	484,289	602,862	0%	5%	5%	4%	4%	0%	0%	0%	0%	0%
Impacted	2019 Jan	120,163	218,840	242,761	409,617	488,665	120,163	218,840	242,761	409,617	488,665	0%	6%	6%	5%	4%	0%	0%	0%	0%	0%
Impacted	2019 Feb	133,037	237,306	263,119	443,081	530,599	133,037	237,306	263,119	443,081	530,599	0%	6%	5%	5%	4%	0%	0%	0%	-1%	0%
Impacted	2019 Mar	180,244	305,086	337,925	567,882	686,455	180,244	305,086	337,925	567,882	686,455	0%	6%	5%	5%	4%	0%	0%	0%	-1%	-1%
Impacted	2019 Apr	434,589	670,352	741,138	1,242,460	1,528,350	434,589	670,352	741,138	1,242,460	1,528,350	0%	5%	5%	4%	4%	0%	0%	0%	-1%	-1%
Impacted	2019 May	1,502,030	2,203,100	2,432,880	4,067,320	5,055,430	1,502,030	2,203,100	2,432,880	4,067,320	5,055,430	0%	5%	4%	4%	3%	0%	0%	0%	-2%	-1%
Impacted	2019 Jun	1,676,270	2,480,650	2,739,360	4,567,680	5,670,400	1,676,270	2,480,650	2,739,360	4,567,680	5,670,400	0%	5%	4%	4%	3%	0%	0%	0%	-2%	-1%
Impacted	2019 Jul	781,058	1,194,590	1,319,800	2,195,480	2,709,300	781,058	1,194,590	1,319,800	2,195,480	2,709,300	0%	5%	5%	4%	3%	0%	0%	0%	-3%	-1%
Impacted	2019 Aug	360,488	577,166	638,111	1,059,270	1,296,410	360,488	577,166	638,111	1,059,270	1,296,410	0%	5%	5%	5%	4%	0%	0%	0%	-3%	-2%
Impacted	2019 Sep	310,420	505,557	559,025	925,907	1,130,120	310,420	505,557	559,025	925,907	1,130,120	0%	6%	5%	5%	4%	0%	0%	0%	-3%	-2%
Impacted	2019 Oct	240,325	403,479	446,330	737,806	895,903	240,325	403,479	446,330	737,806	895,903	0%	6%	5%	5%	4%	0%	0%	0%	-4%	-2%
Impacted	2019 Nov	248,336	417,047	461,264	760,690	924,058	248,336	417,047	461,264	760,690	924,058	0%	6%	5%	5%	4%	0%	0%	0%	-4%	-2%
Impacted	2019 Dec	180,244	316,284	350,042	576,410	694,983	180,244	316,284	350,042	576,410	694,983	0%	6%	5%	5%	4%	0%	0%	0%	-4%	-3%
Impacted	2020 Jan	120,163	225,405	249,762	412,432	491,481	120,163	225,405	249,762	412,432	491,481	0%	7%	6%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 Feb	128,450	235,883	261,335	433,507	518,007	128,450	235,883	261,335	433,507	518,007	0%	6%	6%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 Mar	180,244	310,201	343,362	572,084	690,657	180,244	310,201	343,362	572,084	690,657	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 Apr	434,589	678,592	749,962	1,255,840	1,541,730	434,589	678,592	749,962	1,255,840	1,541,730	0%	5%	5%	4%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 May	1,502,030	2,218,920	2,450,250	4,127,640	5,115,750	1,502,030	2,218,920	2,450,250	4,127,640	5,115,750	0%	5%	5%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2020 Jun	1,676,270	2,452,930	2,708,890	4,591,600	5,694,330	1,676,270	2,452,930	2,708,890	4,591,600	5,694,330	0%	5%	5%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2020 Jul	781,058	1,157,900	1,279,400	2,181,420	2,695,230	781,058	1,157,900	1,279,400	2,181,420	2,695,230	0%	5%	5%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2020 Aug	360,488	554,439	613,217	1,051,100	1,288,240	360,488	554,439	613,217	1,051,100	1,288,240	0%	5%	5%	4%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 Sep	310,420	481,082	532,297	917,451	1,121,660	310,420	481,082	532,297	917,451	1,121,660	0%	5%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 Oct	240,325	380,733	421,540	730,159	888,256	240,325	380,733	421,540	730,159	888,256	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 Nov	248,336	389,619	431,414	751,651	915,019	248,336	389,619	431,414	751,651	915,019	0%	5%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2020 Dec	180,244	293,529	325,304	569,024	687,597	180,244	293,529	325,304	569,024	687,597	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Jan	120,163	210,437	233,486	408,153	487,202	120,163	210,437	233,486	408,153	487,202	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Feb	133,037	228,030	252,863	442,254	529,772	133,037	228,030	252,863	442,254	529,772	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Mar	180,244	292,452	323,929	567,640	686,213	180,244	292,452	323,929	567,640	686,213	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Apr	434,589	640,882	708,445	1,246,250	1,532,140	434,589	640,882	708,445	1,246,250	1,532,140	0%	5%	5%	4%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 May	1,502,030	2,106,160	2,325,200	4,098,380	5,086,490	1,502,030	2,106,160	2,325,200	4,098,380	5,086,490	0%	5%	4%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2021 Jun	1,676,270	2,582,380	2,800,990	4,591,840	5,695,130	1,676,270	2,582,380	2,800,990	4,591,840	5,695,130	0%	5%	5%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2021 Jul	781,058	1,226,780	1,331,650	2,185,160	2,699,240	781,058	1,226,780	1,331,650	2,185,160	2,699,240	0%	5%	5%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2021 Aug	360,488	590,554	642,046	1,055,080	1,292,340	360,488	590,554	642,046	1,055,080	1,292,340	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Sep	310,420	516,192	561,299	921,954	1,126,270	310,420	516,192	561,299	921,954	1,126,270	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Oct	240,325	411,021	447,226	734,479	892,656	240,325	411,021	447,226	734,479	892,656	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Nov	248,336	424,110	461,291	757,014	920,464	248,336	424,110	461,291	757,014	920,464	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2021 Dec	180,244	320,809	349,371	573,735	692,367	180,244	320,809	349,371	573,735	692,367	0%	6%	5%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Jan	120,163	172,852	186,665	304,808	383,897	120,163	172,852	186,665	304,808	383,897	0%	0%	-3%	-6%	-5%	0%	0%	0%	-5%	-3%
Impacted	2022 Feb	133,037	213,965	232,091	380,156	467,718	133,037	213,965	232,091	380,156	467,718	0%	12%	9%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2022 Mar	180,244	321,011	349,496	574,011	692,644	180,244	321,011	349,496	574,011	692,644	0%	24%	22%	18%	15%	0%	0%	0%	-5%	-3%
Impacted	2022 Apr	434,589	710,178	770,549	1,262,220	1,548,260	434,589	710,178	770,549	1,262,220	1,548,260	0%	14%	11%	8%	6%	0%	0%	0%	-5%	-3%
Impacted	2022 May	1,502,030	2,349,030	2,543,110	4,162,770	5,151,380	1,502,030	2,349,030	2,543,110	4,162,770	5,151,380	0%	9%	6%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2022 Jun	1,676,270	2,619,040	2,834,710	4,640,520	5,743,800	1,676,270	2,619,040	2,834,710	4,640,520	5,743,800	0%	9%	6%	3%	2%	0%	0%	0%	-5%	-3%
Impacted	2022 Jul	781,058	1,243,860	1,347,360	2,207,910	2,721,990	781,058	1,243,860	1,347,360	2,207,910	2,721,990	0%	11%	8%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Aug	360,488	598,437	649,298	1,065,610	1,302,870	360,488	598,437	649,298	1,065,610	1,302,870	0%	15%	13%	10%	8%	0%	0%	0%	-5%	-3%
Impacted	2022 Sep	310,420	522,980	567,543	931,048	1,135,360	310,420	522,980	567,543	931,048	1,135,360	0%	17%	15%	11%	9%	0%	0%	0%	-5%	-3%
Impacted	2022 Oct	240,325	416,276	452,061	741,539	899,717	240,325	416,276	452,061	741,539	899,717	0%	21%	18%	15%	12%	0%	0%	-1%	-5%	-3%
Impacted	2022 Nov	248,336	429,540	466,286	764,330	927,780	248,336	429,540	466,286	764,330	927,780	0%	20%	18%	14%	12%	0%	0%	-1%	-5%	-3%
Impacted	2022 Dec	180,244	324,751	352,997	579,060	697,693	180,244	324,751	352,997	579,060	697,693	0%	25%	23%	19%	16%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jan	120,163	171,981	185,139	301,535	380,624	120,163	171,981	185,139	301,535	380,624	0%	0%	-3%	-7%	-5%	0%	0%	-1%	-5%	-3%
Impacted	2023 Feb	133,037	190,156	204,666	333,351	420,914	133,037	190,156	204,666	333,351	420,914	0%	-1%	-4%	-7%	-6%	0%	0%	-1%	-5%	-3%
Impacted	2023 Mar	180,244	285,096	308,218	503,777	622,410	180,244	285,096	308,218	503,777	622,410	0%	10%	7%	4%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Apr	434,589	719,684	779,292	1,274,980	1,561,020	434,589	719,684	779,292	1,274,980	1,561,020	0%	15%	13%	9%	7%	0%	0%	-1%	-5%	-3%
Impacted	2023 May	1,502,030	2,375,030	2,565,620	4,188,040	5,176,640	1,502,030	2,375,030	2,565,620	4,188,040	5,176,640	0%	10%	7%	4%	3%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jun	1,676,270	2,624,290	2,833,050	4,622,080	5,725,360	1,676,270	2,624,290	2,833,050	4,622,080	5,725,360	0%	9%	6%	2%	2%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jul	781,058	1,266,230	1,369,020	2,236,860	2,750,930	781,058	1,266,230	1,369,020	2,236,860	2,750,930	0%	13%	10%	6%	5%	0%	0%	-1%	-5%	-3%
Impacted	2023 Aug	360,488	608,598	659,116	1,078,540	1,315,810	360,488	608,598	659,116	1,078,540	1,315,810	0%	17%	15%	11%	9%	0%	0%	-1%	-5%	-3%
Impacted	2023 Sep	310,420	531,824	576,103	942,329	1,146,640	310,420	531,824	576,103	942,329	1,146,640	0%	19%	17%	13%	10%	0%	0%	-1%	-5%	-3%
Impacted	2023 Oct	240,325	423,195	458,769	750,351	908,529	240,325	423,195	458,769	750,351	908,529	0%	23%	20%	16%	13%	0%	0%	-1%	-5%	-3%
Impacted	2023 Nov	248,336	436,754	473,290	773,579	937,029	248,336	436,754	473,290	773,579	937,029	0%	22%	20%	16%	13%	0%	0%	-1%	-5%	-3%
Impacted	2023 Dec	180,244	327,920	355,752	581,798	700,431	180,244	327,920	355,752	581,798	700,431	0%	27%	24%	20%	16%	0%	0%	-1%	-5%	-3%
Impacted	2024 Jan	120,163	190,655	205,668	334,420	413,509	120,163	190,655	205,668	334,420	413,509	0%	10%	7%	3%	3%	0%	0%	-1%	-5%	-3%
Impacted	2024 Feb	128,450	248,033	269,719	441,575	526,118	128,450	248,033	269,719	441,575	526,118	0%	34%	32%	28%	22%	0%	0%	-1%	-5%	-3%
Impacted	2024 Mar	180,244	328,795	356,862	584,253	702,885	180,244	328,795	356,862	584,253	702,885	0%	27%	24%	20%	16%	0%	0%	-1%	-6%	-3%
Impacted	2024 Apr	434,589	727,758	787,193	1,287,310	1,573,350	434,589	727,758	787,193	1,287,310	1,573,350	0%	17%	14%	10%	8%	0%	-1%	-1%	-6%	-3%
Impacted	2024 May	1,502,030	2,405,940	2,597,070	4,242,790	5,231,400	1,502,030	2,405,940	2,597,070	4,242,790	5,231,400	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jun	1,676,270	2,677,660	2,890,270	4,724,430	5,827,710	1,676,270	2,677,660	2,890,270	4,724,430	5,827,710	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jul	781,058	1,268,680	1,370,840	2,244,380	2,758,460	781,058	1,268,680	1,370,840	2,244,380	2,758,460	0%	13%	10%	7%	5%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Aug	360,488	608,674	658,946	1,080,900	1,318,170	360,488	608,674	658,946	1,080,900	1,318,170	0%	17%	15%	11%	9%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Sep	310,420	530,991	575,104	943,598	1,147,910	310,420	530,991	575,104	943,598	1,147,910	0%	19%	16%	13%	10%	0%	-1%	-1%	-6%	-3%

		Runoff coefficient 0.41																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2024 Oct	240,325	421,855	457,334	750,678	908,856	240,325	421,855	457,334	750,678	908,856	0%	22%	20%	16%	13%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Nov	248,336	434,651	471,126	773,381	936,831	248,336	434,651	471,126	773,381	936,831	0%	22%	19%	16%	13%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Dec	180,244	327,940	356,015	585,008	703,641	180,244	327,940	356,015	585,008	703,641	0%	27%	24%	21%	17%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jan	120,163	233,778	254,440	419,402	498,490	120,163	233,778	254,440	419,402	498,490	0%	35%	33%	30%	24%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Feb	133,037	253,546	275,793	454,784	542,346	133,037	253,546	275,793	454,784	542,346	0%	33%	30%	27%	22%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Mar	180,244	326,499	354,559	584,704	703,337	180,244	326,499	354,559	584,704	703,337	0%	26%	23%	20%	16%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Apr	434,589	722,221	781,640	1,287,370	1,573,400	434,589	722,221	781,640	1,287,370	1,573,400	0%	16%	13%	10%	8%	0%	-1%	-1%	-6%	-3%
Impacted	2025 May	1,502,030	2,386,810	2,577,880	4,241,150	5,229,760	1,502,030	2,386,810	2,577,880	4,241,150	5,229,760	0%	11%	8%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jun	1,676,270	2,656,310	2,868,860	4,722,540	5,825,830	1,676,270	2,656,310	2,868,860	4,722,540	5,825,830	0%	10%	7%	5%	4%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jul	781,058	1,277,460	1,381,950	2,279,320	2,793,400	781,058	1,277,460	1,381,950	2,279,320	2,793,400	0%	14%	11%	8%	7%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Aug	360,488	604,081	654,340	1,081,070	1,318,340	360,488	604,081	654,340	1,081,070	1,318,340	0%	17%	14%	11%	9%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Sep	310,420	527,036	571,137	943,846	1,148,160	310,420	527,036	571,137	943,846	1,148,160	0%	18%	16%	13%	10%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Oct	240,325	418,793	454,264	751,036	909,213	240,325	418,793	454,264	751,036	909,213	0%	21%	19%	16%	13%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Nov	248,336	431,487	467,953	773,726	937,176	248,336	431,487	467,953	773,726	937,176	0%	21%	18%	16%	13%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Dec	180,244	325,644	353,712	585,460	704,092	180,244	325,644	353,712	585,460	704,092	0%	26%	23%	21%	17%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jan	120,163	232,247	252,905	419,315	498,404	120,163	232,247	252,905	419,315	498,404	0%	34%	32%	30%	24%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Feb	133,037	251,852	274,093	454,659	542,221	133,037	251,852	274,093	454,659	542,221	0%	32%	29%	27%	22%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Mar	180,244	324,203	352,257	584,505	703,138	180,244	324,203	352,257	584,505	703,138	0%	25%	23%	20%	16%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Apr	434,589	716,686	776,090	1,286,770	1,572,810	434,589	716,686	776,090	1,286,770	1,572,810	0%	15%	12%	10%	8%	0%	-1%	-2%	-6%	-4%
Impacted	2026 May	1,502,030	2,367,680	2,558,690	4,238,890	5,227,500	1,502,030	2,367,680	2,558,690	4,238,890	5,227,500	0%	10%	7%	5%	4%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jun	1,676,270	2,755,560	2,983,320	4,948,070	6,051,360	1,676,270	2,755,560	2,983,320	4,948,070	6,051,360	0%	14%	12%	10%	8%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jul	781,058	1,283,130	1,389,570	2,307,730	2,821,810	781,058	1,283,130	1,389,570	2,307,730	2,821,810	0%	14%	12%	10%	8%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Aug	360,488	599,490	649,736	1,080,590	1,317,850	360,488	599,490	649,736	1,080,590	1,317,850	0%	16%	13%	11%	9%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Sep	310,420	523,082	567,172	943,444	1,147,760	310,420	523,082	567,172	943,444	1,147,760	0%	17%	15%	13%	10%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Oct	240,325	415,732	451,194	750,743	908,920	240,325	415,732	451,194	750,743	908,920	0%	20%	18%	16%	13%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Nov	248,336	428,324	464,780	773,421	936,871	248,336	428,324	464,780	773,421	936,871	0%	20%	18%	16%	13%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Dec	180,244	320,964	348,724	580,753	699,386	180,244	320,964	348,724	580,753	699,386	0%	24%	22%	20%	16%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jan	120,163	160,570	172,347	286,253	365,342	120,163	160,570	172,347	286,253	365,342	0%	12%	10%	9%	8%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Feb	133,037	177,390	190,428	316,552	404,115	133,037	177,390	190,428	316,552	404,115	0%	12%	10%	9%	8%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Mar	180,244	239,646	257,311	428,231	546,863	180,244	239,646	257,311	428,231	546,863	0%	12%	10%	9%	8%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Apr	434,589	577,605	620,197	1,032,570	1,318,610	434,589	577,605	620,197	1,032,570	1,318,610	0%	12%	10%	9%	8%	0%	-1%	-2%	-7%	-4%
Impacted	2027 May	1,502,030	2,236,010	2,413,230	4,020,060	5,008,660	1,502,030	2,236,010	2,413,230	4,020,060	5,008,660	0%	13%	11%	10%	8%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jun	1,676,270	2,719,220	2,945,710	4,912,170	6,015,460	1,676,270	2,719,220	2,945,710	4,912,170	6,015,460	0%	15%	12%	11%	9%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jul	781,058	1,271,600	1,378,190	2,300,720	2,814,790	781,058	1,271,600	1,378,190	2,300,720	2,814,790	0%	15%	12%	11%	9%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Aug	360,488	596,413	647,041	1,081,310	1,318,580	360,488	596,413	647,041	1,081,310	1,318,580	0%	15%	13%	12%	9%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Sep	310,420	520,607	565,071	944,204	1,148,520	310,420	520,607	565,071	944,204	1,148,520	0%	15%	13%	12%	9%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Oct	240,325	413,951	449,738	751,422	909,599	240,325	413,951	449,738	751,422	909,599	0%	16%	13%	12%	10%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Nov	248,336	426,623	463,451	774,263	937,713	248,336	426,623	463,451	774,263	937,713	0%	16%	13%	12%	10%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Dec	180,244	322,215	350,573	585,920	704,553	180,244	322,215	350,573	585,920	704,553	0%	16%	14%	13%	10%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jan	120,163	230,030	250,899	419,650	498,738	120,163	230,030	250,899	419,650	498,738	0%	16%	14%	13%	10%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Feb	128,450	242,457	264,377	442,425	526,968	128,450	242,457	264,377	442,425	526,968	0%	16%	14%	13%	10%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Mar	180,244	321,071	349,492	585,255	703,887	180,244	321,071	349,492	585,255	703,887	0%	15%	13%	12%	9%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Apr	434,589	709,378	769,732	1,288,950	1,574,990	434,589	709,378	769,732	1,288,950	1,574,990	0%	14%	12%	11%	9%	0%	-1%	-2%	-7%	-4%
Impacted	2028 May	1,502,030	2,343,260	2,537,790	4,248,360	5,236,970	1,502,030	2,343,260	2,537,790	4,248,360	5,236,970	0%	13%	11%	10%	8%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jun	1,676,270	2,771,750	3,007,980	5,032,670	6,135,960	1,676,270	2,771,750	3,007,980	5,032,670	6,135,960	0%	14%	12%	11%	9%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jul	781,058	1,308,390	1,421,080	2,379,590	2,893,670	781,058	1,308,390	1,421,080	2,379,590	2,893,670	0%	14%	12%	11%	9%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Aug	360,488	607,619	660,407	1,107,400	1,344,670	360,488	607,619	660,407	1,107,400	1,344,670	0%	14%	12%	11%	9%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Sep	310,420	528,823	574,981	964,082	1,168,390	310,420	528,823	574,981	964,082	1,168,390	0%	15%	12%	11%	9%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Oct	240,325	417,530	454,308	761,796	919,973	240,325	417,530	454,308	761,796	919,973	0%	15%	12%	12%	9%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Nov	248,336	430,911	468,832	786,047	949,497	248,336	430,911	468,832	786,047	949,497	0%	15%	12%	12%	9%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Dec	180,244	321,905	350,662	588,298	706,931	180,244	321,905	350,662	588,298	706,931	0%	15%	13%	12%	9%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Jan	120,163	229,306	250,382	419,991	499,080	120,163	229,306	250,382	419,991	499,080	0%	16%	14%	13%	10%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Feb	133,037	248,668	271,391	455,500	543,062	133,037	248,668	271,391	455,500	543,062	0%	16%	13%	12%	10%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Mar	180,244	319,988	348,718	585,879	704,511	180,244	319,988	348,718	585,879	704,511	0%	15%	13%	12%	9%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Apr	434,589	723,590	786,626	1,321,290	1,607,330	434,589	723,590	786,626	1,321,290	1,607,330	0%	14%	12%	11%	9%	0%	-1%	-3%	-7%	-4%
Impacted	2029 May	1,502,030	2,440,420	2,649,750	4,447,940	5,436,540	1,502,030	2,440,420	2,649,750	4,447,940	5,436,540	0%	14%	11%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jun	1,676,270	2,755,740	2,993,770	5,027,160	6,130,450	1,676,270	2,755,740	2,993,770	5,027,160	6,130,450	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jul	781,058	1,304,160	1,418,180	2,383,560	2,897,640	781,058	1,304,160	1,418,180	2,383,560	2,897,640	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Aug	360,488	608,589	662,355	1,114,580	1,351,840	360,488	608,589	662,355	1,114,580	1,351,840	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Sep	310,420	529,552	576,541	970,040	1,174,350	310,420	529,552	576,541	970,040	1,174,350	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Oct	240,325	418,044	455,459	766,257	924,434	240,325	418,044	455,459	766,257	924,434	0%	15%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Nov	248,336	431,487	470,071	790,747	954,197	248,336	431,487	470,071	790,747	954,197	0%	15%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Dec	180,244	322,584	351,853	592,115	710,748	180,244	322,584	351,853	592,115	710,748	0%	15%	13%	12%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jan	120,163	228,585	249,866	420,955	500,044	120,163	228,585	249,866	420,955	500,044	0%	16%	14%	13%	10%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Feb	133,037	247,869	270,820	456,564	544,127	133,037	247,869	270,820	456,564	544,127	0%	16%	13%	12%	10%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Mar	180,244	318,905	347,945	587,162	705,795	180,244	318,905	347,945	587,162	705,795	0%	15%	13%	12%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Apr	434,589	704,158	766,001	1,293,380	1,579,420	434,589	704,158	766,001	1,293,380	1,579,420	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2030 May	1,502,030	2,429,520	2,641,210	4,452,360	5,440,970	1,502,030	2,429,520	2,641,210	4,452,360	5,440,970	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jun	1,676,270	2,732,900	2,972,120	5,011,260	6,114,550	1,676,270	2,732,900	2,972,120	5,011,260	6,114,550	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jul	781,058	1,297,780	1,412,940	2,384,760	2,898,840	781,058	1,297,780	1,412,940	2,384,760	2,898,840	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Aug	360,488	601,693	655,532	1,108,200	1,345,460	360,488	601,693	655,532	1,108,200	1,345,460	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Sep	310,420	522,614	569,550	962,789	1,167,100	310,420	522,614	569,550	962,789	1,167,100	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Oct	240,325	410,899	448,069	757,516	915,694	240,325	410,899	448,069	757,516	915,694	0%	15%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Nov	248,336	424,418	462,786	782,273	945,723	248,336	424,418	462,786	782,273	945,723	0%	15%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Dec	180,244	318,964	348,249	588,801	707,434	180,244	318,964	348,249	588,801	707,434	0%	15%	13%	12%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Jan	120,163	227,857	249,345	421,566	500,655	120,163	227,857	249,345	421,566	500,655	0%	32%	30%	30%	24%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Feb	133,037	247,053	270,233	457,232	544,795	133,037	247,053	270,233	457,232	544,795	0%	29%	27%	28%	22%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Mar	180,244	317,784	347,136	588,075	706,708	180,244	317,784	347,136	588,075	706,708	0%	23%	21%	21%	17%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Apr	434,589	701,418	764,017	1,295,600	1,581,640	434,589	701,418	764,017	1,295,600	1,581,640	0%	12%	10%	11%	9%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 May	1,502,030	2,388,280	2,598,940	4,402,820	5,391,430	1,502,030	2,388,280	2,598,940	4,402,820	5,391,430	0%	11%	9%	9%	7%	-1%	-2%	-3%	-7%	-4%
Impacted	2031 Jun	1,676,270	2,721,710	2,963,790	5,019,080	6,122,370	1,676,270	2,721,710	2,963,790	5,019,080	6,122,370	0%	13%	11%	11%	9%	-1%	-2%	-3%	-7%	-4%
Impacted	2031 Jul	781,058	1,286,570	1,402,380	2,377,670	2,891,750	781,058	1,286,570	1,402,380	2,377,670	2,891,750	0%	15%	13%	13%	11%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Aug	360,488	592,424	646,110	1,097,670	1,334,940	360,488	592,424	646,110	1,097,670	1,334,940	0%	14%	13%	13%	11%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Sep	310,420	513,696	560,399	952,099	1,156,410	310,420	513,696	560,399	952,099	1,156,410	0%	15%	13%	14%	11%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Oct	240,325	407,998	445,453	756,537	914,714	240,325	407,998	445,453	756,537	914,714	0%	18%	16%	17%	14%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Nov	248,336	420,458	459,014	779,569	943,019	248,336	420,458	459,014	779,569	943,019	0%	18%	16%	17%	13%	-1%	-3%	-3%	-8%	-5%
Impacted	2031 Dec	180,244	317,730	347,344	589,847	708,480	180,244	317,730	347,344	589,847	708,480	0%	23%	21%	22%	17%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Jan	120,163	227,034	248,742	422,273	501,362	120,163	227,034	248,742	422,273	501,362	0%	16%	14%	15%	12%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Feb	128,450	239,248	262,066	445,239	529,782	128,450	239,248	262,066	445,239	529,782	0%	16%	13%	15%	12%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Mar	180,244	316,558	346,241	589,159	707,792	180,244	316,558	346,241	589,159	707,792	0%	15%	13%	14%	11%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Apr	434,589	698,472	761,875	1,298,250	1,584,280	434,589	698,472	761,875	1,298,250	1,584,280	0%	13%	12%	13%	10%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 May	1,502,030	2,375,040	2,587,930	4,405,070	5,393,680	1,502,030	2,375,040	2,587,930	4,405,070	5,393,680	0%	13%	11%	13%	10%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Jun	1,676,270	2,072,000	2,236,180	3,820,820	4,924,110	1,676,270	2,072,000	2,236,180	3,820,820	4,924,110	0%	10%	9%	10%	8%	-1%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2032 Jul	781,058	960,315	1,036,810	1,774,630	2,288,700	781,058	960,315	1,036,810	1,774,630	2,288,700	0%	10%	9%	10%	8%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Aug	360,488	440,127	475,434	815,959	1,053,220	360,488	440,127	475,434	815,959	1,053,220	0%	10%	9%	10%	8%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Sep	310,420	378,837	409,241	702,466	906,779	310,420	378,837	409,241	702,466	906,779	0%	10%	9%	10%	8%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Oct	240,325	292,951	316,489	543,500	701,677	240,325	292,951	316,489	543,500	701,677	0%	10%	9%	10%	8%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Nov	248,336	302,747	327,070	561,644	725,094	248,336	302,747	327,070	561,644	725,094	0%	10%	9%	10%	8%	-1%	-4%	-4%	-8%	-5%
Impacted	2032 Dec	180,244	312,208	341,610	582,806	701,439	180,244	312,208	341,610	582,806	701,439	0%	14%	12%	14%	11%	-1%	-4%	-4%	-8%	-5%
Impacted	2033 Jan	120,163	226,232	248,163	423,027	502,115	120,163	226,232	248,163	423,027	502,115	0%	13%	11%	13%	10%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Feb	133,037	245,257	268,928	458,857	546,419	133,037	245,257	268,928	458,857	546,419	0%	13%	11%	13%	10%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Mar	180,244	315,357	345,375	590,286	708,919	180,244	315,357	345,375	590,286	708,919	0%	12%	11%	12%	10%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Apr	434,589	698,477	763,019	1,306,210	1,592,250	434,589	698,477	763,019	1,306,210	1,592,250	0%	11%	10%	11%	9%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 May	1,502,030	2,439,760	2,664,230	4,551,110	5,539,710	1,502,030	2,439,760	2,664,230	4,551,110	5,539,710	0%	11%	10%	11%	9%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jun	1,676,270	2,719,120	2,969,550	5,074,770	6,178,050	1,676,270	2,719,120	2,969,550	5,074,770	6,178,050	0%	11%	10%	11%	9%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jul	781,058	1,278,580	1,397,350	2,390,290	2,904,360	781,058	1,278,580	1,397,350	2,390,290	2,904,360	0%	12%	10%	11%	9%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Aug	360,488	602,275	658,989	1,128,730	1,365,990	360,488	602,275	658,989	1,128,730	1,365,990	0%	12%	10%	12%	9%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Sep	310,420	522,354	571,683	979,153	1,183,470	310,420	522,354	571,683	979,153	1,183,470	0%	12%	10%	12%	9%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Oct	240,325	411,193	450,277	771,131	929,308	240,325	411,193	450,277	771,131	929,308	0%	12%	10%	12%	9%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Nov	248,336	424,609	464,946	796,188	959,637	248,336	424,609	464,946	796,188	959,637	0%	12%	10%	12%	9%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Dec	180,244	315,327	345,611	592,104	710,736	180,244	315,327	345,611	592,104	710,736	0%	12%	11%	12%	10%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Jan	120,163	225,442	247,586	423,718	502,807	120,163	225,442	247,586	423,718	502,807	0%	13%	11%	13%	10%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Feb	133,037	245,681	269,714	461,810	549,372	133,037	245,681	269,714	461,810	549,372	0%	13%	11%	13%	10%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Mar	180,244	320,954	352,009	603,161	721,794	180,244	320,954	352,009	603,161	721,794	0%	12%	11%	12%	10%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Apr	434,589	728,642	797,526	1,366,890	1,652,920	434,589	728,642	797,526	1,366,890	1,652,920	0%	12%	10%	11%	9%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 May	1,502,030	2,444,420	2,672,160	4,578,610	5,567,210	1,502,030	2,444,420	2,672,160	4,578,610	5,567,210	0%	11%	10%	11%	9%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Jun	1,676,270	2,722,640	2,976,210	5,100,310	6,203,600	1,676,270	2,722,640	2,976,210	5,100,310	6,203,600	0%	11%	10%	11%	9%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Jul	781,058	1,283,610	1,404,100	2,407,360	2,921,440	781,058	1,283,610	1,404,100	2,407,360	2,921,440	0%	11%	10%	11%	9%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Aug	360,488	608,568	666,467	1,143,340	1,380,610	360,488	608,568	666,467	1,143,340	1,380,610	0%	12%	10%	12%	9%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Sep	310,420	528,616	579,009	992,880	1,197,190	310,420	528,616	579,009	992,880	1,197,190	0%	12%	10%	12%	9%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Oct	240,325	417,724	457,782	784,507	942,684	240,325	417,724	457,782	784,507	942,684	0%	12%	10%	12%	10%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Nov	248,336	430,677	471,897	808,469	971,919	248,336	430,677	471,897	808,469	971,919	0%	12%	10%	12%	10%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Dec	180,244	321,379	352,461	603,775	722,408	180,244	321,379	352,461	603,775	722,408	0%	12%	11%	12%	10%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Jan	120,163	225,131	247,296	423,558	502,647	120,163	225,131	247,296	423,558	502,647	0%	13%	11%	13%	10%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Feb	133,037	244,573	268,542	460,254	547,816	133,037	244,573	268,542	460,254	547,816	0%	13%	11%	12%	10%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Mar	180,244	320,572	351,671	603,083	721,716	180,244	320,572	351,671	603,083	721,716	0%	12%	10%	12%	10%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Apr	434,589	727,417	796,371	1,366,160	1,652,190	434,589	727,417	796,371	1,366,160	1,652,190	0%	11%	10%	11%	9%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 May	1,502,030	2,458,340	2,688,630	4,610,490	5,599,090	1,502,030	2,458,340	2,688,630	4,610,490	5,599,090	0%	11%	10%	11%	9%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jun	1,676,270	2,875,220	3,148,990	5,394,990	6,498,280	1,676,270	2,875,220	3,148,990	5,394,990	6,498,280	0%	12%	10%	12%	9%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jul	781,058	1,324,830	1,450,940	2,488,170	3,002,250	781,058	1,324,830	1,450,940	2,488,170	3,002,250	0%	12%	10%	11%	9%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Aug	360,488	607,007	664,902	1,141,750	1,379,020	360,488	607,007	664,902	1,141,750	1,379,020	0%	12%	10%	11%	9%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Sep	310,420	528,021	578,496	992,866	1,197,180	310,420	528,021	578,496	992,866	1,197,180	0%	12%	10%	11%	9%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Oct	240,325	416,356	456,374	782,855	941,032	240,325	416,356	456,374	782,855	941,032	0%	12%	10%	12%	9%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Nov	248,336	429,901	471,153	807,915	971,365	248,336	429,901	471,153	807,915	971,365	0%	12%	10%	12%	9%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Dec	180,244	321,085	352,221	603,862	722,494	180,244	321,085	352,221	603,862	722,494	0%	12%	10%	12%	10%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Jan	120,163	224,914	247,113	423,578	502,667	120,163	224,914	247,113	423,578	502,667	0%	30%	29%	31%	25%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Feb	128,450	237,033	260,360	446,570	531,113	128,450	237,033	260,360	446,570	531,113	0%	28%	27%	29%	23%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Mar	180,244	314,995	345,539	593,604	712,237	180,244	314,995	345,539	593,604	712,237	0%	22%	20%	22%	18%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Apr	434,589	724,407	793,227	1,362,200	1,648,240	434,589	724,407	793,227	1,362,200	1,648,240	0%	16%	15%	16%	13%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 May	1,502,030	2,433,330	2,661,260	4,568,840	5,557,450	1,502,030	2,433,330	2,661,260	4,568,840	5,557,450	0%	13%	11%	13%	10%	-3%	-7%	-5%	-9%	-5%
Impacted	2036 Jun	1,676,270	2,840,170	3,110,400	5,335,010	6,438,290	1,676,270	2,840,170	3,110,400	5,335,010	6,438,290	0%	18%	16%	18%	15%	-3%	-7%	-5%	-9%	-5%
Impacted	2036 Jul	781,058	1,311,170	1,435,980	2,465,390	2,979,470	781,058	1,311,170	1,435,980	2,465,390	2,979,470	0%	17%	15%	17%	14%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Aug	360,488	604,249	662,003	1,138,000	1,375,260	360,488	604,249	662,003	1,138,000	1,375,260	0%	17%	15%	17%	14%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Sep	310,420	525,514	575,852	989,395	1,193,710	310,420	525,514	575,852	989,395	1,193,710	0%	18%	16%	18%	15%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Oct	240,325	413,791	453,631	779,037	937,214	240,325	413,791	453,631	779,037	937,214	0%	20%	19%	20%	16%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Nov	248,336	427,399	468,484	804,239	967,689	248,336	427,399	468,484	804,239	967,689	0%	20%	19%	20%	16%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Dec	180,244	318,526	349,455	599,848	718,481	180,244	318,526	349,455	599,848	718,481	0%	23%	22%	24%	19%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jan	120,163	225,126	247,408	424,374	503,463	120,163	225,126	247,408	424,374	503,463	0%	30%	29%	31%	25%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Feb	133,037	243,610	267,598	459,423	546,986	133,037	243,610	267,598	459,423	546,986	0%	27%	26%	28%	23%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Mar	180,244	313,235	343,664	591,036	709,669	180,244	313,235	343,664	591,036	709,669	0%	21%	20%	22%	18%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Apr	434,589	722,615	791,441	1,360,450	1,646,480	434,589	722,615	791,441	1,360,450	1,646,480	0%	16%	14%	16%	13%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 May	1,502,030	2,428,750	2,656,880	4,565,690	5,554,300	1,502,030	2,428,750	2,656,880	4,565,690	5,554,300	0%	12%	11%	13%	10%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jun	1,676,270	2,841,990	3,113,330	5,344,670	6,447,950	1,676,270	2,841,990	3,113,330	5,344,670	6,447,950	0%	18%	17%	18%	15%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Jul	781,058	1,318,240	1,444,370	2,481,690	2,995,770	781,058	1,318,240	1,444,370	2,481,690	2,995,770	0%	17%	16%	18%	15%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Aug	360,488	602,878	660,649	1,136,750	1,374,020	360,488	602,878	660,649	1,136,750	1,374,020	0%	16%	15%	17%	14%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Sep	310,420	524,087	574,413	987,876	1,192,190	310,420	524,087	574,413	987,876	1,192,190	0%	17%	16%	18%	15%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Oct	240,325	413,076	452,951	778,566	936,744	240,325	413,076	452,951	778,566	936,744	0%	20%	18%	20%	16%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Nov	248,336	426,370	467,458	803,228	966,678	248,336	426,370	467,458	803,228	966,678	0%	19%	18%	20%	16%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Dec	180,244	317,604	348,516	598,797	717,430	180,244	317,604	348,516	598,797	717,430	0%	23%	21%	23%	19%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jan	120,163	164,255	178,755	308,729	387,818	120,163	164,255	178,755	308,729	387,818	0%	14%	12%	14%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Feb	133,037	179,393	195,162	337,350	424,913	133,037	179,393	195,162	337,350	424,913	0%	13%	12%	14%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Mar	180,244	245,761	267,523	462,552	581,185	180,244	245,761	267,523	462,552	581,185	0%	14%	12%	14%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Apr	434,589	590,481	642,631	1,110,940	1,396,980	434,589	590,481	642,631	1,110,940	1,396,980	0%	14%	12%	14%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 May	1,502,030	2,054,310	2,235,660	3,861,920	4,850,520	1,502,030	2,054,310	2,235,660	3,861,920	4,850,520	0%	14%	12%	14%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jun	1,676,270	2,296,610	2,499,600	4,318,180	5,421,460	1,676,270	2,296,610	2,499,600	4,318,180	5,421,460	0%	14%	12%	14%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jul	781,058	1,332,760	1,460,970	2,510,800	3,024,880	781,058	1,332,760	1,460,970	2,510,800	3,024,880	0%	17%	16%	18%	14%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Aug	360,488	616,810	676,362	1,163,210	1,400,480	360,488	616,810	676,362	1,163,210	1,400,480	0%	17%	16%	18%	14%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Sep	310,420	538,191	590,293	1,014,480	1,218,790	310,420	538,191	590,293	1,014,480	1,218,790	0%	17%	16%	18%	14%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Oct	240,325	427,386	469,027	805,300	963,477	240,325	427,386	469,027	805,300	963,477	0%	18%	16%	19%	14%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Nov	248,336	440,589	483,436	829,824	993,273	248,336	440,589	483,436	829,824	993,273	0%	18%	16%	19%	14%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Dec	180,244	332,175	364,852	625,796	744,429	180,244	332,175	364,852	625,796	744,429	0%	18%	17%	19%	15%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jan	120,163	237,184	260,969	447,010	526,099	120,163	237,184	260,969	447,010	526,099	0%	17%	16%	18%	14%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Feb	133,037	257,352	283,045	485,154	572,717	133,037	257,352	283,045	485,154	572,717	0%	17%	15%	18%	14%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Mar	180,244	331,687	364,398	625,541	744,174	180,244	331,687	364,398	625,541	744,174	0%	16%	15%	17%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Apr	434,589	734,812	805,398	1,385,030	1,671,070	434,589	734,812	805,398	1,385,030	1,671,070	0%	15%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 May	1,502,030	2,466,830	2,700,930	4,645,740	5,634,350	1,502,030	2,466,830	2,700,930	4,645,740	5,634,350	0%	14%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jun	1,676,270	2,868,790	3,144,740	5,403,950	6,507,230	1,676,270	2,868,790	3,144,740	5,403,950	6,507,230	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jul	781,058	1,327,990	1,455,790	2,503,230	3,017,300	781,058	1,327,990	1,455,790	2,503,230	3,017,300	0%	15%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Aug	360,488	614,784	674,157	1,159,930	1,397,190	360,488	614,784	674,157	1,159,930	1,397,190	0%	15%	13%	16%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Sep	310,420	536,311	588,229	1,011,300	1,215,610	310,420	536,311	588,229	1,011,300	1,215,610	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Oct	240,325	426,017	467,514	802,924	961,101	240,325	426,017	467,514	802,924	961,101	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Nov	248,336	438,997	481,664	826,969	990,418	248,336	438,997	481,664	826,969	990,418	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Dec	180,244	331,127	363,678	623,861	742,494	180,244	331,127	363,678	623,861	742,494	0%	16%	15%	17%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jan	120,163	235,925	259,559	444,687	523,776	120,163	235,925	259,559	444,687	523,776	0%	17%	16%	18%	14%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Feb	128,450	248,710	273,555	468,927	553,470	128,450	248,710	273,555	468,927	553,470	0%	17%	15%	18%	14%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Mar	180,244	329,777	362,259	622,018	740,651	180,244	329,777	362,259	622,018	740,651	0%	16%	15%	17%	13%	-4%	-9%	-6%	-10%	-6%

		Runoff coefficient 0.41																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2040 Apr	434,589	730,205	800,239	1,376,540	1,662,570	434,589	730,205	800,239	1,376,540	1,662,570	0%	15%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 May	1,502,030	2,451,290	2,683,530	4,617,100	5,605,710	1,502,030	2,451,290	2,683,530	4,617,100	5,605,710	0%	14%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jun	1,676,270	2,851,280	3,125,140	5,371,670	6,474,960	1,676,270	2,851,280	3,125,140	5,371,670	6,474,960	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jul	781,058	1,319,970	1,446,820	2,488,460	3,002,540	781,058	1,319,970	1,446,820	2,488,460	3,002,540	0%	15%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Aug	360,488	610,964	669,879	1,152,880	1,390,150	360,488	610,964	669,879	1,152,880	1,390,150	0%	15%	13%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Sep	310,420	533,018	584,541	1,005,230	1,209,540	310,420	533,018	584,541	1,005,230	1,209,540	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Oct	240,325	423,470	464,661	798,226	956,403	240,325	423,470	464,661	798,226	956,403	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Nov	248,336	436,365	478,717	822,115	985,565	248,336	436,365	478,717	822,115	985,565	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Dec	180,244	329,216	361,539	620,339	738,971	180,244	329,216	361,539	620,339	738,971	0%	16%	15%	17%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jan	120,163	234,644	258,125	442,326	521,414	120,163	234,644	258,125	442,326	521,414	0%	17%	16%	18%	14%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Feb	133,037	254,514	279,865	479,918	567,480	133,037	254,514	279,865	479,918	567,480	0%	17%	15%	18%	14%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Mar	180,244	327,821	360,067	618,408	737,041	180,244	327,821	360,067	618,408	737,041	0%	16%	15%	17%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Apr	434,589	725,437	794,898	1,367,730	1,653,770	434,589	725,437	794,898	1,367,730	1,653,770	0%	15%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 May	1,502,030	2,441,600	2,672,720	4,599,530	5,588,140	1,502,030	2,441,600	2,672,720	4,599,530	5,588,140	0%	14%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jun	1,676,270	2,833,440	3,105,160	5,338,770	6,442,060	1,676,270	2,833,440	3,105,160	5,338,770	6,442,060	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jul	781,058	1,312,100	1,438,000	2,473,960	2,988,040	781,058	1,312,100	1,438,000	2,473,960	2,988,040	0%	15%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Aug	360,488	606,842	665,261	1,145,260	1,382,530	360,488	606,842	665,261	1,145,260	1,382,530	0%	15%	13%	16%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Sep	310,420	529,434	580,525	998,606	1,202,920	310,420	529,434	580,525	998,606	1,202,920	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Oct	240,325	420,665	461,518	793,041	951,219	240,325	420,665	461,518	793,041	951,219	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Nov	248,336	433,437	475,436	816,702	980,151	248,336	433,437	475,436	816,702	980,151	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Dec	180,244	327,071	359,134	616,370	735,003	180,244	327,071	359,134	616,370	735,003	0%	16%	15%	17%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jan	120,163	233,141	256,439	439,539	518,628	120,163	233,141	256,439	439,539	518,628	0%	35%	34%	36%	29%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Feb	133,037	252,715	277,847	476,574	564,137	133,037	252,715	277,847	476,574	564,137	0%	32%	31%	33%	27%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Mar	180,244	325,202	357,127	613,526	732,159	180,244	325,202	357,127	613,526	732,159	0%	26%	24%	26%	21%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Apr	434,589	718,669	787,295	1,355,090	1,641,130	434,589	718,669	787,295	1,355,090	1,641,130	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 May	1,502,030	2,421,510	2,650,160	4,562,020	5,550,630	1,502,030	2,421,510	2,650,160	4,562,020	5,550,630	0%	12%	11%	13%	10%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jun	1,676,270	2,803,740	3,071,770	5,283,070	6,386,360	1,676,270	2,803,740	3,071,770	5,283,070	6,386,360	0%	16%	15%	17%	14%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jul	781,058	1,297,440	1,421,510	2,446,420	2,960,500	781,058	1,297,440	1,421,510	2,446,420	2,960,500	0%	16%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Aug	360,488	599,717	657,244	1,131,860	1,369,130	360,488	599,717	657,244	1,131,860	1,369,130	0%	16%	14%	17%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Sep	310,420	522,975	573,255	986,440	1,190,750	310,420	522,975	573,255	986,440	1,190,750	0%	17%	16%	18%	15%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Oct	240,325	415,414	455,606	783,138	941,316	240,325	415,414	455,606	783,138	941,316	0%	20%	19%	21%	17%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Nov	248,336	427,752	469,034	805,969	969,419	248,336	427,752	469,034	805,969	969,419	0%	20%	19%	21%	17%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Dec	180,244	322,756	354,274	608,217	726,850	180,244	322,756	354,274	608,217	726,850	0%	25%	23%	25%	20%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jan	120,163	220,339	241,907	416,119	495,280	120,163	220,339	241,907	416,119	495,280	0%	9%	7%	11%	8%	-4%	-7%	-5%	-9%	-5%
Impacted	2043 Feb	133,037	235,324	258,112	444,398	532,040	133,037	235,324	258,112	444,398	532,040	0%	9%	7%	10%	8%	-4%	-7%	-5%	-10%	-6%
Impacted	2043 Mar	180,244	290,272	317,530	548,085	666,826	180,244	290,272	317,530	548,085	666,826	0%	8%	7%	9%	7%	-4%	-7%	-6%	-10%	-6%
Impacted	2043 Apr	434,589	586,324	637,668	1,106,740	1,393,040	434,589	586,324	637,668	1,106,740	1,393,040	0%	7%	5%	8%	6%	-4%	-8%	-6%	-10%	-6%
Impacted	2043 May	1,502,030	1,828,810	1,981,240	3,451,340	4,440,840	1,502,030	1,828,810	1,981,240	3,451,340	4,440,840	0%	6%	5%	7%	6%	-4%	-8%	-6%	-10%	-6%
Impacted	2043 Jun	1,676,270	2,031,620	2,200,550	3,834,040	4,938,330	1,676,270	2,031,620	2,200,550	3,834,040	4,938,330	0%	6%	5%	7%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2043 Jul	781,058	1,233,740	1,348,810	2,329,460	2,844,000	781,058	1,233,740	1,348,810	2,329,460	2,844,000	0%	8%	6%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2043 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	8%	6%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2043 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	8%	6%	9%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2043 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	8%	6%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2043 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2043 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	8%	7%	9%	7%	-4%	-3%	-3%	-8%	-4%
Impacted	2044 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	7%	6%	8%	6%	-4%	-2%	-3%	-7%	-4%
Impacted	2044 Feb	128,450	204,240	223,334	385,634	470,254	128,450	204,240	223,334	385,634	470,254	0%	7%	6%	8%	6%	-4%	-2%	-3%	-8%	-4%
Impacted	2044 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	7%	6%	8%	6%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	7%	6%	8%	7%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	7%	6%	8%	6%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	7%	6%	8%	7%	-4%	-3%	-3%	-8%	-4%
Impacted	2045 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	7%	6%	8%	6%	-4%	-2%	-3%	-7%	-4%
Impacted	2045 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	7%	6%	8%	6%	-4%	-2%	-3%	-8%	-4%
Impacted	2045 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	7%	6%	8%	6%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	7%	6%	8%	6%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	7%	6%	8%	7%	-4%	-3%	-3%	-8%	-4%
Impacted	2046 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	7%	6%	8%	6%	-4%	-2%	-3%	-7%	-4%
Impacted	2046 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	7%	6%	8%	6%	-4%	-2%	-3%	-8%	-4%
Impacted	2046 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	7%	6%	8%	6%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	7%	6%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	7%	6%	8%	6%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	7%	6%	8%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	7%	6%	8%	7%	-4%	-3%	-3%	-8%	-4%
Impacted	2047 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2047 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2047 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%

		Runoff coefficient 0.41																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2048 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2048 Feb	128,450	204,240	223,334	385,634	470,254	128,450	204,240	223,334	385,634	470,254	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2048 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2048 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2048 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2048 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2049 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2049 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2049 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2050 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2050 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2050 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2051 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2051 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2051 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2052 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2052 Feb	128,450	204,240	223,334	385,634	470,254	128,450	204,240	223,334	385,634	470,254	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2052 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2053 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2053 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2053 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2054 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2054 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2054 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2055 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2055 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2055 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2055 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2056 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2056 Feb	128,450	204,240	223,334	385,634	470,254	128,450	204,240	223,334	385,634	470,254	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2056 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2057 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2057 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2057 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2058 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2058 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2058 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2059 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2059 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2059 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2060 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2060 Feb	128,450	204,240	223,334	385,634	470,254	128,450	204,240	223,334	385,634	470,254	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2060 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2061 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2061 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2061 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2062 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2062 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2062 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2063 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2063 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2063 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2063 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2064 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2064 Feb	128,450	204,240	223,334	385,634	470,254	128,450	204,240	223,334	385,634	470,254	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2064 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2065 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2065 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2065 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2066 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2066 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2066 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2067 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2067 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2067 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2068 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2068 Feb	128,450	204,240	223,334	385,634	470,254	128,450	204,240	223,334	385,634	470,254	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2068 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2069 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2069 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2069 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2070 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2070 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2070 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2071 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2071 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2071 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2071 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2071 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2071 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2072 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2072 Feb	128,450	204,240	223,334	385,634	470,254	128,450	204,240	223,334	385,634	470,254	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2072 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2073 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2073 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2073 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2074 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2074 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2074 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Jul	781,058	1,237,990	1,353,600	2,337,490	2,852,030	781,058	1,237,990	1,353,600	2,337,490	2,852,030	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Aug	360,488	565,222	617,798	1,067,190	1,304,680	360,488	565,222	617,798	1,067,190	1,304,680	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Sep	310,420	490,314	536,042	925,770	1,130,270	310,420	490,314	536,042	925,770	1,130,270	0%	10%	8%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Oct	240,325	382,380	418,135	721,988	880,309	240,325	382,380	418,135	721,988	880,309	0%	11%	9%	12%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Nov	248,336	397,609	434,871	750,750	914,349	248,336	397,609	434,871	750,750	914,349	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Dec	180,244	288,619	315,668	544,959	663,700	180,244	288,619	315,668	544,959	663,700	0%	11%	10%	12%	10%	-4%	-3%	-3%	-8%	-4%
Impacted	2075 Jan	120,163	191,949	209,922	362,429	441,590	120,163	191,949	209,922	362,429	441,590	0%	11%	10%	12%	10%	-4%	-2%	-3%	-7%	-4%
Impacted	2075 Feb	133,037	211,535	231,310	399,407	487,049	133,037	211,535	231,310	399,407	487,049	0%	11%	9%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2075 Mar	180,244	284,572	311,108	537,304	656,046	180,244	284,572	311,108	537,304	656,046	0%	10%	8%	11%	9%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Apr	434,589	688,792	753,109	1,300,530	1,586,820	434,589	688,792	753,109	1,300,530	1,586,820	0%	10%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 May	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	1,502,030	2,399,680	2,624,390	4,530,960	5,520,470	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Jun	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	1,676,270	2,676,710	2,927,310	5,054,030	6,158,320	0%	11%	10%	12%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Jul	781,058	1,262,180	1,380,850	2,383,230	2,897,780	781,058	1,262,180	1,380,850	2,383,230	2,897,780	0%	12%	11%	13%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2076 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2076 Feb	128,450	208,862	228,541	394,375	478,995	128,450	208,862	228,541	394,375	478,995	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2076 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2077 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2077 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2077 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2077 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2077 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2077 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2077 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2078 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2078 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2078 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2078 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2078 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2078 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2078 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%

		Runoff coefficient 0.41																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2079 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2079 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2079 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2080 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2080 Feb	128,450	208,862	228,541	394,375	478,995	128,450	208,862	228,541	394,375	478,995	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2080 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2081 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2081 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2081 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2082 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2082 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2082 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2083 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2083 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2083 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2084 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2084 Feb	128,450	208,862	228,541	394,375	478,995	128,450	208,862	228,541	394,375	478,995	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2084 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2085 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2085 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2085 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2086 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2086 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2086 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2086 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2087 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2087 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2087 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2088 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2088 Feb	128,450	208,862	228,541	394,375	478,995	128,450	208,862	228,541	394,375	478,995	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2088 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2089 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2089 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2089 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2090 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2090 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2090 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2091 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2091 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2091 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2092 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2092 Feb	128,450	208,862	228,541	394,375	478,995	128,450	208,862	228,541	394,375	478,995	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2092 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2093 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2093 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2093 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2094 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2094 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2094 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		1 in 10 Wet Years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2094 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2095 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2095 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2095 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2096 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2096 Feb	128,450	208,862	228,541	394,375	478,995	128,450	208,862	228,541	394,375	478,995	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2096 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2097 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2097 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2097 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2098 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2098 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2098 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%
Impacted	2099 Jan	120,163	197,713	216,416	373,330	452,491	120,163	197,713	216,416	373,330	452,491	0%	14%	13%	15%	12%	-4%	-2%	-3%	-7%	-4%
Impacted	2099 Feb	133,037	216,379	236,768	408,569	496,211	133,037	216,379	236,768	408,569	496,211	0%	13%	12%	14%	11%	-4%	-2%	-3%	-8%	-4%
Impacted	2099 Mar	180,244	288,177	315,169	544,122	662,863	180,244	288,177	315,169	544,122	662,863	0%	11%	10%	12%	10%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Apr	434,589	704,390	770,682	1,330,030	1,616,320	434,589	704,390	770,682	1,330,030	1,616,320	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 May	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	1,502,030	2,490,790	2,727,030	4,703,270	5,692,780	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Jun	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	1,676,270	2,776,250	3,039,460	5,242,280	6,346,570	0%	15%	14%	16%	13%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Jul	781,058	1,267,430	1,386,770	2,393,170	2,907,720	781,058	1,267,430	1,386,770	2,393,170	2,907,720	0%	13%	11%	14%	11%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Aug	360,488	567,203	620,030	1,070,940	1,308,420	360,488	567,203	620,030	1,070,940	1,308,420	0%	9%	8%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Sep	310,420	498,065	544,774	940,428	1,144,930	310,420	498,065	544,774	940,428	1,144,930	0%	12%	10%	13%	10%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Oct	240,325	392,871	429,954	741,827	900,148	240,325	392,871	429,954	741,827	900,148	0%	14%	12%	15%	12%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Nov	248,336	412,834	452,023	779,543	943,142	248,336	412,834	452,023	779,543	943,142	0%	16%	14%	17%	13%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Dec	180,244	299,283	327,682	565,127	683,868	180,244	299,283	327,682	565,127	683,868	0%	16%	14%	17%	13%	-4%	-3%	-3%	-8%	-4%

		Runoff coefficient 0.41																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Baseline	2017 Jan	88,498	127,200	141,133	238,370	296,588	22,732	92,640	200,953	222,552	384,026	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Feb	97,980	140,829	156,227	263,883	328,338	25,168	102,565	222,483	246,397	425,172	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Mar	132,747	190,800	211,625	357,481	444,808	34,098	138,959	301,429	333,828	576,040	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Apr	320,067	460,041	510,159	861,833	1,072,390	82,214	335,047	726,779	804,896	1,388,900	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 May	1,106,220	1,590,000	1,762,900	2,978,370	3,706,090	284,149	1,158,000	2,511,910	2,781,900	4,800,330	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jun	1,234,540	1,774,440	1,967,040	3,323,500	4,135,640	317,110	1,292,320	2,803,290	3,104,600	5,357,170	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jul	575,236	826,801	916,373	1,548,420	1,926,830	147,758	602,157	1,306,190	1,446,590	2,496,170	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Aug	265,493	381,600	422,863	714,574	889,228	68,196	277,919	602,858	667,655	1,152,080	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Sep	228,619	328,600	364,065	615,261	765,658	58,724	239,319	519,128	574,926	992,068	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Oct	176,996	254,400	281,806	476,280	592,716	45,464	185,279	401,905	445,104	768,053	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Nov	182,895	262,880	291,146	492,103	612,420	46,979	191,455	415,302	459,940	793,654	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Dec	132,747	190,800	211,277	357,133	444,460	34,098	138,959	301,429	333,828	576,040	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Impacted	2018 Jan	88,498	127,200	140,825	238,062	296,280	22,732	92,640	200,953	222,552	384,026	0%	0%	0%	0%	-30800%	0%	0%	0%	0%	0%
Impacted	2018 Feb	97,980	140,829	155,886	263,541	327,997	25,168	102,565	222,483	246,397	425,172	0%	0%	0%	0%	-34100%	0%	0%	0%	0%	0%
Impacted	2018 Mar	132,747	190,800	211,163	357,019	444,345	34,098	138,959	301,429	333,828	576,040	0%	0%	0%	0%	-46200%	0%	0%	0%	0%	0%
Impacted	2018 Apr	320,067	460,041	509,044	860,718	1,071,270	82,214	335,047	726,779	804,896	1,388,900	0%	0%	0%	0%	-111500%	0%	0%	0%	0%	0%
Impacted	2018 May	1,106,220	1,590,000	1,759,050	2,974,510	3,702,240	284,149	1,158,000	2,511,910	2,781,900	4,800,330	0%	0%	0%	0%	-385000%	0%	0%	0%	0%	0%
Impacted	2018 Jun	1,234,540	1,774,440	1,962,740	3,319,190	4,131,330	317,110	1,292,320	2,803,290	3,104,600	5,357,170	0%	0%	0%	0%	-430000%	0%	0%	0%	0%	0%
Impacted	2018 Jul	575,236	826,801	914,369	1,546,410	1,924,830	147,758	602,157	1,306,190	1,446,590	2,496,170	0%	0%	0%	0%	-200400%	0%	0%	0%	0%	0%
Impacted	2018 Aug	265,493	381,600	421,938	713,650	888,303	68,196	277,919	602,858	667,655	1,152,080	0%	0%	0%	0%	-92500%	0%	0%	0%	0%	0%
Impacted	2018 Sep	228,619	328,600	363,269	614,465	764,861	58,724	239,319	519,128	574,926	992,068	0%	0%	0%	0%	-79600%	0%	0%	0%	0%	0%
Impacted	2018 Oct	176,996	254,400	281,189	475,663	592,099	45,464	185,279	401,905	445,104	768,053	0%	0%	0%	0%	-61700%	0%	0%	0%	0%	0%
Impacted	2018 Nov	182,895	262,880	290,509	491,465	611,783	46,979	191,455	415,302	459,940	793,654	0%	0%	0%	0%	-63700%	0%	0%	0%	0%	0%
Impacted	2018 Dec	132,747	190,800	210,814	356,670	443,997	34,098	138,959	301,429	333,828	576,040	0%	0%	0%	0%	-46300%	0%	0%	0%	0%	0%
Impacted	2019 Jan	88,498	173,332	192,489	324,672	382,890	22,732	92,640	200,953	222,122	383,597	29%	0%	0%	4613200%	5135600%	0%	0%	0%	0%	0%
Impacted	2019 Feb	97,980	186,931	207,482	349,318	413,773	25,168	102,565	222,483	244,986	423,761	26%	0%	0%	4610200%	5125500%	0%	0%	0%	-1%	0%
Impacted	2019 Mar	132,747	236,850	262,576	441,232	528,559	34,098	138,959	301,429	330,649	572,860	19%	0%	0%	4605000%	5095100%	0%	0%	0%	-1%	-1%
Impacted	2019 Apr	320,067	505,862	559,535	938,044	1,148,600	82,214	335,047	726,779	794,073	1,378,070	7%	0%	0%	4582100%	4937600%	0%	0%	0%	-1%	-1%
Impacted	2019 May	1,106,220	1,634,700	1,805,480	3,018,510	3,746,230	284,149	1,158,000	2,511,910	2,733,570	4,752,000	1%	0%	0%	4470000%	4258000%	0%	0%	0%	-2%	-1%
Impacted	2019 Jun	1,234,540	1,818,610	2,008,090	3,348,230	4,160,380	317,110	1,292,320	2,803,290	3,038,480	5,291,050	1%	0%	0%	4417000%	4105000%	0%	0%	0%	-2%	-1%
Impacted	2019 Jul	575,236	889,670	983,134	1,635,600	2,014,020	147,758	602,157	1,306,190	1,410,100	2,459,690	5%	0%	0%	6286900%	6676100%	0%	0%	0%	-3%	-1%
Impacted	2019 Aug	265,493	436,676	483,030	802,077	976,731	68,196	277,919	602,858	648,153	1,132,580	10%	0%	0%	5507600%	6016700%	0%	0%	0%	-3%	-2%
Impacted	2019 Sep	228,619	384,157	425,033	704,275	854,671	58,724	239,319	519,128	555,876	973,018	12%	0%	0%	5555700%	6096800%	0%	0%	0%	-3%	-2%
Impacted	2019 Oct	176,996	309,165	342,244	566,094	682,530	45,464	185,279	401,905	428,609	751,558	15%	0%	0%	5476500%	6043800%	0%	0%	0%	-4%	-2%
Impacted	2019 Nov	182,895	319,251	353,348	583,125	703,441	46,979	191,455	415,302	441,091	774,805	15%	0%	0%	5637100%	6220200%	0%	0%	0%	-4%	-2%
Impacted	2019 Dec	132,747	245,058	271,454	447,437	534,764	34,098	138,959	301,429	318,836	561,048	20%	0%	0%	5425800%	6017700%	0%	0%	0%	-4%	-3%
Impacted	2020 Jan	88,498	178,122	197,594	326,661	384,879	22,732	92,640	200,953	212,128	373,602	30%	0%	0%	5092200%	5646100%	0%	0%	0%	-5%	-3%
Impacted	2020 Feb	94,601	185,798	206,072	342,105	404,338	24,300	99,029	214,812	226,757	399,368	28%	0%	1%	4982517%	5523214%	0%	0%	0%	-5%	-3%
Impacted	2020 Mar	132,747	240,417	266,354	443,948	531,274	34,098	138,959	301,429	318,192	560,404	19%	0%	0%	4961700%	5472900%	0%	0%	0%	-5%	-3%
Impacted	2020 Apr	320,067	511,552	565,607	947,187	1,157,740	82,214	335,047	726,779	767,196	1,351,190	8%	0%	0%	5151100%	5544800%	0%	0%	0%	-5%	-3%
Impacted	2020 May	1,106,220	1,645,800	1,817,640	3,061,890	3,789,620	284,149	1,158,000	2,511,910	2,651,600	4,670,030	2%	0%	0%	5580000%	5474000%	0%	0%	0%	-5%	-3%
Impacted	2020 Jun	1,234,540	1,818,040	2,008,000	3,403,370	4,215,510	317,110	1,292,320	2,803,290	2,959,180	5,211,750	2%	0%	0%	4360000%	4096000%	0%	0%	0%	-5%	-3%
Impacted	2020 Jul	575,236	864,254	955,194	1,628,290	2,006,710	147,758	602,157	1,306,190	1,378,830	2,428,410	4%	0%	0%	3745300%	3882100%	0%	0%	0%	-5%	-3%
Impacted	2020 Aug	265,493	419,938	464,696	796,061	970,714	68,196	277,919	602,858	636,384	1,120,810	9%	0%	0%	3833800%	4183300%	0%	0%	0%	-5%	-3%
Impacted	2020 Sep	228,619	366,132	405,348	698,047	848,443	58,724	239,319	519,128	547,997	965,139	11%	0%	0%	3753200%	4128300%	0%	0%	0%	-5%	-3%
Impacted	2020 Oct	176,996	292,413	323,987	560,462	676,898	45,464	185,279	401,905	424,256	747,205	14%	0%	0%	3801300%	4218100%	0%	0%	0%	-5%	-3%
Impacted	2020 Nov	182,895	299,051	331,365	576,467	696,784	46,979	191,455	415,302	438,398	772,112	14%	0%	0%	3617100%	4021900%	0%	0%	0%	-5%	-3%
Impacted	2020 Dec	132,747	228,299	253,236	441,997	529,324	34,098	138,959	301,429	318,192	560,404	19%	0%	0%	3749900%	4195900%	0%	0%	0%	-5%	-3%
Impacted	2021 Jan	88,498	167,098	185,607	323,510	381,727	22,732	92,633	200,928	212,103	373,578	29%	0%	0%	3989800%	4447400%	0%	0%	0%	-5%	-3%
Impacted	2021 Feb	97,980	180,011	199,828	348,542	412,997	25,168	102,546	222,406	234,778	413,553	26%	0%	0%	3918200%	4360100%	0%	0%	0%	-5%	-3%
Impacted	2021 Mar	132,747	227,345	252,042	440,675	528,002	34,098	138,915	301,255	318,018	560,230	19%	0%	0%	3654500%	4041700%	0%	0%	0%	-5%	-3%
Impacted	2021 Apr	320,067	483,780	535,031	940,124	1,150,680	82,214	334,897	726,190	766,607	1,350,610	7%	0%	0%	2373900%	2487200%	0%	0%	0%	-5%	-3%
Impacted	2021 May	1,106,220	1,562,760	1,725,550	3,040,340	3,768,060	284,149	1,157,330	2,509,280	2,648,970	4,667,410	2%	0%	0%	-2724000%	-3735000%	0%	0%	0%	-5%	-3%
Impacted	2021 Jun	1,234,540	1,912,780	2,075,320	3,403,550	4,216,100	317,110	1,291,410	2,799,700	2,955,600	5,208,170	2%	0%	0%	13834000%	10828000%	0%	0%	0%	-5%	-3%
Impacted	2021 Jul	575,236	914,810	993,582	1,631,480	2,010,090	147,758	601,656	1,304,220	1,376,850	2,426,440	4%	0%	0%	8800900%	7720900%	0%	0%	0%	-5%	-3%
Impacted	2021 Aug	265,493	446,389	485,852	799,340	974,082	68,196	277,651	601,802	635,328	1,119,750	10%	0%	0%	6478900%	6298900%	0%	0%	0%	-5%	-3%
Impacted	2021 Sep	228,619	391,901	426,661	701,575	852,047	58,724	239,058	518,097	546,966	964,109	11%	0%	0%	6330100%	6259600%	0%	0%	0%	-5%	-3%
Impacted	2021 Oct	176,996	314,680	342,884	563,738	680,233	45,464	185,053	401,013	423,364	746,313	15%	0%	0%	6028000%	6107800%	0%	0%	0%	-5%	-3%
Impacted	2021 Nov	182,895	324,437	353,360	580,452	700,830	46,979	191,197	414,283	437,378	771,092	14%	0%	0%	6155700%	6221400%	0%	0%	0%	-5%	-3%
Impacted	2021 Dec	132,747	248,380	270,955	445,492	532,863	34,098	138,754	300,619	317,381	559,593	20%	0%	0%	5758000%	5967800%	0%	0%	0%	-5%	-3%
Impacted	2022 Jan	88,498	127,246	137,418	224,429	282,676	22,732	92,491	200,365	211,540	373,014	-5%	0%	0%	4600%	-371500%	0%	0%	0%	-5%	-3%
Impacted	2022 Feb	97,980	157,332	170,665	279,616	344,104	25,168	102,387	221,782	234,154	412,930	5%	0%	0%	1650300%	1443800%	0%	0%	0%	-5%	-3%
Impacted	2022 Mar	132,747	248,326	270,843	445,492	532,863	34,098	138,701	300,410	317,173	559,385	20%	0%	0%	5752600%	5921800%	0%	0%	0%	-5%	-3%
Impacted	2022 Apr	320,067	534,716	580,717	952,121	1,162,780	82,214	334,381	724,152	764,569	1,348,570	8%	0%	0%	7467500%	7055800%	0%	0%	0%	-5%	-3%
Impacted	2022 May	1,106,220	1,740,400	1,884,880	3,082,190	3,810,280	284,149	1,155,550	2,502,240	2,641,930	4,660,360	3%	0%	0%	15040000%	12198000%	0%	0%	0%	-5%	-3%
Impacted	2022 Jun	1,234,540	1,938,940	2,099,320	3,431,780	4,244,330	317,110	1,289,420	2,791,840	2,947,740	5,200,310	3%	0%	0%	16450000%	13228000%	0%	0%	0%	-5%	-3%
Impacted	2022 Jul	575,236	927,389	1,005,150	1,645,020	2,023,630	147,758	600,728	1,300,550	1,373,190	2,422,780	5%	0%	0%	10058800%	8877700%	0%	0%	0%	-5%	-3%
Impacted	2022 Aug	265,493	452,195	491,192	805,590	980,333	68,196	277,223	600,112	633,637	1,118,060	10%	0%	0%	7059500%	6832900%	0%	0%	0%	-5%	-3%
Impacted	2022 Sep	228,619	396,900	431,260	707,120	857,592	58,724	238,689	516,641	545,511	962,653	12%	0%	0%	6830000%	6719500%	0%	0%	0%	-5%	-3%
Impacted	2022 Oct	176,996	318,550	346,444	568,938	685,432	45,464	184,767	399,886	422,237	745,185	16%	0%	0%	6415000%	6463800%	0%	0%	-1%	-5%	-3%
Impacted	2022 Nov	182,895	328,436	357,039	585,841	706,219	46,979	190,902	413,118	436,214	769,928	15%	0%	0%	6555600%	6589300%	0%	0%	-1%	-5%	-3%
Impacted	2022 Dec	132,747	251,283	273,625	449,414	536,785	34,098	138,540	299,773	316,536	558,748	21%	0%	0%	6048300%	6234800%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jan	88,498	126,603	136,294	221,960	280,207	22,732	92,348	199,801	210,976	372,450	-6%	0%	0%	-59700%	-483900%	0%	0%	-1%	-5%	-3%
Impacted	2023 Feb	97,980	139,924	150,611	245,328	309,816	25,168	102,229	221,157	233,530	412,305	-6%	0%	0%	-90500%	-561600%	0%	0%	-1%	-5%	-3%
Impacted	2023 Mar	132,747	203,976	220,278	359,853	447,224	34,098	138,487	299,564	316,327	558,539	1%	0%	0%	1317600%	865300%	0%	0%	-1%	-5%	-3%
Impacted	2023 Apr	320,067	541,716	587,157	961,461	1,172,120	82,214	333,864	722,114	762,531	1,346,530	9%	0%	0%	8167500%	7699800%	0%	0%	-1%	-5%	-3%
Impacted	2023 May	1,106,220	1,759,200	1,901,050	3,104,890	3,832,980	284,149	1,153,760	2,495,200	2,634,890	4,653,320	3%	0%	0%	16920000%	13815000%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jun	1,234,540	1,925,120	2,078,170	3,391,490	4,204,050	317,110	1,287,430	2,783,980	2,939,880	5,192,450	2%	0%	0%	15068000%	11113000%	0%	0%	-1%	-5%	-3%
Impacted	2023 Jul	575,236	943,741	1,020,970	1,669,270	2,047,870	147,758	599,800	1,296,890	1,369,530	2,419,110	6%	0%	0%	11694000%	10459700%	0%	0%	-1%	-5%	-3%
Impacted	2023 Aug	265,493	459,583	498,316	816,380	991,122	68,196	276,794	598,421	631,946	1,116,370	11%	0%	0%	7798300%	7545300%	0%	0%	-1%	-5%	-3%
Impacted	2023 Sep	228,619	403,356	437,499	716,412	866,885	58,724	238,320	515,185	544,054	961,197	13%	0%	0%	7475600%	7343400%	0%	0%	-1%	-5%	-3%
Impacted	2023 Oct	176,996	323,620	351,356	575,322	691,817	45,464	184,482	398,759	421,109	744,058	17%	0%	0%	6922000%	6955000%	0%	0%	-1%	-5%	-3%
Impacted	2023 Nov	182,895	333,740	362,187	592,570	712,948	46,979	190,606	411,953	435,049	768,763	16%	0%	0%	7086000%	7104100%	0%	0%	-1%	-5%	-3%
Impacted	2023 Dec	132,747	253,359	275,364	450,883	538,254	34,098	138,325	298,928	315,691	557,902	21%	0%	0%	6255900%	6408700%	0%	0%	-1%	-5%	-3%
Impacted	2024 Jan	88,498	140,447	151,515	246,400	304,648	22,732	92,205	199,223	210,398	371,873	3%	0%	0%	1324700%	1038200%	0%	0%	-1%	-5%	-3%
Impacted	2024 Feb	94,601	194,699	212,208	348,015	410,279	24,300	98,550	212,884	224,830	397,441	29%	0%	1%	5872617%	6136814%	0%	0%	-1%	-5%	-3%
Impacted	2024 Mar	132,747	254,024	276,230	452,656	540,027	34,098	138,269	298,615	315,377	557,589	21%	0%	0%	6322400%	6460500%	0%	0%	-1%	-6%	-3%
Impacted	2024 Apr	320,067	547,598	592,902	969,995	1,180,660	82,214	333,336	719,723	760,140	1,344,140	10%	0%	0%	8755700%	8274300%	0%	-1%	-1%	-6%	-3%
Impacted	2024 May	1,106,220	1,782,220	1,924,510	3,145,520	3,873,610	284,149	1,151,920	2,486,590	2,626,280	4,644,710	5%	0%	0%	19222000%	16161000%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jun	1,234,540	1,982,000	2,140,110	3,499,920	4,312,470	317,110	1,285,370	2,773,990	2,929,880	5,182,450	4%	0%	0%	20756000%	17307000%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jul	575,236	945,553	1,022,310	1,674,670	2,053,270	147,758	598,835	1,292,050	1,364,690	2,414,280	7%	0%	0%	11875200%	10593700%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Aug	265,493	459,638	498,191	817,955	992,697	68,196	276,346	596,106	629,631	1,114,060	12%	0%	0%	7803800%	7532800%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Sep	228,619	402,742	436,762	717,184	867,657	58,724	237,932	513,120	541,990	959,132	13%	0%	0%	7414200%	7269700%	0%	-1%	-1%	-6%	-3%

		Runoff coefficient 0.41																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2024 Oct	176,996	322,633	350,299	575,399	691,893	45,464	184,180	397,105	419,456	742,405	17%	0%	0%	6823300%	6849300%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Nov	182,895	332,191	360,592	592,267	712,645	46,979	190,293	410,188	433,283	766,997	16%	0%	0%	6931100%	6944600%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Dec	132,747	253,625	275,840	453,561	540,932	34,098	138,097	297,605	314,368	556,579	22%	0%	0%	6282500%	6456300%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jan	88,498	184,268	201,024	331,774	390,022	22,732	92,052	198,327	209,502	370,977	32%	0%	0%	5706800%	5989100%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Feb	97,980	198,755	216,676	357,759	422,247	25,168	101,901	219,497	231,869	410,644	29%	0%	0%	5792600%	6044900%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Mar	132,747	252,333	274,534	453,275	540,646	34,098	138,040	297,274	314,037	556,249	22%	0%	0%	6153300%	6290900%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Apr	320,067	543,521	588,813	970,491	1,181,150	82,214	332,785	716,492	756,909	1,340,910	10%	0%	0%	8348000%	7865400%	0%	-1%	-1%	-6%	-3%
Impacted	2025 May	1,106,220	1,768,130	1,910,380	3,144,540	3,872,640	284,149	1,150,020	2,475,420	2,615,110	4,633,540	4%	0%	0%	17813000%	14748000%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jun	1,234,540	1,966,270	2,124,340	3,498,720	4,311,270	317,110	1,283,240	2,761,530	2,917,420	5,169,990	4%	0%	0%	19183000%	15730000%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jul	575,236	938,224	1,014,960	1,674,500	2,053,110	147,758	597,844	1,286,250	1,358,890	2,408,470	7%	0%	0%	11142300%	9858700%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Aug	265,493	456,256	494,799	818,274	993,016	68,196	275,889	593,425	626,951	1,111,370	12%	0%	0%	7465600%	7193600%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Sep	228,619	399,829	433,841	717,560	868,033	58,724	237,538	510,812	539,681	956,824	13%	0%	0%	7122900%	6977600%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Oct	176,996	320,378	348,038	575,855	692,350	45,464	183,875	395,318	417,669	740,618	17%	0%	0%	6597800%	6623200%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Nov	182,895	329,861	358,255	592,715	713,093	46,979	189,978	408,341	431,437	765,151	16%	0%	0%	6698100%	6710900%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Dec	132,747	251,933	274,144	454,083	541,454	34,098	137,868	296,265	313,027	555,239	22%	0%	0%	6113300%	6286700%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jan	88,498	183,141	199,894	331,738	389,986	22,732	91,899	197,434	208,609	370,084	31%	0%	0%	5594100%	5876100%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Feb	97,980	197,507	215,425	357,689	422,177	25,168	101,732	218,508	230,880	409,655	29%	0%	0%	5667800%	5919800%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Mar	132,747	250,642	272,838	453,151	540,522	34,098	137,812	295,934	312,697	554,909	22%	0%	0%	5984200%	6121300%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Apr	320,067	539,444	584,724	970,074	1,180,740	82,214	332,233	713,261	753,678	1,337,680	10%	0%	0%	7940300%	7456500%	0%	-1%	-2%	-6%	-4%
Impacted	2026 May	1,106,220	1,754,040	1,896,250	3,142,900	3,870,990	284,149	1,148,110	2,464,250	2,603,940	4,622,380	4%	0%	0%	16404000%	13335000%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jun	1,234,540	1,950,550	2,108,570	3,496,880	4,309,430	317,110	1,281,120	2,749,070	2,904,960	5,157,530	4%	0%	0%	17611000%	14153000%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jul	575,236	930,898	1,007,610	1,673,690	2,052,290	147,758	596,853	1,280,440	1,353,080	2,402,670	7%	0%	0%	10409700%	9123700%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Aug	265,493	452,874	491,407	817,941	992,683	68,196	275,432	590,745	624,271	1,108,690	12%	0%	0%	7127400%	6854400%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Sep	228,619	396,917	430,921	717,286	867,758	58,724	237,144	508,504	537,374	954,516	13%	0%	0%	6831700%	6685600%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Oct	176,996	318,123	345,777	575,662	692,156	45,464	183,570	393,532	415,882	738,831	17%	0%	0%	6372300%	6397100%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Nov	182,895	327,531	355,919	592,512	712,890	46,979	189,663	406,495	429,591	763,304	16%	0%	0%	6465100%	6477300%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Dec	132,747	248,134	270,073	449,975	537,346	34,098	137,639	294,925	311,688	553,899	21%	0%	0%	5733400%	5879600%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jan	88,498	118,200	126,874	210,713	268,960	22,731	91,744	196,561	207,737	369,211	-9%	0%	0%	-900000%	-1425900%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Feb	97,980	130,522	140,125	232,951	297,439	25,165	101,554	217,584	229,957	408,732	-9%	0%	0%	-1030700%	-1610200%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Mar	132,747	176,241	189,251	315,082	402,453	34,092	137,563	294,741	311,503	553,715	-10%	0%	0%	-1455900%	-2237400%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Apr	320,067	424,917	456,285	759,933	970,595	82,194	331,615	710,527	750,943	1,334,940	-9%	0%	0%	-3512400%	-5387400%	0%	-1%	-2%	-7%	-4%
Impacted	2027 May	1,106,220	1,581,240	1,703,690	2,838,290	3,566,380	284,060	1,145,910	2,455,300	2,594,990	4,613,420	-4%	0%	0%	-876000%	-5921000%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jun	1,234,540	1,938,610	2,097,570	3,498,430	4,310,980	316,989	1,278,590	2,739,630	2,895,520	5,148,090	4%	0%	0%	16417000%	13053000%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jul	575,236	925,659	1,002,900	1,674,610	2,053,220	147,690	595,640	1,276,300	1,348,940	2,398,520	7%	0%	0%	9885800%	8652700%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Aug	265,493	450,608	489,422	818,431	993,173	68,160	274,856	588,956	622,482	1,106,900	12%	0%	0%	6900800%	6655900%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Sep	228,619	395,094	429,374	717,797	868,269	58,689	236,635	507,066	535,935	953,078	13%	0%	0%	6649400%	6530900%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Oct	176,996	316,812	344,704	576,111	692,606	45,434	183,165	392,498	414,848	737,797	17%	0%	0%	6241200%	6289800%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Nov	182,895	326,279	354,941	593,083	713,461	46,945	189,233	405,509	428,604	762,318	16%	0%	0%	6339900%	6379500%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Dec	132,747	249,408	271,832	454,397	541,768	34,070	137,320	294,268	311,031	553,243	22%	0%	0%	5860800%	6055500%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jan	88,498	181,508	198,417	331,963	390,210	22,712	91,528	196,143	207,319	368,793	32%	0%	0%	5430800%	5728400%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Feb	94,601	190,593	208,274	348,654	410,918	24,277	97,822	209,634	221,580	394,190	30%	0%	1%	5462017%	5743414%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Mar	132,747	248,335	270,802	453,675	541,047	34,063	137,239	294,112	310,875	553,087	22%	0%	0%	5753500%	5917700%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Apr	320,067	534,061	580,043	971,654	1,182,310	82,125	330,834	709,011	749,428	1,333,430	10%	0%	0%	7402000%	6988400%	0%	-1%	-2%	-7%	-4%
Impacted	2028 May	1,106,220	1,736,060	1,880,850	3,149,240	3,877,330	283,821	1,143,210	2,450,060	2,589,750	4,608,190	5%	0%	0%	14606000%	11795000%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jun	1,234,540	1,931,180	2,092,260	3,504,620	4,317,180	316,722	1,275,570	2,733,780	2,889,680	5,142,250	4%	0%	0%	15674000%	12522000%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jul	575,236	922,194	1,000,420	1,677,550	2,056,160	147,566	594,234	1,273,580	1,346,220	2,395,800	7%	0%	0%	9539300%	8404700%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Aug	265,493	449,009	488,279	819,824	994,567	68,103	274,207	587,698	621,224	1,105,650	12%	0%	0%	6740900%	6541600%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Sep	228,619	393,718	428,390	719,007	869,479	58,640	236,077	505,984	534,853	951,996	14%	0%	0%	6511800%	6432500%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Oct	176,996	315,746	343,942	577,072	693,567	45,395	182,733	391,660	414,010	736,959	17%	0%	0%	6134600%	6213600%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Nov	182,895	325,177	354,153	594,071	714,449	46,905	188,787	404,643	427,738	761,452	17%	0%	0%	6229700%	6300700%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Dec	132,747	248,609	271,261	455,133	542,505	34,042	136,995	293,640	310,403	552,614	22%	0%	0%	5780900%	5998400%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Jan	88,498	180,975	198,035	332,130	390,378	22,693	91,312	195,724	206,900	368,374	32%	0%	0%	5377500%	5690200%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Feb	97,980	195,162	213,434	358,220	422,708	25,123	101,076	216,657	229,030	407,805	29%	0%	0%	5433300%	5720700%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Mar	132,747	247,537	270,232	454,050	541,421	34,035	136,916	293,485	310,248	552,460	22%	0%	0%	5673700%	5860700%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Apr	320,067	532,139	578,669	972,977	1,183,640	82,056	330,054	707,500	747,917	1,331,920	10%	0%	0%	7209800%	6851000%	0%	-1%	-3%	-7%	-4%
Impacted	2029 May	1,106,220	1,729,410	1,876,100	3,154,430	3,882,520	283,583	1,140,520	2,444,840	2,584,530	4,602,960	5%	0%	0%	13941000%	11320000%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jun	1,234,540	1,923,760	2,086,960	3,510,460	4,323,010	316,456	1,272,560	2,727,950	2,883,850	5,136,420	5%	0%	0%	14932000%	11992000%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jul	575,236	918,739	997,953	1,680,120	2,058,730	147,442	592,834	1,270,860	1,343,500	2,393,080	7%	0%	0%	9193800%	8158000%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Aug	265,493	449,933	489,948	825,415	1,000,160	68,046	273,560	586,445	619,970	1,104,390	12%	0%	0%	6833300%	6708500%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Sep	228,619	398,262	434,007	730,588	881,060	58,591	235,519	504,904	533,773	950,915	15%	0%	0%	6966200%	6994200%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Oct	176,996	316,489	345,197	580,948	697,443	45,357	182,302	390,824	413,174	736,123	18%	0%	0%	6208900%	6339100%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Nov	182,895	326,569	356,145	599,221	719,599	46,866	188,341	403,779	426,874	760,588	18%	0%	0%	6368900%	6499900%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Dec	132,747	247,811	270,691	455,512	542,883	34,013	136,672	293,013	309,776	551,988	22%	0%	0%	5701100%	5941400%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jan	88,498	180,444	197,656	332,960	391,207	22,674	91,097	195,306	206,482	367,956	32%	0%	0%	5324400%	5652300%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Feb	97,980	194,573	213,014	359,090	423,579	25,102	100,837	216,195	228,567	407,343	29%	0%	0%	5374400%	5678700%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Mar	132,747	246,740	269,662	455,112	542,483	34,006	136,592	292,859	309,621	551,833	22%	0%	0%	5594000%	5803700%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Apr	320,067	530,216	577,294	974,948	1,185,610	81,987	329,275	705,988	746,405	1,330,410	11%	0%	0%	7017500%	6713500%	0%	-2%	-3%	-7%	-4%
Impacted	2030 May	1,106,220	1,772,170	1,926,440	3,249,730	3,977,830	283,345	1,137,820	2,439,620	2,579,310	4,597,740	7%	0%	0%	18217000%	16354000%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jun	1,234,540	2,004,090	2,179,500	3,675,820	4,488,370	316,190	1,269,560	2,722,120	2,878,020	5,130,590	9%	0%	0%	22965000%	21246000%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jul	575,236	945,812	1,029,530	1,738,640	2,117,250	147,318	591,432	1,268,140	1,340,780	2,390,370	10%	0%	0%	11901100%	11315700%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Aug	265,493	448,746	489,262	827,867	1,002,610	67,988	272,914	585,191	618,717	1,103,140	13%	0%	0%	6714600%	6639900%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Sep	228,619	391,536	427,056	722,420	872,893	58,541	234,963	503,824	532,694	949,836	14%	0%	0%	6293600%	6299100%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Oct	176,996	313,620	342,422	578,946	695,440	45,319	181,870	389,988	412,338	735,287	17%	0%	0%	5922000%	6061600%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Nov	182,895	322,980	352,583	596,004	716,382	46,827	187,896	402,915	426,011	759,725	17%	0%	0%	6010000%	6143700%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Dec	132,747	247,014	270,121	456,575	543,946	33,985	136,349	292,386	309,149	551,361	22%	0%	0%	5621400%	5884400%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Jan	88,498	179,908	197,272	333,401	391,649	22,650	90,854	194,865	206,040	367,514	32%	0%	0%	5270800%	5613900%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Feb	97,980	193,972	212,582	359,582	424,070	25,065	100,514	215,657	228,030	406,805	29%	0%	0%	5314300%	5635500%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Mar	132,747	245,914	269,067	455,785	543,156	33,942	136,079	292,065	308,828	551,040	22%	0%	0%	5511400%	5744200%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Apr	320,067	528,198	575,834	976,586	1,187,250	81,799	327,853	703,913	744,330	1,328,330	11%	0%	0%	6815700%	6567500%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 May	1,106,220	1,718,050	1,868,830	3,170,270	3,898,360	282,576	1,132,270	2,431,890	2,571,580	4,590,010	5%	0%	0%	12805000%	10593000%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Jun	1,234,540	1,995,600	2,173,120	3,681,360	4,493,910	315,199	1,262,640	2,712,870	2,868,760	5,121,330	9%	0%	0%	22116000%	20608000%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Jul	575,236	937,746	1,021,980	1,733,900	2,112,510	146,794	587,877	1,263,540	1,336,180	2,385,760	10%	0%	0%	11094500%	10560700%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Aug	265,493	444,061	484,712	823,993	998,735	67,717	271,116	582,928	616,454	1,100,880	12%	0%	0%	6246100%	6184900%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Sep	228,619	389,444	425,308	722,649	873,121	58,284	233,283	501,760	530,629	947,772	14%	0%	0%	6084400%	6124300%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Oct	176,996	312,427	341,549	579,934	696,429	45,101	180,467	388,299	410,650	733,599	17%	0%	0%	5802700%	5974300%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Nov	182,895	321,738	351,672	597,046	717,424	46,581	186,340	401,078	424,173	757,887	17%	0%	0%	5885800%	6052600%	-1%	-3%	-3%	-8%	-5%
Impacted	2031 Dec	132,747	246,106	269,455	457,344	544,716	33,792	135,144	290,986	307,749	549,960	23%	0%	0%	5530600%	5817800%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Jan	88,498	179,302	196,828	333,922	392,169	22,517	90,025	193,909	205,085	366,559	32%	0%	0%	5210200%	5569500%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Feb	94,601	188,229	206,572	350,755	413,019	24,058	96,161	207,199	219,145	391,755	30%	0%	1%	5225617%	5573214%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Mar	132,747	245,011	268,408	456,584	543,955	33,743	134,834	290,629	307,391	549,603	22%	0%	0%	5421100%	5678300%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Apr	320,067	526,030	574,256	978,530	1,189,190	81,317	324,849	700,449	740,866	1,324,870	11%	0%	0%	6598900%	6409700%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 May	1,106,220	1,698,810	1,850,180	3,154,990	3,883,080	280,910	1,121,880	2,419,900	2,559,590	4,578,020	5%	0%	0%	10881000%	8728000%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Jun	1,234,540	1,522,750	1,643,660	2,809,870	3,622,420	313,340	1,251,050	2,699,500	2,855,390	5,107,960	-12%	0%	0%	-25169000%	-32338000%	-1%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2032 Jul	575,236	705,778	762,118	1,305,500	1,684,110	145,928	582,475	1,257,310	1,329,950	2,379,530	-13%	0%	0%	-12102300%	-15425500%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Aug	265,493	322,808	348,811	599,602	774,344	67,318	268,624	580,054	613,579	1,098,000	-13%	0%	0%	-5879200%	-7405200%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Sep	228,619	278,160	300,552	516,507	666,980	57,940	231,137	499,286	528,155	945,297	-13%	0%	0%	-5044000%	-6351300%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Oct	176,996	215,564	232,899	400,089	516,583	44,834	178,807	386,384	408,734	731,683	-13%	0%	0%	-3883600%	-4890700%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Nov	182,895	222,896	240,809	413,569	533,947	46,306	184,624	399,098	422,194	755,908	-13%	0%	0%	-3998400%	-5033700%	-1%	-4%	-4%	-8%	-5%
Impacted	2032 Dec	132,747	161,549	174,550	299,939	387,310	33,592	133,897	289,548	306,311	548,523	-13%	0%	0%	-2925100%	-3672700%	-1%	-4%	-4%	-8%	-5%
Impacted	2033 Jan	88,498	107,451	116,118	199,710	257,957	22,384	89,194	192,951	204,126	365,601	-13%	0%	0%	-1974900%	-2501500%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Feb	97,980	118,608	128,205	220,751	285,239	24,770	98,677	213,539	225,911	404,687	-13%	0%	0%	-2222100%	-2802200%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Mar	132,747	160,081	173,083	298,467	385,838	33,543	133,591	289,195	305,958	548,169	-13%	0%	0%	-3071900%	-3854200%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Apr	320,067	471,791	514,014	881,989	1,092,650	80,836	321,851	696,992	737,409	1,321,410	2%	0%	0%	1175000%	385500%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 May	1,106,220	1,759,330	1,920,670	3,285,560	4,013,650	279,249	1,111,520	2,407,960	2,547,650	4,566,080	8%	0%	0%	16933000%	15777000%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jun	1,234,540	2,007,860	2,193,280	3,748,840	4,561,390	311,486	1,239,490	2,686,160	2,842,060	5,094,630	10%	0%	0%	23342000%	22624000%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jul	575,236	946,666	1,034,950	1,771,150	2,149,750	145,064	577,088	1,251,100	1,323,730	2,373,320	12%	0%	0%	11986500%	11857700%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Aug	265,493	449,353	492,007	843,309	1,018,050	66,919	266,139	577,187	610,713	1,095,140	14%	0%	0%	6775300%	6914400%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Sep	228,619	391,327	428,608	734,440	884,913	57,596	228,996	496,817	525,686	942,828	16%	0%	0%	6272700%	6454300%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Oct	176,996	310,068	339,846	582,150	698,645	44,568	177,149	384,472	406,823	729,772	18%	0%	0%	5566800%	5804000%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Nov	182,895	319,300	349,913	599,335	719,713	46,031	182,911	397,123	420,218	753,932	18%	0%	0%	5642000%	5876700%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Dec	132,747	244,335	268,177	459,007	546,378	33,393	132,654	288,115	304,878	547,089	23%	0%	0%	5353500%	5690000%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Jan	88,498	178,130	195,977	334,986	393,234	22,253	88,367	192,002	203,178	364,652	33%	0%	0%	5093000%	5484400%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Feb	97,980	192,023	211,152	361,253	425,741	24,629	97,764	212,503	224,875	403,651	30%	0%	0%	5119400%	5492500%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Mar	132,747	243,300	267,136	457,934	545,306	33,358	132,357	287,810	304,573	546,785	23%	0%	0%	5250000%	5551100%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Apr	320,067	533,367	583,916	1,002,140	1,212,800	80,402	318,887	693,701	734,118	1,318,120	13%	0%	0%	7332600%	7375700%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 May	1,106,220	1,806,810	1,975,640	3,385,580	4,113,670	277,796	1,101,310	2,396,750	2,536,440	4,554,870	11%	0%	0%	21681000%	21274000%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jun	1,234,540	2,012,090	2,200,020	3,770,620	4,583,170	309,918	1,228,130	2,673,850	2,829,740	5,082,310	11%	0%	0%	23765000%	23298000%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jul	575,236	952,540	1,042,340	1,787,650	2,166,250	144,358	571,815	1,245,440	1,318,080	2,367,670	12%	0%	0%	12573900%	12596700%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Aug	265,493	455,699	499,423	857,171	1,031,910	66,605	263,712	574,617	608,143	1,092,570	16%	0%	0%	7409900%	7656000%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Sep	228,619	397,669	435,932	747,683	898,155	57,335	226,913	494,637	523,507	940,649	17%	0%	0%	6906900%	7186700%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Oct	176,996	315,348	345,898	592,854	709,348	44,374	175,541	382,812	405,162	728,111	20%	0%	0%	6094800%	6409200%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Nov	182,895	325,505	356,969	611,524	731,902	45,838	181,255	395,435	418,530	752,244	20%	0%	0%	6262500%	6582300%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Dec	132,747	245,330	269,361	461,334	548,705	33,258	131,456	286,909	303,672	545,884	23%	0%	0%	5453000%	5808400%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Jan	88,498	177,900	195,763	334,869	393,116	22,165	87,570	191,206	202,381	363,855	33%	0%	0%	5070000%	5463000%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Feb	97,980	191,791	210,941	361,164	425,652	24,532	96,882	211,621	223,993	402,769	30%	0%	0%	5096200%	5471400%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Mar	132,747	243,015	266,883	457,871	545,241	33,226	131,162	286,615	303,378	545,590	23%	0%	0%	5221500%	5525800%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Apr	320,067	538,484	589,778	1,012,500	1,223,160	80,084	316,005	690,819	731,236	1,315,240	14%	0%	0%	7844300%	7961900%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 May	1,106,220	1,803,280	1,972,230	3,382,970	4,111,060	276,696	1,091,350	2,386,790	2,526,480	4,544,920	11%	0%	0%	21328000%	20933000%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jun	1,234,540	2,007,950	2,196,010	3,767,360	4,579,910	308,691	1,217,020	2,662,740	2,818,630	5,071,200	11%	0%	0%	23351000%	22897000%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jul	575,236	950,857	1,040,740	1,786,570	2,165,180	143,787	566,639	1,240,270	1,312,910	2,362,490	12%	0%	0%	12405600%	12436700%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Aug	265,493	455,253	499,055	857,274	1,032,020	66,341	261,322	572,228	605,754	1,090,180	16%	0%	0%	7365300%	7619200%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Sep	228,619	396,920	435,208	747,111	897,584	57,108	224,855	492,580	521,449	938,591	17%	0%	0%	6832000%	7114300%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Oct	176,996	314,815	345,390	592,496	708,990	44,198	173,948	381,218	403,569	726,518	20%	0%	0%	6041500%	6358400%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Nov	182,895	325,011	356,508	611,257	731,635	45,656	179,609	393,788	416,884	750,598	19%	0%	0%	6213100%	6536200%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Dec	132,747	244,613	268,627	460,492	547,863	33,126	130,262	285,714	302,477	544,689	23%	0%	0%	5381300%	5735000%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Jan	88,498	177,741	195,628	334,883	393,130	22,077	86,774	190,409	201,584	363,059	33%	0%	0%	5054100%	5449500%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Feb	94,601	186,597	205,315	351,735	413,999	23,592	92,688	203,471	215,417	388,027	31%	0%	1%	5062417%	5447514%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Mar	132,747	242,775	266,680	457,892	545,263	33,093	129,964	285,417	302,180	544,392	23%	0%	0%	5197500%	5505500%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Apr	320,067	530,108	580,594	998,434	1,209,100	79,765	313,117	687,931	728,348	1,312,350	13%	0%	0%	7006700%	7043500%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 May	1,106,220	1,798,290	1,967,220	3,377,750	4,105,840	275,593	1,081,370	2,376,810	2,516,500	4,534,930	11%	0%	0%	20829000%	20432000%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Jun	1,234,540	2,002,730	2,190,790	3,762,150	4,574,700	307,460	1,205,880	2,651,590	2,807,480	5,060,050	11%	0%	0%	22829000%	22375000%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Jul	575,236	947,060	1,036,790	1,781,670	2,160,280	143,213	561,445	1,235,070	1,307,710	2,357,300	12%	0%	0%	12025900%	12041700%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Aug	265,493	452,853	496,509	853,842	1,028,580	66,076	258,926	569,831	603,357	1,087,780	16%	0%	0%	7125300%	7364600%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Sep	228,619	393,986	432,048	742,584	893,056	56,880	222,792	490,516	519,385	936,528	17%	0%	0%	6538600%	6798300%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Oct	176,996	313,150	343,620	590,089	706,584	44,021	172,351	379,621	401,971	724,920	19%	0%	0%	5875000%	6181400%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Nov	182,895	322,590	353,897	607,502	727,880	45,473	177,958	392,138	415,233	748,947	19%	0%	0%	5971000%	6275100%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Dec	132,747	243,469	267,416	458,876	546,247	32,994	129,064	284,517	301,279	543,491	23%	0%	0%	5266900%	5613900%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jan	88,498	177,580	195,493	334,898	393,145	21,988	85,975	189,610	200,785	362,260	33%	0%	0%	5038000%	5436000%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Feb	97,980	191,437	210,642	361,196	425,684	24,337	95,115	209,854	222,227	401,002	30%	0%	0%	5060800%	5441500%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Mar	132,747	242,535	266,478	457,914	545,285	32,961	128,769	284,222	300,985	543,197	23%	0%	0%	5173500%	5485300%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Apr	320,067	526,832	577,098	993,601	1,204,260	79,447	310,236	685,050	725,467	1,309,470	12%	0%	0%	6679100%	6693900%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 May	1,106,220	1,794,250	1,963,240	3,374,210	4,102,300	274,494	1,071,410	2,366,850	2,506,540	4,524,970	11%	0%	0%	20425000%	20034000%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jun	1,234,540	1,998,540	2,186,720	3,758,800	4,571,350	306,232	1,194,770	2,640,480	2,796,370	5,048,940	11%	0%	0%	22410000%	21968000%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Jul	575,236	945,261	1,035,060	1,780,390	2,158,990	142,641	556,270	1,229,900	1,302,540	2,352,120	12%	0%	0%	11846000%	11868700%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Aug	265,493	451,189	494,783	851,740	1,026,480	65,812	256,537	567,442	600,968	1,085,390	15%	0%	0%	6958900%	7192000%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Sep	228,619	393,449	431,561	742,396	892,869	56,652	220,735	488,459	517,328	934,471	17%	0%	0%	6484900%	6749600%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Oct	176,996	312,003	342,428	588,620	705,114	43,845	170,758	378,029	400,379	723,328	19%	0%	0%	5760300%	6062200%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Nov	182,895	321,993	353,320	607,048	727,426	45,292	176,312	390,492	413,587	747,301	19%	0%	0%	5911300%	6217400%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Dec	132,747	243,229	267,213	458,898	546,269	32,862	127,869	283,322	300,085	542,296	23%	0%	0%	5242900%	5593600%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jan	88,498	125,773	137,091	236,673	294,920	21,900	85,178	188,813	199,989	361,463	-1%	0%	0%	-142700%	-404200%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Feb	97,980	137,682	150,017	259,087	323,576	24,239	94,233	208,972	221,345	400,120	-1%	0%	0%	-314700%	-621000%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Mar	132,747	189,273	206,383	356,556	443,927	32,829	127,574	283,027	299,790	542,002	0%	0%	0%	-152700%	-524200%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Apr	320,067	454,333	495,267	855,421	1,066,080	79,129	307,355	682,169	722,586	1,306,580	-1%	0%	0%	-570800%	-1489200%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 May	1,106,220	1,582,410	1,725,000	2,976,440	3,704,530	273,394	1,061,450	2,356,900	2,496,590	4,515,020	0%	0%	0%	-759000%	-3790000%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jun	1,234,540	1,755,580	1,913,460	3,302,630	4,115,180	305,005	1,183,650	2,629,370	2,785,260	5,037,830	0%	0%	0%	-1886000%	-5358000%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jul	575,236	820,551	894,693	1,545,440	1,924,050	142,069	551,091	1,224,720	1,297,360	2,346,940	0%	0%	0%	-625000%	-2168000%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Aug	265,493	377,414	411,634	711,980	886,722	65,548	254,146	565,052	598,578	1,083,000	0%	0%	0%	-418600%	-1122900%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Sep	228,619	323,787	353,025	610,278	760,751	56,425	218,676	486,401	515,270	932,412	-1%	0%	0%	-481300%	-1104000%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Oct	176,996	252,520	275,333	475,564	592,059	43,669	169,165	376,435	398,786	721,735	0%	0%	0%	-188000%	-647300%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Nov	182,895	259,908	283,299	489,101	609,479	45,110	174,666	388,846	411,941	745,655	0%	0%	0%	-297200%	-784700%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Dec	132,747	189,629	206,739	356,912	444,283	32,730	126,674	282,127	298,890	541,101	0%	0%	0%	-117100%	-453800%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jan	88,498	126,360	137,767	237,882	296,129	21,816	84,416	188,052	199,227	360,701	0%	0%	0%	-84000%	-336600%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Feb	97,980	180,581	198,385	340,476	404,964	24,154	93,460	208,199	220,572	399,347	23%	0%	0%	3975200%	4215800%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Mar	132,747	256,155	281,781	483,379	570,750	32,725	126,622	282,075	298,838	541,050	28%	0%	0%	6535500%	7015600%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Apr	320,067	552,793	606,311	1,042,450	1,253,110	78,902	305,298	680,112	720,529	1,304,530	17%	0%	0%	9275200%	9615200%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 May	1,106,220	1,800,380	1,970,940	3,391,340	4,119,430	272,704	1,055,170	2,350,610	2,490,300	4,508,730	11%	0%	0%	21038000%	20804000%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jun	1,234,540	2,002,490	2,192,020	3,772,280	4,584,830	304,337	1,177,560	2,623,270	2,779,160	5,031,730	11%	0%	0%	22805000%	22498000%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jul	575,236	955,203	1,046,550	1,801,160	2,179,770	141,806	548,678	1,222,310	1,294,950	2,344,530	13%	0%	0%	12840200%	13017700%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Aug	265,493	464,141	509,396	876,382	1,051,130	65,449	253,234	564,139	597,665	1,082,090	18%	0%	0%	8254100%	8653300%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Sep	228,619	406,661	446,430	767,270	917,743	56,359	218,060	485,785	514,654	931,796	20%	0%	0%	7806100%	8236500%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Oct	176,996	325,699	357,797	614,099	730,594	43,633	168,820	376,090	398,440	721,389	23%	0%	0%	7129900%	7599100%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Nov	182,895	335,392	368,355	631,956	752,333	45,087	174,445	388,625	412,005	745,719	23%	0%	0%	7251200%	7720900%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Dec	132,747	255,972	281,484	482,397	569,768	32,725	126,612	282,065	299,081	541,293	28%	0%	0%	6517200%	7020700%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jan	88,498	185,850	204,795	350,430	408,678	21,816	84,408	188,043	199,387	360,861	38%	0%	0%	5865000%	6366200%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Feb	94,601	195,198	215,034	368,202	430,466	23,321	90,228	201,010	213,137	385,747	36%	0%	1%	5922517%	6419414%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Mar	132,747	254,748	280,205	480,784	568,155	32,725	126,609	282,062	299,078	541,290	28%	0%	0%	6394800%	6858000%	-4%	-9%	-6%	-10%	-6%

		Runoff coefficient 0.41																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2040 Apr	320,067	549,401	602,511	1,036,190	1,246,850	78,902	305,266	680,080	721,107	1,305,110	16%	0%	0%	8936000%	9235200%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 May	1,106,220	1,788,650	1,957,800	3,369,710	4,097,800	272,704	1,055,060	2,350,500	2,492,300	4,510,730	11%	0%	0%	19865000%	19490000%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jun	1,234,540	1,989,400	2,177,370	3,748,140	4,560,690	304,337	1,177,430	2,623,140	2,781,390	5,033,960	10%	0%	0%	21496000%	21033000%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jul	575,236	949,104	1,039,720	1,789,910	2,168,520	141,806	548,620	1,222,250	1,295,990	2,345,570	13%	0%	0%	12230300%	12334700%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Aug	265,493	461,326	506,244	871,191	1,045,930	65,449	253,207	564,113	598,145	1,082,570	18%	0%	0%	7972600%	8338100%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Sep	228,619	404,237	443,715	762,800	913,273	56,359	218,038	485,762	515,067	932,210	19%	0%	0%	7563700%	7965000%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Oct	176,996	323,822	355,695	610,638	727,132	43,633	168,802	376,072	398,760	721,709	23%	0%	0%	6942200%	7388900%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Nov	182,895	333,453	366,183	628,379	748,757	45,087	174,427	388,606	412,051	745,765	22%	0%	0%	7057300%	7503700%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Dec	132,747	254,564	279,908	479,801	567,172	32,725	126,599	282,052	299,068	541,280	28%	0%	0%	6376400%	6863100%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jan	88,498	184,907	203,738	348,690	406,938	21,816	84,398	188,033	199,377	360,852	37%	0%	0%	5770700%	6260500%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Feb	97,980	199,467	219,676	376,290	440,778	24,154	93,438	208,177	220,736	399,511	34%	0%	0%	5863800%	6344900%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Mar	132,747	253,306	278,591	478,125	565,496	32,725	126,590	282,042	299,058	541,270	27%	0%	0%	6250600%	6696600%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Apr	320,067	545,889	598,577	1,029,710	1,240,370	78,902	305,213	680,027	721,054	1,305,050	16%	0%	0%	8584800%	8841800%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 May	1,106,220	1,776,380	1,944,060	3,347,060	4,075,160	272,704	1,054,850	2,350,290	2,492,090	4,510,520	10%	0%	0%	18638000%	18116000%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jun	1,234,540	1,975,570	2,161,870	3,722,600	4,535,150	304,337	1,177,180	2,622,890	2,781,140	5,033,710	10%	0%	0%	20113000%	19483000%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jul	575,236	942,592	1,032,420	1,777,880	2,156,490	141,806	548,491	1,222,120	1,295,860	2,345,440	12%	0%	0%	11579100%	11604700%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Aug	265,493	458,289	502,841	865,580	1,040,320	65,449	253,142	564,048	598,080	1,082,500	17%	0%	0%	7668900%	7997800%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Sep	228,619	401,595	440,755	757,918	908,390	56,359	217,977	485,702	515,007	932,149	19%	0%	0%	7299500%	7669000%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Oct	176,996	321,756	353,381	606,819	723,314	43,633	168,752	376,022	398,710	721,659	22%	0%	0%	6735600%	7157500%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Nov	182,895	331,297	363,767	624,393	744,771	45,087	174,372	388,551	411,995	745,709	22%	0%	0%	6841700%	7262100%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Dec	132,747	252,984	278,137	476,879	564,250	32,725	126,556	282,009	299,025	541,237	27%	0%	0%	6218400%	6686000%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jan	88,498	183,799	202,496	346,638	404,886	21,816	84,370	188,005	199,349	360,823	37%	0%	0%	5659900%	6136300%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Feb	97,980	198,142	218,189	373,827	438,315	24,154	93,409	208,148	220,708	399,483	33%	0%	0%	5731300%	6196200%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Mar	132,747	251,378	276,425	474,530	561,901	32,725	126,555	282,007	299,023	541,235	26%	0%	0%	6057800%	6480000%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Apr	320,067	540,904	592,977	1,020,400	1,231,060	78,902	305,137	679,951	720,978	1,304,980	15%	0%	0%	8086300%	8281800%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 May	1,106,220	1,758,000	1,923,400	3,312,650	4,040,740	272,704	1,054,620	2,350,060	2,491,860	4,510,290	9%	0%	0%	16800000%	16050000%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jun	1,234,540	1,953,770	2,137,350	3,681,710	4,494,260	304,337	1,176,960	2,622,670	2,780,920	5,033,490	9%	0%	0%	17933000%	17031000%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Jul	575,236	931,833	1,020,320	1,757,670	2,136,280	141,806	548,403	1,222,030	1,295,770	2,345,350	11%	0%	0%	10503200%	10394700%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Aug	265,493	453,042	496,937	855,709	1,030,450	65,449	253,109	564,015	598,046	1,082,470	16%	0%	0%	7144200%	7407400%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Sep	228,619	396,838	435,401	748,957	899,430	56,359	217,955	485,679	514,984	932,127	17%	0%	0%	6823800%	7133600%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Oct	176,996	317,889	349,027	599,526	716,020	43,633	168,739	376,010	398,697	721,646	21%	0%	0%	6348900%	6722100%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Nov	182,895	327,110	359,052	616,488	736,866	45,087	174,364	388,543	411,987	745,701	20%	0%	0%	6423000%	6790600%	-4%	-9%	-6%	-10%	-6%
Impacted	2042 Dec	132,747	249,807	274,558	470,875	558,246	32,725	126,555	282,007	299,023	541,235	26%	0%	0%	5900700%	6328100%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jan	88,498	183,481	202,051	346,569	404,869	21,816	87,414	191,049	202,392	363,867	37%	0%	0%	5628100%	6091800%	-4%	-6%	-5%	-9%	-5%
Impacted	2043 Feb	97,980	194,518	213,985	367,395	431,942	24,154	96,453	211,192	223,751	402,526	32%	0%	0%	5368900%	5775800%	-4%	-6%	-5%	-9%	-5%
Impacted	2043 Mar	132,747	234,986	257,746	443,760	531,210	32,725	129,598	285,051	302,067	544,278	19%	0%	0%	4418600%	4612100%	-4%	-7%	-5%	-10%	-6%
Impacted	2043 Apr	320,067	453,023	493,522	855,200	1,066,050	78,902	308,181	682,995	724,021	1,308,020	-1%	0%	0%	-701800%	-1663700%	-4%	-8%	-6%	-10%	-6%
Impacted	2043 May	1,106,220	1,368,090	1,483,040	2,581,950	3,310,710	272,704	1,057,670	2,353,110	2,494,900	4,513,330	-11%	0%	0%	-22191000%	-27986000%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jun	1,234,540	1,517,460	1,644,560	2,863,810	3,677,100	304,337	1,211,280	2,656,990	2,815,240	5,067,810	-11%	0%	0%	-25698000%	-32248000%	-4%	-6%	-5%	-9%	-5%
Impacted	2043 Jul	575,236	750,035	814,698	1,415,670	1,794,620	141,806	577,916	1,251,540	1,325,280	2,374,860	-7%	0%	0%	-7676600%	-10167500%	-4%	-4%	-4%	-8%	-5%
Impacted	2043 Aug	265,493	389,501	424,831	735,332	910,233	65,449	267,250	578,155	612,186	1,096,610	2%	0%	0%	790100%	196800%	-4%	-4%	-4%	-8%	-5%
Impacted	2043 Sep	228,619	346,580	378,419	654,339	804,949	56,359	231,208	498,932	528,237	945,379	5%	0%	0%	1798000%	1435400%	-4%	-3%	-4%	-8%	-5%
Impacted	2043 Oct	176,996	286,491	313,441	540,950	657,551	43,633	180,193	387,463	410,150	733,099	11%	0%	0%	3209100%	3163500%	-4%	-3%	-4%	-8%	-5%
Impacted	2043 Nov	182,895	293,358	320,867	553,909	674,396	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	3047800%	2972100%	-4%	-3%	-4%	-8%	-5%
Impacted	2043 Dec	132,747	234,986	257,746	443,760	531,210	32,725	136,239	291,692	308,707	550,919	20%	0%	0%	4418600%	4646900%	-4%	-2%	-3%	-8%	-4%
Impacted	2044 Jan	88,498	183,481	202,051	346,569	404,869	21,816	91,756	195,392	206,735	368,210	37%	0%	0%	5628100%	6091800%	-4%	-1%	-3%	-7%	-4%
Impacted	2044 Feb	94,601	190,585	209,733	359,975	422,296	23,321	97,702	208,485	220,611	393,221	33%	0%	1%	5461217%	5889314%	-4%	-1%	-3%	-7%	-4%
Impacted	2044 Mar	132,747	234,986	257,746	443,760	531,210	32,725	135,503	290,956	307,971	550,183	19%	0%	0%	4418600%	4612100%	-4%	-2%	-3%	-8%	-4%
Impacted	2044 Apr	320,067	469,063	511,592	885,534	1,096,390	78,902	322,901	697,715	738,741	1,322,740	2%	0%	0%	902200%	143300%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2045 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2045 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2045 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2045 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2046 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2046 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2046 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2046 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2047 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2047 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2047 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2047 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%

		Runoff coefficient 0.41																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2048 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2048 Feb	94,601	149,849	163,839	282,935	345,256	23,321	97,702	208,485	220,611	393,221	9%	0%	1%	1387617%	1299914%	-4%	-1%	-3%	-7%	-4%
Impacted	2048 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2048 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2048 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2048 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2048 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2049 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2049 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2049 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2049 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2050 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2050 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2050 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2050 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2051 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2051 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2051 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2051 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2052 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2052 Feb	94,601	149,849	163,839	282,935	345,256	23,321	97,702	208,485	220,611	393,221	9%	0%	1%	1387617%	1299914%	-4%	-1%	-3%	-7%	-4%
Impacted	2052 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2052 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2053 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2053 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2053 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2053 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2054 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2054 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2054 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2054 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2055 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2055 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2055 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2055 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2055 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2056 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2056 Feb	94,601	149,849	163,839	282,935	345,256	23,321	97,702	208,485	220,611	393,221	9%	0%	1%	1387617%	1299914%	-4%	-1%	-3%	-7%	-4%
Impacted	2056 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2056 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2057 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2057 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2057 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2057 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2058 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2058 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2058 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2058 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2059 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2059 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2059 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2059 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2060 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2060 Feb	94,601	149,849	163,839	282,935	345,256	23,321	97,702	208,485	220,611	393,221	9%	0%	1%	1387617%	1299914%	-4%	-1%	-3%	-7%	-4%
Impacted	2060 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2060 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2061 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2061 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2061 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2061 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2062 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2062 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2062 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2062 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2063 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2063 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2063 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2063 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2063 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2064 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2064 Feb	94,601	149,849	163,839	282,935	345,256	23,321	97,702	208,485	220,611	393,221	9%	0%	1%	1387617%	1299914%	-4%	-1%	-3%	-7%	-4%
Impacted	2064 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2064 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2065 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2065 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2065 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2065 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2066 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2066 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2066 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2066 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2067 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2067 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2067 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2067 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2068 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2068 Feb	94,601	149,849	163,839	282,935	345,256	23,321	97,702	208,485	220,611	393,221	9%	0%	1%	1387617%	1299914%	-4%	-1%	-3%	-7%	-4%
Impacted	2068 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2068 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2069 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2069 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2069 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2069 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2070 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2070 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2070 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2070 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2071 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2071 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2071 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%

		Runoff coefficient 0.41																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2071 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2071 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2071 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2071 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2072 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2072 Feb	94,601	149,849	163,839	282,935	345,256	23,321	97,702	208,485	220,611	393,221	9%	0%	1%	1387617%	1299914%	-4%	-1%	-3%	-7%	-4%
Impacted	2072 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2072 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2073 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2073 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2073 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2073 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2074 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2074 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2074 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2074 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2075 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2075 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2075 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2075 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2076 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2076 Feb	94,601	149,849	163,839	282,935	345,256	23,321	97,702	208,485	220,611	393,221	9%	0%	1%	1387617%	1299914%	-4%	-1%	-3%	-7%	-4%
Impacted	2076 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2076 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%

		Runoff coefficient 0.41																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2079 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2079 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2079 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2079 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2080 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2080 Feb	94,601	149,849	163,839	282,935	345,256	23,321	97,702	208,485	220,611	393,221	9%	0%	1%	1387617%	1299914%	-4%	-1%	-3%	-7%	-4%
Impacted	2080 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2080 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2081 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2081 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2081 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2081 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2082 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2082 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2082 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2082 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2083 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2083 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2083 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2083 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2084 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2084 Feb	94,601	149,849	163,839	282,935	345,256	23,321	97,702	208,485	220,611	393,221	9%	0%	1%	1387617%	1299914%	-4%	-1%	-3%	-7%	-4%
Impacted	2084 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2084 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2085 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2085 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2085 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2085 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2086 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2086 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2086 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2086 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2086 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2087 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2087 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2087 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2087 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2088 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2088 Feb	94,601	149,849	163,839	282,935	345,256	23,321	97,702	208,485	220,611	393,221	9%	0%	1%	1387617%	1299914%	-4%	-1%	-3%	-7%	-4%
Impacted	2088 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2088 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2089 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2089 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2089 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2089 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2090 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2090 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2090 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2090 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2091 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2091 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2091 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2091 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2092 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2092 Feb	94,601	149,849	163,839	282,935	345,256	23,321	97,702	208,485	220,611	393,221	9%	0%	1%	1387617%	1299914%	-4%	-1%	-3%	-7%	-4%
Impacted	2092 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2092 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2093 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2093 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2093 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2093 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Jun	1,234,540	1,966,910	2,150,910	3,713,800	4,527,090	304,337	1,240,400	2,686,120	2,844,360	5,096,930	9%	0%	0%	19247000%	18387000%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Jul	575,236	907,260	991,830	1,713,010	2,091,960	141,806	577,916	1,251,540	1,325,280	2,374,860	9%	0%	0%	8045900%	7545700%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Oct	176,996	280,616	306,823	529,840	646,441	43,633	180,193	387,463	410,150	733,099	9%	0%	0%	2621600%	2501700%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Nov	182,895	292,454	319,848	552,198	672,685	45,087	186,549	400,729	424,172	757,886	10%	0%	0%	2957400%	2870200%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Dec	132,747	212,296	232,183	400,849	488,299	32,725	136,239	291,692	308,707	550,919	10%	0%	0%	2149600%	2090600%	-4%	-2%	-3%	-8%	-4%
Impacted	2094 Jan	88,498	141,067	154,266	266,355	324,656	21,816	91,756	195,392	206,735	368,210	9%	0%	0%	1386700%	1313300%	-4%	-1%	-3%	-7%	-4%
Impacted	2094 Feb	97,980	155,201	169,691	293,040	357,587	24,154	101,083	215,822	228,381	407,156	9%	0%	0%	1437200%	1346400%	-4%	-1%	-3%	-7%	-4%
Impacted	2094 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2094 Apr	320,067	504,769	551,819	953,061	1,163,910	78,902	322,901	697,715	738,741	1,322,740	9%	0%	0%	4472800%	4166000%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 May	1,106,220	1,763,660	1,928,690	3,330,040	4,058,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	10%	0%	0%	17366000%	16579000%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Jun	1,234,540	2,025,960	2,217,440	3,825,480	4,638,770	304,337	1,240,400	2,686,120	2,844,360	5,096,930	12%	0%	0%	25152000%	25040000%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		Mean Average Precipitation																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2094 Jul	575,236	920,673	1,006,940	1,738,380	2,117,330	141,806	577,916	1,251,540	1,325,280	2,374,860	10%	0%	0%	9387200%	9056700%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Oct	176,996	282,100	308,494	532,645	649,246	43,633	180,193	387,463	410,150	733,099	10%	0%	0%	2770000%	2668800%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Nov	182,895	302,582	331,258	571,352	691,839	45,087	186,549	400,729	424,172	757,886	13%	0%	0%	3970200%	4011200%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Dec	132,747	219,261	240,030	414,020	501,471	32,725	136,239	291,692	308,707	550,919	13%	0%	0%	2846100%	2875300%	-4%	-2%	-3%	-8%	-4%
Impacted	2095 Jan	88,498	144,365	157,982	272,592	330,893	21,816	91,756	195,392	206,735	368,210	12%	0%	0%	1716500%	1684900%	-4%	-1%	-3%	-7%	-4%
Impacted	2095 Feb	97,980	157,315	172,072	297,038	361,585	24,154	101,083	215,822	228,381	407,156	10%	0%	0%	1648600%	1584500%	-4%	-1%	-3%	-7%	-4%
Impacted	2095 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2095 Apr	320,067	511,350	559,234	965,507	1,176,360	78,902	322,901	697,715	738,741	1,322,740	10%	0%	0%	5130900%	4907500%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 May	1,106,220	1,823,940	1,996,600	3,444,050	4,172,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	13%	0%	0%	23394000%	23370000%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Jun	1,234,540	2,032,040	2,224,300	3,836,990	4,650,280	304,337	1,240,400	2,686,120	2,844,360	5,096,930	12%	0%	0%	25760000%	25726000%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Jul	575,236	920,673	1,006,940	1,738,380	2,117,330	141,806	577,916	1,251,540	1,325,280	2,374,860	10%	0%	0%	9387200%	9056700%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Oct	176,996	282,100	308,494	532,645	649,246	43,633	180,193	387,463	410,150	733,099	10%	0%	0%	2770000%	2668800%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Nov	182,895	302,582	331,258	571,352	691,839	45,087	186,549	400,729	424,172	757,886	13%	0%	0%	3970200%	4011200%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Dec	132,747	219,261	240,030	414,020	501,471	32,725	136,239	291,692	308,707	550,919	13%	0%	0%	2846100%	2875300%	-4%	-2%	-3%	-8%	-4%
Impacted	2096 Jan	88,498	144,365	157,982	272,592	330,893	21,816	91,756	195,392	206,735	368,210	12%	0%	0%	1716500%	1684900%	-4%	-1%	-3%	-7%	-4%
Impacted	2096 Feb	94,601	151,835	166,076	286,690	349,011	23,321	97,702	208,485	220,611	393,221	10%	0%	1%	1586217%	1523614%	-4%	-1%	-3%	-7%	-4%
Impacted	2096 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2096 Apr	320,067	511,350	559,234	965,507	1,176,360	78,902	322,901	697,715	738,741	1,322,740	10%	0%	0%	5130900%	4907500%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 May	1,106,220	1,823,940	1,996,600	3,444,050	4,172,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	13%	0%	0%	23394000%	23370000%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Jun	1,234,540	2,032,040	2,224,300	3,836,990	4,650,280	304,337	1,240,400	2,686,120	2,844,360	5,096,930	12%	0%	0%	25760000%	25726000%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Jul	575,236	920,673	1,006,940	1,738,380	2,117,330	141,806	577,916	1,251,540	1,325,280	2,374,860	10%	0%	0%	9387200%	9056700%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Oct	176,996	282,100	308,494	532,645	649,246	43,633	180,193	387,463	410,150	733,099	10%	0%	0%	2770000%	2668800%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Nov	182,895	302,582	331,258	571,352	691,839	45,087	186,549	400,729	424,172	757,886	13%	0%	0%	3970200%	4011200%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Dec	132,747	219,261	240,030	414,020	501,471	32,725	136,239	291,692	308,707	550,919	13%	0%	0%	2846100%	2875300%	-4%	-2%	-3%	-8%	-4%
Impacted	2097 Jan	88,498	144,365	157,982	272,592	330,893	21,816	91,756	195,392	206,735	368,210	12%	0%	0%	1716500%	1684900%	-4%	-1%	-3%	-7%	-4%
Impacted	2097 Feb	97,980	157,315	172,072	297,038	361,585	24,154	101,083	215,822	228,381	407,156	10%	0%	0%	1648600%	1584500%	-4%	-1%	-3%	-7%	-4%
Impacted	2097 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2097 Apr	320,067	511,350	559,234	965,507	1,176,360	78,902	322,901	697,715	738,741	1,322,740	10%	0%	0%	5130900%	4907500%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 May	1,106,220	1,823,940	1,996,600	3,444,050	4,172,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	13%	0%	0%	23394000%	23370000%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Jun	1,234,540	2,032,040	2,224,300	3,836,990	4,650,280	304,337	1,240,400	2,686,120	2,844,360	5,096,930	12%	0%	0%	25760000%	25726000%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Jul	575,236	920,673	1,006,940	1,738,380	2,117,330	141,806	577,916	1,251,540	1,325,280	2,374,860	10%	0%	0%	9387200%	9056700%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Oct	176,996	282,100	308,494	532,645	649,246	43,633	180,193	387,463	410,150	733,099	10%	0%	0%	2770000%	2668800%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Nov	182,895	302,582	331,258	571,352	691,839	45,087	186,549	400,729	424,172	757,886	13%	0%	0%	3970200%	4011200%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Dec	132,747	219,261	240,030	414,020	501,471	32,725	136,239	291,692	308,707	550,919	13%	0%	0%	2846100%	2875300%	-4%	-2%	-3%	-8%	-4%
Impacted	2098 Jan	88,498	144,365	157,982	272,592	330,893	21,816	91,756	195,392	206,735	368,210	12%	0%	0%	1716500%	1684900%	-4%	-1%	-3%	-7%	-4%
Impacted	2098 Feb	97,980	157,315	172,072	297,038	361,585	24,154	101,083	215,822	228,381	407,156	10%	0%	0%	1648600%	1584500%	-4%	-1%	-3%	-7%	-4%
Impacted	2098 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2098 Apr	320,067	511,350	559,234	965,507	1,176,360	78,902	322,901	697,715	738,741	1,322,740	10%	0%	0%	5130900%	4907500%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 May	1,106,220	1,823,940	1,996,600	3,444,050	4,172,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	13%	0%	0%	23394000%	23370000%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Jun	1,234,540	2,032,040	2,224,300	3,836,990	4,650,280	304,337	1,240,400	2,686,120	2,844,360	5,096,930	12%	0%	0%	25760000%	25726000%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Jul	575,236	920,673	1,006,940	1,738,380	2,117,330	141,806	577,916	1,251,540	1,325,280	2,374,860	10%	0%	0%	9387200%	9056700%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Oct	176,996	282,100	308,494	532,645	649,246	43,633	180,193	387,463	410,150	733,099	10%	0%	0%	2770000%	2668800%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Nov	182,895	302,582	331,258	571,352	691,839	45,087	186,549	400,729	424,172	757,886	13%	0%	0%	3970200%	4011200%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Dec	132,747	219,261	240,030	414,020	501,471	32,725	136,239	291,692	308,707	550,919	13%	0%	0%	2846100%	2875300%	-4%	-2%	-3%	-8%	-4%
Impacted	2099 Jan	88,498	144,365	157,982	272,592	330,893	21,816	91,756	195,392	206,735	368,210	12%	0%	0%	1716500%	1684900%	-4%	-1%	-3%	-7%	-4%
Impacted	2099 Feb	97,980	157,315	172,072	297,038	361,585	24,154	101,083	215,822	228,381	407,156	10%	0%	0%	1648600%	1584500%	-4%	-1%	-3%	-7%	-4%
Impacted	2099 Mar	132,747	208,249	227,623	393,194	480,645	32,725	135,503	290,956	307,971	550,183	8%	0%	0%	1744900%	1599800%	-4%	-2%	-3%	-8%	-4%
Impacted	2099 Apr	320,067	511,350	559,234	965,507	1,176,360	78,902	322,901	697,715	738,741	1,322,740	10%	0%	0%	5130900%	4907500%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 May	1,106,220	1,823,940	1,996,600	3,444,050	4,172,800	272,704	1,112,010	2,407,450	2,549,240	4,567,670	13%	0%	0%	23394000%	23370000%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Jun	1,234,540	2,032,040	2,224,300	3,836,990	4,650,280	304,337	1,240,400	2,686,120	2,844,360	5,096,930	12%	0%	0%	25760000%	25726000%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Jul	575,236	920,673	1,006,940	1,738,380	2,117,330	141,806	577,916	1,251,540	1,325,280	2,374,860	10%	0%	0%	9387200%	9056700%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Aug	265,493	412,577	450,829	778,973	953,874	65,449	267,250	578,155	612,186	1,096,610	7%	0%	0%	3097700%	2796600%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Sep	228,619	358,869	392,263	677,580	828,189	56,359	231,208	498,932	528,237	945,379	8%	0%	0%	3026900%	2819800%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Oct	176,996	282,100	308,494	532,645	649,246	43,633	180,193	387,463	410,150	733,099	10%	0%	0%	2770000%	2668800%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Nov	182,895	302,582	331,258	571,352	691,839	45,087	186,549	400,729	424,172	757,886	13%	0%	0%	3970200%	4011200%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Dec	132,747	219,261	240,030	414,020	501,471	32,725	136,239	291,692	308,707	550,919	13%	0%	0%	2846100%	2875300%	-4%	-2%	-3%	-8%	-4%

		Runoff coefficient 0.41																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Baseline	2017 Jan	6.53E+04	9.39E+04	1.04E+05	1.76E+05	2.19E+05	16772.3	68352.5	148269	164206	283347	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Feb	7.23E+04	1.04E+05	1.15E+05	1.95E+05	2.42E+05	18569.4	75676	164155	181800	313706	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Mar	9.79E+04	1.41E+05	1.56E+05	2.64E+05	3.28E+05	25158.5	102529	222404	246309	425021	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Apr	2.36E+05	3.39E+05	3.76E+05	6.36E+05	7.91E+05	60660	247208	5.36E+05	5.94E+05	1.02E+06	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 May	8.16E+05	1.17E+06	1.30E+06	2.20E+06	2.73E+06	2.10E+05	8.54E+05	1.85E+06	2.05E+06	3.54E+06	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jun	9.11E+05	1.31E+06	1.45E+06	2.45E+06	3.05E+06	2.34E+05	9.54E+05	2.07E+06	2.29E+06	3.95E+06	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Jul	4.24E+05	6.10E+05	6.76E+05	1.14E+06	1.42E+06	109020	4.44E+05	9.64E+05	1.07E+06	1.84E+06	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Aug	1.96E+05	2.82E+05	3.12E+05	5.27E+05	6.56E+05	50317.1	205058	4.45E+05	4.93E+05	8.50E+05	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Sep	1.69E+05	2.42E+05	2.69E+05	4.54E+05	5.65E+05	43328.6	176577	383029	424199	7.32E+05	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Oct	1.31E+05	1.88E+05	2.08E+05	3.51E+05	4.37E+05	33544.7	136705	296539	328412	5.67E+05	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Nov	1.35E+05	1.94E+05	2.15E+05	3.63E+05	4.52E+05	34662.9	141262	306424	339359	5.86E+05	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Baseline	2017 Dec	9.79E+04	1.41E+05	1.56E+05	2.64E+05	3.28E+05	25158.5	102529	222404	246309	425021	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Impacted	2018 Jan	6.53E+04	9.39E+04	1.04E+05	1.76E+05	2.19E+05	16772.3	68352.5	148269	164206	283347	0%	9%	8%	8%	6%	0%	0%	0%	0%	0%
Impacted	2018 Feb	7.23E+04	1.04E+05	1.15E+05	1.94E+05	2.42E+05	18569.4	75676	164155	181800	313706	0%	9%	8%	8%	6%	0%	0%	0%	0%	0%
Impacted	2018 Mar	9.79E+04	1.41E+05	1.56E+05	2.63E+05	3.28E+05	25158.5	102529	222404	246309	425021	0%	9%	8%	8%	6%	0%	0%	0%	0%	0%
Impacted	2018 Apr	2.36E+05	3.39E+05	3.76E+05	6.35E+05	7.90E+05	60660	247208	5.36E+05	5.94E+05	1.02E+06	0%	9%	8%	8%	6%	0%	0%	0%	0%	0%
Impacted	2018 May	8.16E+05	1.17E+06	1.30E+06	2.19E+06	2.73E+06	2.10E+05	8.54E+05	1.85E+06	2.05E+06	3.54E+06	0%	9%	8%	8%	6%	0%	0%	0%	0%	0%
Impacted	2018 Jun	9.11E+05	1.31E+06	1.45E+06	2.45E+06	3.05E+06	2.34E+05	9.54E+05	2.07E+06	2.29E+06	3.95E+06	0%	9%	8%	8%	6%	0%	0%	0%	0%	0%
Impacted	2018 Jul	4.24E+05	6.10E+05	6.75E+05	1.14E+06	1.42E+06	109020	4.44E+05	9.64E+05	1.07E+06	1.84E+06	0%	9%	8%	8%	6%	0%	0%	0%	0%	0%
Impacted	2018 Aug	1.96E+05	2.82E+05	3.11E+05	5.27E+05	6.55E+05	50317.1	205058	4.45E+05	4.93E+05	8.50E+05	0%	9%	8%	8%	6%	0%	0%	0%	0%	0%
Impacted	2018 Sep	1.69E+05	2.42E+05	2.68E+05	4.53E+05	5.64E+05	43328.6	176577	383029	424199	7.32E+05	0%	9%	8%	8%	6%	0%	0%	0%	0%	0%
Impacted	2018 Oct	1.31E+05	1.88E+05	2.07E+05	3.51E+05	4.37E+05	33544.7	136705	296539	328412	5.67E+05	0%	9%	8%	8%	6%	0%	0%	0%	0%	0%
Impacted	2018 Nov	1.35E+05	1.94E+05	2.14E+05	3.63E+05	4.51E+05	34662.9	141262	306424	339359	5.86E+05	0%	9%	8%	8%	6%	0%	0%	0%	0%	0%
Impacted	2018 Dec	9.79E+04	1.41E+05	1.56E+05	2.63E+05	3.28E+05	25158.5	102529	222404	246309	425021	0%	9%	8%	8%	6%	0%	0%	0%	0%	0%
Impacted	2019 Jan	6.53E+04	1.40E+05	1.56E+05	2.62E+05	3.05E+05	16772.3	68352.5	148269	163889	283030	0%	12%	11%	11%	8%	0%	0%	0%	0%	0%
Impacted	2019 Feb	7.23E+04	1.50E+05	1.67E+05	2.81E+05	3.28E+05	18569.4	75676	164155	180758	312665	0%	12%	11%	11%	8%	0%	0%	0%	-1%	0%
Impacted	2019 Mar	9.79E+04	1.87E+05	2.07E+05	3.48E+05	4.13E+05	25158.5	102529	222404	243964	422675	0%	11%	10%	10%	8%	0%	0%	0%	-1%	-1%
Impacted	2019 Apr	2.36E+05	3.85E+05	4.26E+05	7.15E+05	8.70E+05	60660	247208	5.36E+05	5.86E+05	1.02E+06	0%	9%	9%	8%	7%	0%	0%	0%	-1%	-1%
Impacted	2019 May	8.16E+05	1.22E+06	1.35E+06	2.25E+06	2.79E+06	2.10E+05	8.54E+05	1.85E+06	2.02E+06	3.51E+06	0%	8%	8%	8%	6%	0%	0%	0%	-2%	-1%
Impacted	2019 Jun	9.11E+05	1.35E+06	1.50E+06	2.49E+06	3.09E+06	2.34E+05	9.54E+05	2.07E+06	2.24E+06	3.90E+06	0%	8%	8%	7%	6%	0%	0%	0%	-2%	-1%
Impacted	2019 Jul	4.24E+05	6.55E+05	7.24E+05	1.20E+06	1.48E+06	109020	4.44E+05	9.64E+05	1.04E+06	1.81E+06	0%	9%	8%	8%	6%	0%	0%	0%	-3%	-1%
Impacted	2019 Aug	1.96E+05	3.27E+05	3.62E+05	6.01E+05	7.30E+05	50317.1	205058	4.45E+05	4.78E+05	8.36E+05	0%	9%	9%	8%	7%	0%	0%	0%	-3%	-2%
Impacted	2019 Sep	1.69E+05	2.93E+05	3.24E+05	5.37E+05	6.48E+05	43328.6	176577	383029	410143	7.18E+05	0%	10%	9%	9%	7%	0%	0%	0%	-3%	-2%
Impacted	2019 Oct	1.31E+05	2.40E+05	2.66E+05	4.40E+05	5.26E+05	33544.7	136705	296539	316241	5.55E+05	0%	10%	10%	9%	7%	0%	0%	0%	-4%	-2%
Impacted	2019 Nov	1.35E+05	2.48E+05	2.74E+05	4.53E+05	5.42E+05	34662.9	141262	306424	325451	5.72E+05	0%	10%	10%	9%	7%	0%	0%	0%	-4%	-2%
Impacted	2019 Dec	9.79E+04	1.93E+05	2.14E+05	3.53E+05	4.17E+05	25158.5	102529	222404	235248	413960	0%	11%	10%	10%	8%	0%	0%	0%	-4%	-3%
Impacted	2020 Jan	6.53E+04	1.43E+05	1.59E+05	2.64E+05	3.07E+05	16772.3	68352.5	148269	156515	275656	0%	12%	12%	11%	8%	0%	0%	0%	-5%	-3%
Impacted	2020 Feb	6.98E+04	1.49E+05	1.66E+05	2.75E+05	3.21E+05	17929.1	73066.5	158495	167309	294667	0%	12%	11%	11%	8%	0%	0%	0%	-5%	-3%
Impacted	2020 Mar	9.79E+04	1.89E+05	2.10E+05	3.50E+05	4.14E+05	25158.5	102529	222404	234772	413484	0%	11%	10%	10%	8%	0%	0%	0%	-5%	-3%
Impacted	2020 Apr	2.36E+05	3.89E+05	4.31E+05	7.21E+05	8.76E+05	60660	247208	5.36E+05	5.66E+05	9.97E+05	0%	9%	9%	8%	7%	0%	0%	0%	-5%	-3%
Impacted	2020 May	8.16E+05	1.23E+06	1.35E+06	2.28E+06	2.82E+06	2.10E+05	8.54E+05	1.85E+06	1.96E+06	3.45E+06	0%	8%	8%	8%	6%	0%	0%	0%	-5%	-3%
Impacted	2020 Jun	9.11E+05	1.35E+06	1.49E+06	2.53E+06	3.13E+06	2.34E+05	9.54E+05	2.07E+06	2.18E+06	3.85E+06	0%	8%	8%	8%	6%	0%	0%	0%	-5%	-3%
Impacted	2020 Jul	4.24E+05	6.49E+05	7.18E+05	1.22E+06	1.50E+06	109020	4.44E+05	9.64E+05	1.02E+06	1.79E+06	0%	9%	8%	8%	6%	0%	0%	0%	-5%	-3%
Impacted	2020 Aug	1.96E+05	3.21E+05	3.56E+05	6.09E+05	7.38E+05	50317.1	205058	4.45E+05	4.70E+05	8.27E+05	0%	9%	9%	8%	7%	0%	0%	0%	-5%	-3%
Impacted	2020 Sep	1.69E+05	2.82E+05	3.12E+05	5.37E+05	6.48E+05	43328.6	176577	383029	404330	7.12E+05	0%	9%	9%	9%	7%	0%	0%	0%	-5%	-3%
Impacted	2020 Oct	1.31E+05	2.28E+05	2.53E+05	4.36E+05	5.22E+05	33544.7	136705	296539	313030	5.51E+05	0%	10%	9%	9%	7%	0%	0%	0%	-5%	-3%
Impacted	2020 Nov	1.35E+05	2.33E+05	2.58E+05	4.48E+05	5.37E+05	34662.9	141262	306424	323464	5.70E+05	0%	10%	9%	9%	7%	0%	0%	0%	-5%	-3%
Impacted	2020 Dec	9.79E+04	1.81E+05	2.00E+05	3.49E+05	4.13E+05	25158.5	102529	222404	234772	413484	0%	10%	10%	10%	8%	0%	0%	0%	-5%	-3%
Impacted	2021 Jan	6.53E+04	1.35E+05	1.51E+05	2.61E+05	3.04E+05	16772.3	68347.9	148251	156497	275638	0%	11%	11%	11%	8%	0%	0%	0%	-5%	-3%
Impacted	2021 Feb	7.23E+04	1.45E+05	1.61E+05	2.80E+05	3.27E+05	18569.4	75661.5	164098	173227	305133	0%	11%	11%	10%	8%	0%	0%	0%	-5%	-3%
Impacted	2021 Mar	9.79E+04	1.80E+05	1.99E+05	3.48E+05	4.12E+05	25158.5	102496	222276	234644	413356	0%	10%	10%	10%	7%	0%	0%	0%	-5%	-3%
Impacted	2021 Apr	2.36E+05	3.69E+05	4.08E+05	7.16E+05	8.71E+05	60660	247098	5.36E+05	5.66E+05	9.97E+05	0%	9%	8%	8%	7%	0%	0%	0%	-5%	-3%
Impacted	2021 May	8.16E+05	1.16E+06	1.29E+06	2.27E+06	2.80E+06	2.10E+05	8.54E+05	1.85E+06	1.95E+06	3.44E+06	0%	8%	7%	8%	6%	0%	0%	0%	-5%	-3%
Impacted	2021 Jun	9.11E+05	1.42E+06	1.54E+06	2.53E+06	3.13E+06	2.34E+05	9.53E+05	2.07E+06	2.18E+06	3.84E+06	0%	9%	8%	8%	6%	0%	0%	0%	-5%	-3%
Impacted	2021 Jul	4.24E+05	6.86E+05	7.46E+05	1.23E+06	1.51E+06	109020	4.44E+05	9.62E+05	1.02E+06	1.79E+06	0%	9%	8%	8%	6%	0%	0%	0%	-5%	-3%
Impacted	2021 Aug	1.96E+05	3.41E+05	3.71E+05	6.12E+05	7.41E+05	50317.1	204860	444029	4.69E+05	8.26E+05	0%	10%	9%	8%	7%	0%	0%	0%	-5%	-3%
Impacted	2021 Sep	1.69E+05	3.01E+05	3.28E+05	5.40E+05	6.51E+05	43328.6	176385	382269	403569	7.11E+05	0%	10%	9%	9%	7%	0%	0%	0%	-5%	-3%
Impacted	2021 Oct	1.31E+05	2.44E+05	2.66E+05	4.39E+05	5.25E+05	33544.7	136538	295881	312371	5.51E+05	0%	10%	10%	9%	7%	0%	0%	0%	-5%	-3%
Impacted	2021 Nov	1.35E+05	2.51E+05	2.74E+05	4.51E+05	5.40E+05	34662.9	141071	305671	322712	5.69E+05	0%	10%	10%	9%	7%	0%	0%	0%	-5%	-3%
Impacted	2021 Dec	9.79E+04	1.95E+05	2.13E+05	3.52E+05	4.16E+05	25158.5	102377	221806	234174	412886	0%	11%	10%	10%	8%	0%	0%	0%	-5%	-3%
Impacted	2022 Jan	6.53E+04	9.38E+04	1.01E+05	1.66E+05	2.09E+05	16772.3	68242.5	147836	156081	275222	0%	0%	-3%	-6%	-5%	0%	0%	0%	-5%	-3%
Impacted	2022 Feb	7.23E+04	1.16E+05	1.26E+05	2.06E+05	2.54E+05	18569.4	75544.8	163638	172767	304673	0%	11%	9%	6%	5%	0%	0%	0%	-5%	-3%
Impacted	2022 Mar	9.79E+04	1.95E+05	2.13E+05	3.51E+05	4.16E+05	25158.5	102338	221652	234021	412732	0%	39%	37%	33%	27%	0%	0%	0%	-5%	-3%
Impacted	2022 Apr	2.36E+05	4.06E+05	4.42E+05	7.25E+05	8.80E+05	60660	246717	5.34E+05	5.64E+05	9.95E+05	0%	20%	17%	14%	11%	0%	0%	0%	-5%	-3%
Impacted	2022 May	8.16E+05	1.30E+06	1.40E+06	2.30E+06	2.83E+06	2.10E+05	8.53E+05	1.85E+06	1.95E+06	3.44E+06	0%	10%	8%	4%	4%	0%	0%	0%	-5%	-3%
Impacted	2022 Jun	9.11E+05	1.44E+06	1.56E+06	2.55E+06	3.15E+06	2.34E+05	9.51E+05	2.06E+06	2.17E+06	3.84E+06	0%	10%	8%	4%	3%	0%	0%	0%	-5%	-3%
Impacted	2022 Jul	4.24E+05	6.96E+05	7.54E+05	1.24E+06	1.52E+06	109020	4.43E+05	9.60E+05	1.01E+06	1.79E+06	0%	14%	12%	8%	7%	0%	0%	0%	-5%	-3%
Impacted	2022 Aug	1.96E+05	3.45E+05	3.75E+05	6.17E+05	7.46E+05	50317.1	204544	4.43E+05	4.68E+05	8.25E+05	0%	23%	20%	17%	14%	0%	0%	0%	-5%	-3%
Impacted	2022 Sep	1.69E+05	3.05E+05	3.31E+05	5.44E+05	6.55E+05	43328.6	176112	381195	402495	7.10E+05	0%	26%	23%	20%	16%	0%	0%	0%	-5%	-3%
Impacted	2022 Oct	1.31E+05	2.47E+05	2.69E+05	4.42E+05	5.28E+05	33544.7	136328	295049	311540	5.50E+05	0%	32%	29%	26%	21%	0%	0%	0%	-5%	-3%
Impacted	2022 Nov	1.35E+05	2.54E+05	2.77E+05	4.54E+05	5.43E+05	34662.9	140853	304812	321853	5.68E+05	0%	31%	29%	25%	20%	0%	0%	0%	-5%	-3%
Impacted	2022 Dec	9.79E+04	1.97E+05	2.15E+05	3.54E+05	4.18E+05	25158.5	102219	221183	233551	412263	0%	40%	38%	34%	28%	0%	0%	0%	-5%	-3%
Impacted	2023 Jan	6.53E+04	9.34E+04	1.01E+05	1.63E+05	2.06E+05	16772.3	68137.2	147420	155665	274806	0%	-1%	-3%	-7%	-6%	0%	0%	0%	-5%	-3%
Impacted	2023 Feb	7.23E+04	1.03E+05	1.11E+05	1.81E+05	2.28E+05	18569.4	75428.1	163177	172306	304213	0%	-1%	-4%	-7%	-6%	0%	0%	0%	-5%	-3%
Impacted	2023 Mar	9.79E+04	1.45E+05	1.56E+05	2.54E+05	3.18E+05	25158.5	102180	221029	233397	412109	0%	3%	0%	-4%	-3%	0%	0%	0%	-5%	-3%
Impacted	2023 Apr	2.36E+05	4.11E+05	4.46E+05	7.30E+05	8.86E+05	60660	246336	5.33E+05	5.63E+05	9.94E+05	0%	21%	19%	15%	12%	0%	0%	0%	-5%	-3%
Impacted	2023 May	8.16E+05	1.31E+06	1.42E+06	2.32E+06	2.85E+06	2.10E+05	8.51E+05	1.84E+06	1.94E+06	3.43E+06	0%	12%	9%	5%	4%	0%	0%	0%	-5%	-3%
Impacted	2023 Jun	9.11E+05	1.41E+06	1.53E+06	2.48E+06	3.08E+06	2.34E+05	9.50E+05	2.05E+06	2.17E+06	3.83E+06	0%	8%	5%	1%	1%	0%	0%	0%	-5%	-3%
Impacted	2023 Jul	4.24E+05	7.05E+05	7.63E+05	1.25E+06	1.53E+06	109020	4.43E+05	9.57E+05	1.01E+06	1.78E+06	0%	16%	13%	9%	7%	0%	0%	0%	-5%	-3%
Impacted	2023 Aug	1.96E+05	3.49E+05	3.79E+05	6.22E+05	7.51E+05	50317.1	204228	4.42E+05	4.66E+05	8.24E+05	0%	24%	22%	18%	14%	0%	0%	0%	-5%	-3%
Impacted	2023 Sep	1.69E+05	3.09E+05	3.36E+05	5.51E+05	6.62E+05	43328.6	175840	380120	401421	7.09E+05	0%	28%	25%	21%	17%	0%	0%	0%	-5%	-3%
Impacted	2023 Oct	1.31E+05	2.51E+05	2.73E+05	4.47E+05	5.33E+05	33544.7	136117	294217	310708	5.49E+05	0%	34%	31%	27%	22%	0%	0%	0%	-5%	-3%
Impacted	2023 Nov	1.35E+05	2.58E+05	2.81E+05	4.60E+05	5.49E+05	34662.9	140636	303953	320993	5.67E+05	0%	33%	31%	27%	21%	0%	0%	0%	-5%	-3%
Impacted	2023 Dec	9.79E+04	1.99E+05	2.16E+05	3.55E+05	4.19E+05	25158.5	102061	220559	232927	411639	0%	41%	39%	35%	28%	0%	0%	0%	-5%	-3%
Impacted	2024 Jan	6.53E+04	1.04E+05	1.12E+05	1.82E+05	2.25E+05	16772.3	68031.5	146993	155239	274380	0%	10%	7%	3%	3%	0%	0%	0%	-5%	-3%
Impacted	2024 Feb	6.98E+04	1.56E+05	1.70E+05	2.80E+05	3.25E+05	17929.1	72713.4	157073	165887	293245	0%	55%	53%	49%	39%	0%	0%	0%	-5%	-3%
Impacted	2024 Mar	9.79E+04	1.99E+05	2.17E+05	3.57E+05	4.21E+05	25158.5	102020	220328	232696	411407	0%	42%	39%	35%	28%	0%	0%	0%	-6%	-3%
Impacted	2024 Apr	2.36E+05	4.16E+05	4.51E+05	7.37E+05	8.93E+05	60660	245946	5.31E+05	5.61E+05	9.92E+05	0%	22%	20%	16%	13%	0%	-1%	-1%	-6%	-3%
Impacted	2024 May	8.16E+05	1.33E+06	1.43E+06	2.34E+06	2.88E+06	2.10E+05	8.50E+05	1.83E+06	1.94E+06	3.43E+06	0%	13%	10%	7%	5%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jun	9.11E+05	1.47E+06	1.59E+06	2.60E+06	3.20E+06	2.34E+05	9.48E+05	2.05E+06	2.16E+06	3.82E+06	0%	13%	10%	6%	5%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Jul	4.24E+05	7.09E+05	7.67E+05	1.26E+06	1.54E+06	109020	4.42E+05	9.53E+05	1.01E+06	1.78E+06	0%	16%	13%	10%	8%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Aug	1.96E+05	3.50E+05	3.80E+05	6.25E+05	7.54E+05	50317.1	203898	4.40E+05	4.65E+05	8.22E+05	0%	24%	22%	19%	15%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Sep	1.69E+05	3.09E+05	3.35E+05	5.51E+05	6.62E+05	43328.6	175554	378597	4.00E+05	7.08E+05	0%	27%	25%	21%	17%	0%	-1%	-1%	-6%	-3%

		Runoff coefficient 0.41																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2024 Oct	1.31E+05	2.50E+05	2.72E+05	4.47E+05	5.33E+05	33544.7	135894	292997	309488	5.48E+05	0%	33%	31%	27%	22%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Nov	1.35E+05	2.57E+05	2.80E+05	4.60E+05	5.48E+05	34662.9	140404	302650	319690	5.66E+05	0%	33%	30%	27%	21%	0%	-1%	-1%	-6%	-3%
Impacted	2024 Dec	9.79E+04	1.99E+05	2.17E+05	3.57E+05	4.22E+05	25158.5	101892	219583	231951	410663	0%	41%	39%	36%	29%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jan	6.53E+04	1.48E+05	1.62E+05	2.67E+05	3.10E+05	16772.3	67918.6	146332	154578	273719	0%	58%	55%	52%	42%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Feb	7.23E+04	1.59E+05	1.73E+05	2.87E+05	3.34E+05	18569.4	75185.6	161952	171080	302987	0%	53%	50%	47%	38%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Mar	9.79E+04	1.98E+05	2.16E+05	3.57E+05	4.21E+05	25158.5	101851	219339	231707	410418	0%	41%	38%	35%	28%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Apr	2.36E+05	4.13E+05	4.48E+05	7.38E+05	8.94E+05	60660	245539	5.29E+05	5.58E+05	9.89E+05	0%	22%	19%	16%	13%	0%	-1%	-1%	-6%	-3%
Impacted	2025 May	8.16E+05	1.32E+06	1.42E+06	2.34E+06	2.88E+06	2.10E+05	8.49E+05	1.83E+06	1.93E+06	3.42E+06	0%	12%	9%	7%	5%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jun	9.11E+05	1.46E+06	1.58E+06	2.60E+06	3.20E+06	2.34E+05	9.47E+05	2.04E+06	2.15E+06	3.81E+06	0%	12%	9%	6%	5%	0%	-1%	-1%	-6%	-3%
Impacted	2025 Jul	4.24E+05	7.03E+05	7.62E+05	1.26E+06	1.54E+06	109020	4.41E+05	9.49E+05	1.00E+06	1.78E+06	0%	15%	13%	10%	8%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Aug	1.96E+05	3.48E+05	3.78E+05	6.26E+05	7.55E+05	50317.1	203560	437848	4.63E+05	8.20E+05	0%	24%	21%	19%	15%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Sep	1.69E+05	3.07E+05	3.33E+05	5.52E+05	6.63E+05	43328.6	175263	376894	398195	7.06E+05	0%	26%	24%	22%	17%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Oct	1.31E+05	2.48E+05	2.70E+05	4.47E+05	5.33E+05	33544.7	135669	291679	308169	5.46E+05	0%	32%	30%	27%	22%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Nov	1.35E+05	2.55E+05	2.78E+05	4.60E+05	5.49E+05	34662.9	140172	301287	318328	5.65E+05	0%	32%	29%	27%	21%	0%	-1%	-2%	-6%	-4%
Impacted	2025 Dec	9.79E+04	1.98E+05	2.16E+05	3.58E+05	4.22E+05	25158.5	101724	218594	230962	409673	0%	41%	38%	36%	29%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jan	6.53E+04	1.47E+05	1.61E+05	2.68E+05	3.11E+05	16772.3	67806.1	145673	153919	273060	0%	57%	55%	52%	42%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Feb	7.23E+04	1.58E+05	1.72E+05	2.87E+05	3.34E+05	18569.4	75061	161222	170351	302257	0%	52%	50%	47%	38%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Mar	9.79E+04	1.97E+05	2.15E+05	3.57E+05	4.21E+05	25158.5	101682	218350	230718	409430	0%	40%	37%	35%	28%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Apr	2.36E+05	4.10E+05	4.45E+05	7.38E+05	8.93E+05	60660	245133	5.26E+05	5.56E+05	9.87E+05	0%	21%	18%	16%	13%	0%	-1%	-2%	-6%	-4%
Impacted	2026 May	8.16E+05	1.31E+06	1.41E+06	2.34E+06	2.88E+06	2.10E+05	8.47E+05	1.82E+06	1.92E+06	3.41E+06	0%	11%	9%	7%	5%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jun	9.11E+05	1.45E+06	1.57E+06	2.60E+06	3.20E+06	2.34E+05	9.45E+05	2.03E+06	2.14E+06	3.81E+06	0%	11%	8%	6%	5%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Jul	4.24E+05	6.98E+05	7.56E+05	1.26E+06	1.54E+06	109020	4.40E+05	9.45E+05	9.98E+05	1.77E+06	0%	14%	12%	10%	8%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Aug	1.96E+05	3.45E+05	3.75E+05	6.25E+05	7.54E+05	50317.1	203222	435871	4.61E+05	8.18E+05	0%	23%	20%	19%	15%	0%	-1%	-2%	-6%	-4%
Impacted	2026 Sep	1.69E+05	3.04E+05	3.31E+05	5.52E+05	6.63E+05	43328.6	174973	375191	396492	7.04E+05	0%	26%	23%	22%	17%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Oct	1.31E+05	2.47E+05	2.69E+05	4.47E+05	5.33E+05	33544.7	135444	290360	306851	5.45E+05	0%	31%	29%	27%	22%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Nov	1.35E+05	2.54E+05	2.76E+05	4.60E+05	5.49E+05	34662.9	139939	299925	316966	5.63E+05	0%	31%	29%	27%	21%	0%	-1%	-2%	-7%	-4%
Impacted	2026 Dec	9.79E+04	1.95E+05	2.12E+05	3.54E+05	4.19E+05	25158.5	101555	217605	229973	408685	0%	38%	36%	34%	28%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jan	6.53E+04	8.72E+04	9.36E+04	1.55E+05	1.98E+05	16771.7	67691.6	145030	153275	272416	0%	13%	11%	10%	8%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Feb	7.23E+04	9.62E+04	1.03E+05	1.72E+05	2.19E+05	18567.4	74930	160541	169670	301576	0%	13%	11%	10%	8%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Mar	9.79E+04	1.30E+05	1.39E+05	2.32E+05	2.97E+05	25154.2	101499	217469	229838	408549	0%	13%	11%	10%	8%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Apr	2.36E+05	3.13E+05	3.36E+05	5.60E+05	7.16E+05	60645.3	244677	5.24E+05	5.54E+05	9.85E+05	0%	13%	11%	10%	8%	0%	-1%	-2%	-7%	-4%
Impacted	2027 May	8.16E+05	1.10E+06	1.18E+06	1.97E+06	2.51E+06	2.10E+05	8.45E+05	1.81E+06	1.91E+06	3.40E+06	0%	13%	11%	10%	9%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jun	9.11E+05	1.44E+06	1.56E+06	2.60E+06	3.20E+06	2.34E+05	9.43E+05	2.02E+06	2.14E+06	3.80E+06	0%	15%	13%	12%	10%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Jul	4.24E+05	6.94E+05	7.53E+05	1.26E+06	1.54E+06	108971	4.39E+05	9.42E+05	9.95E+05	1.77E+06	0%	16%	13%	13%	10%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Aug	1.96E+05	3.44E+05	3.74E+05	6.26E+05	7.55E+05	50290.7	202797	4.35E+05	4.59E+05	8.17E+05	0%	17%	14%	14%	11%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Sep	1.69E+05	3.03E+05	3.30E+05	5.52E+05	6.63E+05	43302.8	174597	374130	395431	7.03E+05	0%	17%	15%	14%	11%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Oct	1.31E+05	2.46E+05	2.68E+05	4.48E+05	5.34E+05	33522.4	135145	289597	306088	5.44E+05	0%	18%	15%	15%	11%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Nov	1.35E+05	2.53E+05	2.75E+05	4.60E+05	5.49E+05	34637.4	139623	299198	316238	5.62E+05	0%	18%	15%	14%	11%	0%	-1%	-2%	-7%	-4%
Impacted	2027 Dec	9.79E+04	1.96E+05	2.14E+05	3.58E+05	4.22E+05	25138.3	101319	217121	229489	408201	0%	19%	16%	16%	12%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jan	6.53E+04	1.46E+05	1.60E+05	2.68E+05	3.11E+05	16757.7	67532.5	144721	152966	272108	0%	20%	17%	16%	12%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Feb	6.98E+04	1.53E+05	1.67E+05	2.80E+05	3.26E+05	17912.1	72175.9	154675	163489	290847	0%	19%	16%	16%	12%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Mar	9.79E+04	1.95E+05	2.13E+05	3.57E+05	4.22E+05	25133	101259	217006	229374	408085	0%	17%	15%	14%	11%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Apr	2.36E+05	4.06E+05	4.41E+05	7.39E+05	8.95E+05	60594.3	244100	5.23E+05	5.53E+05	9.84E+05	0%	15%	13%	12%	10%	0%	-1%	-2%	-7%	-4%
Impacted	2028 May	8.16E+05	1.29E+06	1.40E+06	2.35E+06	2.88E+06	2.09E+05	8.43E+05	1.81E+06	1.91E+06	3.40E+06	0%	14%	12%	11%	9%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jun	9.11E+05	1.44E+06	1.56E+06	2.61E+06	3.21E+06	2.34E+05	9.41E+05	2.02E+06	2.13E+06	3.79E+06	0%	14%	12%	11%	9%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Jul	4.24E+05	6.92E+05	7.51E+05	1.26E+06	1.54E+06	108879	4.38E+05	9.40E+05	9.93E+05	1.77E+06	0%	14%	12%	11%	9%	0%	-1%	-2%	-7%	-4%
Impacted	2028 Aug	1.96E+05	3.43E+05	3.73E+05	6.27E+05	7.56E+05	50248.4	202319	433624	4.58E+05	8.16E+05	0%	15%	13%	12%	10%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Sep	1.69E+05	3.02E+05	3.29E+05	5.53E+05	6.64E+05	43266.4	174185	373331	394632	7.02E+05	0%	16%	13%	13%	10%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Oct	1.31E+05	2.45E+05	2.67E+05	4.48E+05	5.34E+05	33494.2	134826	288979	305470	5.44E+05	0%	16%	14%	13%	10%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Nov	1.35E+05	2.52E+05	2.75E+05	4.61E+05	5.50E+05	34608.3	139293	298558	315599	5.62E+05	0%	16%	14%	13%	10%	0%	-1%	-3%	-7%	-4%
Impacted	2028 Dec	9.79E+04	1.95E+05	2.14E+05	3.59E+05	4.23E+05	25117.1	101080	216657	229025	407737	0%	18%	15%	14%	11%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Jan	6.53E+04	1.46E+05	1.60E+05	2.68E+05	3.11E+05	16743.5	67372.9	144412	152657	271798	0%	20%	17%	16%	12%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Feb	7.23E+04	1.56E+05	1.71E+05	2.87E+05	3.35E+05	18536.3	74577.3	159857	168986	300892	0%	19%	16%	15%	12%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Mar	9.79E+04	1.94E+05	2.13E+05	3.57E+05	4.22E+05	25111.9	101021	216543	228911	407623	0%	17%	15%	14%	11%	0%	-1%	-3%	-7%	-4%
Impacted	2029 Apr	2.36E+05	4.04E+05	4.40E+05	7.40E+05	8.96E+05	60543.4	243525	5.22E+05	5.52E+05	9.83E+05	0%	15%	13%	12%	10%	0%	-1%	-3%	-7%	-4%
Impacted	2029 May	8.16E+05	1.29E+06	1.40E+06	2.35E+06	2.89E+06	2.09E+05	8.42E+05	1.80E+06	1.91E+06	3.40E+06	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jun	9.11E+05	1.43E+06	1.55E+06	2.61E+06	3.21E+06	2.33E+05	9.39E+05	2.01E+06	2.13E+06	3.79E+06	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Jul	4.24E+05	6.89E+05	7.49E+05	1.26E+06	1.54E+06	108788	4.37E+05	9.38E+05	9.91E+05	1.77E+06	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Aug	1.96E+05	3.41E+05	3.72E+05	6.28E+05	7.56E+05	50206.2	201842	432698	4.57E+05	8.15E+05	0%	15%	13%	12%	10%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Sep	1.69E+05	3.01E+05	3.28E+05	5.53E+05	6.64E+05	43230.1	173774	372535	393835	7.02E+05	0%	16%	13%	13%	10%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Oct	1.31E+05	2.44E+05	2.67E+05	4.49E+05	5.35E+05	33466.1	134508	288362	304853	5.43E+05	0%	16%	14%	13%	10%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Nov	1.35E+05	2.51E+05	2.74E+05	4.61E+05	5.50E+05	34579.2	138964	297921	314962	5.61E+05	0%	16%	14%	13%	10%	0%	-2%	-3%	-7%	-4%
Impacted	2029 Dec	9.79E+04	1.95E+05	2.13E+05	3.59E+05	4.23E+05	25096	100841	216195	228563	407274	0%	18%	15%	14%	11%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jan	6.53E+04	1.45E+05	1.59E+05	2.68E+05	3.11E+05	16729.5	67214.1	144104	152349	271490	0%	20%	17%	16%	12%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Feb	7.23E+04	1.56E+05	1.71E+05	2.88E+05	3.35E+05	18520.7	74401.4	159516	168645	300551	0%	19%	16%	15%	12%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Mar	9.79E+04	1.94E+05	2.12E+05	3.58E+05	4.23E+05	25090.8	100782	216081	228449	407160	0%	18%	15%	14%	11%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Apr	2.36E+05	4.03E+05	4.39E+05	7.42E+05	8.97E+05	60492.5	242950	5.21E+05	5.51E+05	9.82E+05	0%	15%	13%	12%	10%	0%	-2%	-3%	-7%	-4%
Impacted	2030 May	8.16E+05	1.28E+06	1.39E+06	2.35E+06	2.89E+06	2.09E+05	8.40E+05	1.80E+06	1.90E+06	3.39E+06	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jun	9.11E+05	1.43E+06	1.55E+06	2.62E+06	3.22E+06	2.33E+05	9.37E+05	2.01E+06	2.12E+06	3.79E+06	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Jul	4.24E+05	6.86E+05	7.47E+05	1.26E+06	1.54E+06	108696	4.36E+05	9.36E+05	9.89E+05	1.76E+06	0%	14%	12%	11%	9%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Aug	1.96E+05	3.40E+05	3.71E+05	6.29E+05	7.58E+05	50164	201365	431773	4.57E+05	8.14E+05	0%	15%	13%	12%	10%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Sep	1.69E+05	3.00E+05	3.28E+05	5.55E+05	6.66E+05	43193.7	173363	371738	3.93E+05	7.01E+05	0%	16%	13%	13%	10%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Oct	1.31E+05	2.43E+05	2.66E+05	4.50E+05	5.36E+05	33437.9	134190	287746	304236	5.43E+05	0%	16%	14%	13%	10%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Nov	1.35E+05	2.50E+05	2.74E+05	4.63E+05	5.51E+05	34550.1	138636	297284	314325	5.61E+05	0%	16%	14%	13%	10%	0%	-2%	-3%	-7%	-4%
Impacted	2030 Dec	9.79E+04	1.94E+05	2.13E+05	3.60E+05	4.24E+05	25074.9	100603	215732	228100	406812	0%	18%	15%	14%	11%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Jan	6.53E+04	1.45E+05	1.59E+05	2.69E+05	3.12E+05	16711.8	67035.2	143778	152023	271165	0%	54%	53%	53%	42%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Feb	7.23E+04	1.55E+05	1.70E+05	2.88E+05	3.36E+05	18493.5	74162.8	159120	168249	300155	0%	49%	48%	48%	39%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Mar	9.79E+04	1.93E+05	2.12E+05	3.59E+05	4.23E+05	25043.8	100404	215496	227864	406576	0%	37%	36%	36%	29%	0%	-2%	-3%	-7%	-4%
Impacted	2031 Apr	2.36E+05	4.01E+05	4.38E+05	7.43E+05	8.98E+05	60353.6	241900	5.19E+05	5.49E+05	9.80E+05	0%	18%	16%	17%	14%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 May	8.16E+05	1.28E+06	1.39E+06	2.36E+06	2.90E+06	2.08E+05	8.35E+05	1.79E+06	1.90E+06	3.39E+06	0%	9%	7%	7%	6%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Jun	9.11E+05	1.42E+06	1.54E+06	2.62E+06	3.22E+06	2.33E+05	9.32E+05	2.00E+06	2.12E+06	3.78E+06	0%	8%	6%	7%	6%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Jul	4.24E+05	6.84E+05	7.45E+05	1.27E+06	1.55E+06	108310	4.34E+05	9.32E+05	9.86E+05	1.76E+06	0%	12%	10%	11%	9%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Aug	1.96E+05	3.39E+05	3.70E+05	6.30E+05	7.59E+05	49964.2	200039	430104	4.55E+05	8.12E+05	0%	20%	19%	19%	16%	-1%	-2%	-3%	-8%	-4%
Impacted	2031 Sep	1.69E+05	2.99E+05	3.27E+05	5.56E+05	6.67E+05	43003.5	172124	370215	391515	6.99E+05	0%	23%	22%	22%	18%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Oct	1.31E+05	2.42E+05	2.65E+05	4.51E+05	5.36E+05	33276.8	133156	286501	302992	5.41E+05	0%	29%	28%	28%	23%	-1%	-3%	-3%	-8%	-4%
Impacted	2031 Nov	1.35E+05	2.49E+05	2.73E+05	4.63E+05	5.52E+05	34369.1	137489	295929	312970	5.59E+05	0%	29%	27%	28%	22%	-1%	-3%	-3%	-8%	-5%
Impacted	2031 Dec	9.79E+04	1.94E+05	2.12E+05	3.60E+05	4.25E+05	24933	99713.5	214699	227067	405779	0%	38%	36%	37%	30%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Jan	6.53E+04	1.44E+05	1.59E+05	2.69E+05	3.12E+05	16613.7	66423.7	143073	151318	270459	0%	14%	11%	14%	10%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Feb	6.98E+04	1.51E+05	1.66E+05	2.82E+05	3.27E+05	17750.8	70950.9	152878	161692	289050	0%	13%	11%	13%	10%	-1%	-3%	-3%	-8%	-5%
Impacted	2032 Mar	9.79E+04	1.93E+05	2.11E+05	3.59E+05	4.24E+05	24896.3	99484.8	214435	226803	405515	0%	12%	10%	12%	9%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Apr	2.36E+05	4.00E+05	4.37E+05	7.44E+05	9.00E+05	59998.2	239684	5.17E+05	5.47E+05	9.78E+05	0%	10%	9%	11%	8%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 May	8.16E+05	1.27E+06	1.39E+06	2.36E+06	2.90E+06	2.07E+05	8.28E+05	1.79E+06	1.89E+06	3.38E+06	0%	10%	8%	10%	8%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Jun	9.11E+05	1.12E+06	1.21E+06	2.07E+06	2.67E+06	2.31E+05	9.23E+05	1.99E+06	2.11E+06	3.77E+06	0%	8%	6%	8%	6%	-1%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2032 Jul	4.24E+05	5.18E+05	5.59E+05	9.60E+05	1.24E+06	107670	4.30E+05	9.28E+05	9.81E+05	1.76E+06	0%	8%	6%	8%	6%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Aug	1.96E+05	2.37E+05	2.57E+05	4.42E+05	5.71E+05	49669.4	198201	427984	4.53E+05	8.10E+05	0%	8%	6%	8%	6%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Sep	1.69E+05	2.05E+05	2.21E+05	3.81E+05	4.92E+05	42749.7	170541	368389	389690	6.97E+05	0%	8%	6%	8%	6%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Oct	1.31E+05	1.59E+05	1.72E+05	2.95E+05	3.81E+05	33080.1	131929	285087	301578	5.40E+05	0%	8%	6%	8%	6%	-1%	-3%	-4%	-8%	-5%
Impacted	2032 Nov	1.35E+05	1.64E+05	1.78E+05	3.05E+05	3.94E+05	34165.9	136221	294468	311508	5.58E+05	0%	8%	6%	8%	6%	-1%	-4%	-4%	-8%	-5%
Impacted	2032 Dec	9.79E+04	1.19E+05	1.29E+05	2.21E+05	2.86E+05	24785.5	98793.7	213638	226006	404718	0%	8%	6%	8%	6%	-1%	-4%	-4%	-8%	-5%
Impacted	2033 Jan	6.53E+04	7.92E+04	8.56E+04	1.47E+05	1.90E+05	16515.3	65810.6	142366	150611	269752	0%	7%	6%	7%	6%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Feb	7.23E+04	8.74E+04	9.45E+04	1.63E+05	2.10E+05	18276.1	72807	157556	166685	298591	0%	7%	6%	7%	6%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Mar	9.79E+04	1.18E+05	1.27E+05	2.20E+05	2.84E+05	24749.2	98567.5	213377	225746	404457	0%	7%	6%	7%	6%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Apr	2.36E+05	2.84E+05	3.07E+05	5.30E+05	6.86E+05	59643.5	237472	5.14E+05	5.44E+05	9.75E+05	0%	7%	6%	7%	6%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 May	8.16E+05	9.85E+05	1.06E+06	1.84E+06	2.37E+06	2.06E+05	8.20E+05	1.78E+06	1.88E+06	3.37E+06	0%	7%	6%	7%	6%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jun	9.11E+05	1.40E+06	1.53E+06	2.62E+06	3.22E+06	2.30E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	9%	7%	9%	7%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Jul	4.24E+05	6.78E+05	7.41E+05	1.27E+06	1.55E+06	107034	4.26E+05	9.23E+05	9.77E+05	1.75E+06	0%	9%	8%	9%	7%	-2%	-4%	-4%	-8%	-5%
Impacted	2033 Aug	1.96E+05	3.36E+05	3.69E+05	6.32E+05	7.61E+05	49375.2	196366	425868	4.51E+05	8.08E+05	0%	10%	8%	10%	8%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Sep	1.69E+05	2.97E+05	3.25E+05	5.58E+05	6.69E+05	42496.3	168961	366567	3.88E+05	6.96E+05	0%	10%	8%	10%	8%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Oct	1.31E+05	2.41E+05	2.64E+05	4.52E+05	5.38E+05	32884	130706	283676	300167	5.38E+05	0%	11%	9%	11%	8%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Nov	1.35E+05	2.48E+05	2.72E+05	4.65E+05	5.54E+05	33963.2	134958	293010	310051	5.56E+05	0%	11%	9%	11%	8%	-2%	-4%	-4%	-9%	-5%
Impacted	2033 Dec	9.79E+04	1.92E+05	2.11E+05	3.61E+05	4.26E+05	24638.4	97876.5	212580	224949	403660	0%	12%	9%	12%	9%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Jan	6.53E+04	1.43E+05	1.58E+05	2.70E+05	3.13E+05	16418.7	65200.1	141665	149911	269052	0%	11%	9%	11%	9%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Feb	7.23E+04	1.54E+05	1.69E+05	2.89E+05	3.37E+05	18172.1	72133.2	156791	165920	297826	0%	11%	9%	11%	9%	-2%	-5%	-4%	-9%	-5%
Impacted	2034 Mar	9.79E+04	1.91E+05	2.10E+05	3.60E+05	4.25E+05	24612.3	97657.6	212356	224724	403436	0%	10%	8%	10%	8%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Apr	2.36E+05	3.97E+05	4.35E+05	7.46E+05	9.02E+05	59323.5	235286	5.12E+05	5.42E+05	9.73E+05	0%	9%	7%	9%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 May	8.16E+05	1.26E+06	1.38E+06	2.37E+06	2.91E+06	2.05E+05	8.13E+05	1.77E+06	1.87E+06	3.36E+06	0%	8%	7%	8%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jun	9.11E+05	1.40E+06	1.53E+06	2.63E+06	3.23E+06	2.29E+05	9.06E+05	1.97E+06	2.09E+06	3.75E+06	0%	8%	6%	8%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Jul	4.24E+05	6.89E+05	7.54E+05	1.30E+06	1.57E+06	106512	4.22E+05	9.19E+05	9.73E+05	1.75E+06	0%	8%	7%	8%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Aug	1.96E+05	3.44E+05	3.77E+05	6.48E+05	7.76E+05	49143	194575	423972	4.49E+05	8.06E+05	0%	9%	7%	9%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Sep	1.69E+05	3.01E+05	3.31E+05	5.67E+05	6.78E+05	42303.5	167424	364960	3.86E+05	6.94E+05	0%	9%	8%	9%	7%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Oct	1.31E+05	2.41E+05	2.65E+05	4.54E+05	5.40E+05	32740.3	129520	282451	298942	5.37E+05	0%	10%	8%	10%	8%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Nov	1.35E+05	2.49E+05	2.73E+05	4.68E+05	5.56E+05	33820.4	133736	291765	308805	5.55E+05	0%	10%	8%	10%	8%	-2%	-5%	-5%	-9%	-5%
Impacted	2034 Dec	9.79E+04	1.92E+05	2.11E+05	3.61E+05	4.26E+05	24539	96993.3	211692	224060	402771	0%	10%	8%	10%	8%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Jan	6.53E+04	1.43E+05	1.58E+05	2.70E+05	3.13E+05	16353.8	64612.3	141078	149323	268464	0%	11%	9%	11%	9%	-2%	-5%	-5%	-9%	-5%
Impacted	2035 Feb	7.23E+04	1.53E+05	1.69E+05	2.89E+05	3.37E+05	18100.2	71482.5	156141	165270	297176	0%	11%	9%	11%	8%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Mar	9.79E+04	1.91E+05	2.10E+05	3.60E+05	4.25E+05	24515	96776	211474	223842	402554	0%	10%	8%	10%	8%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Apr	2.36E+05	3.96E+05	4.34E+05	7.46E+05	9.02E+05	59088.7	233160	5.10E+05	5.40E+05	9.70E+05	0%	8%	7%	8%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 May	8.16E+05	1.33E+06	1.46E+06	2.50E+06	3.04E+06	2.04E+05	8.05E+05	1.76E+06	1.86E+06	3.35E+06	0%	8%	7%	8%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jun	9.11E+05	1.49E+06	1.63E+06	2.80E+06	3.40E+06	2.28E+05	8.98E+05	1.96E+06	2.08E+06	3.74E+06	0%	8%	7%	8%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Jul	4.24E+05	7.09E+05	7.76E+05	1.33E+06	1.61E+06	106090	4.18E+05	9.15E+05	9.69E+05	1.74E+06	0%	8%	7%	8%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Aug	1.96E+05	3.43E+05	3.76E+05	6.47E+05	7.76E+05	48948.2	192812	422208	4.47E+05	8.04E+05	0%	9%	7%	9%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Sep	1.69E+05	3.01E+05	3.30E+05	5.67E+05	6.79E+05	42135.8	165906	363442	3.85E+05	6.93E+05	0%	9%	7%	9%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Oct	1.31E+05	2.40E+05	2.64E+05	4.53E+05	5.39E+05	32610.5	128345	281276	297767	5.36E+05	0%	9%	8%	9%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Nov	1.35E+05	2.48E+05	2.73E+05	4.67E+05	5.56E+05	33686.3	132522	290550	307591	5.54E+05	0%	9%	8%	9%	7%	-3%	-6%	-5%	-9%	-5%
Impacted	2035 Dec	9.79E+04	1.92E+05	2.11E+05	3.61E+05	4.26E+05	24441.6	96111.6	210810	223178	401890	0%	10%	8%	10%	8%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Jan	6.53E+04	1.43E+05	1.58E+05	2.70E+05	3.13E+05	16288.9	64024.6	140490	148735	267877	0%	53%	52%	53%	43%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Feb	6.98E+04	1.50E+05	1.65E+05	2.82E+05	3.28E+05	17406.5	68388.4	150127	158941	286299	0%	49%	48%	50%	40%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Mar	9.79E+04	1.91E+05	2.10E+05	3.60E+05	4.25E+05	24417.3	95891.9	210590	222958	401670	0%	36%	35%	37%	29%	-3%	-6%	-5%	-9%	-5%
Impacted	2036 Apr	2.36E+05	3.96E+05	4.34E+05	7.46E+05	9.02E+05	58853.3	231028	5.08E+05	5.37E+05	9.68E+05	0%	17%	15%	17%	14%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 May	8.16E+05	1.32E+06	1.45E+06	2.49E+06	3.02E+06	2.03E+05	7.98E+05	1.75E+06	1.86E+06	3.35E+06	0%	13%	11%	13%	11%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Jun	9.11E+05	1.48E+06	1.62E+06	2.79E+06	3.39E+06	2.27E+05	8.90E+05	1.96E+06	2.07E+06	3.73E+06	0%	13%	12%	14%	11%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Jul	4.24E+05	7.06E+05	7.74E+05	1.33E+06	1.61E+06	105667	4.14E+05	9.11E+05	9.65E+05	1.74E+06	0%	16%	14%	16%	13%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Aug	1.96E+05	3.41E+05	3.74E+05	6.44E+05	7.73E+05	48752.9	191044	420440	4.45E+05	8.03E+05	0%	21%	20%	22%	18%	-3%	-7%	-5%	-10%	-6%
Impacted	2036 Sep	1.69E+05	2.99E+05	3.28E+05	5.64E+05	6.75E+05	41967.6	164383	361919	3.83E+05	6.91E+05	0%	23%	22%	24%	20%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Oct	1.31E+05	2.40E+05	2.63E+05	4.52E+05	5.38E+05	32480.3	127167	280097	296588	5.35E+05	0%	28%	27%	29%	23%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Nov	1.35E+05	2.47E+05	2.71E+05	4.65E+05	5.54E+05	33551.8	131304	289333	306373	5.53E+05	0%	27%	26%	28%	23%	-3%	-7%	-6%	-10%	-6%
Impacted	2036 Dec	9.79E+04	1.92E+05	2.11E+05	3.61E+05	4.26E+05	24344	95227.6	209926	222294	401006	0%	36%	35%	37%	30%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jan	6.53E+04	1.43E+05	1.58E+05	2.70E+05	3.13E+05	16223.8	63435.2	139901	148146	267287	0%	52%	52%	53%	43%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Feb	7.23E+04	1.53E+05	1.69E+05	2.89E+05	3.37E+05	17956.2	70179.2	154837	163966	295873	0%	47%	47%	49%	39%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Mar	9.79E+04	1.91E+05	2.10E+05	3.60E+05	4.25E+05	24319.9	95010.2	209708	222076	400788	0%	36%	34%	37%	29%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Apr	2.36E+05	3.95E+05	4.33E+05	7.47E+05	9.02E+05	58618.4	228903	5.05E+05	5.35E+05	9.66E+05	0%	16%	15%	17%	14%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 May	8.16E+05	1.31E+06	1.44E+06	2.47E+06	3.01E+06	2.03E+05	7.91E+05	1.75E+06	1.85E+06	3.34E+06	0%	12%	11%	13%	10%	-3%	-7%	-6%	-10%	-6%
Impacted	2037 Jun	9.11E+05	1.48E+06	1.62E+06	2.79E+06	3.39E+06	2.26E+05	8.82E+05	1.95E+06	2.06E+06	3.73E+06	0%	13%	12%	14%	11%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Jul	4.24E+05	7.05E+05	7.72E+05	1.33E+06	1.61E+06	105245	4.10E+05	9.07E+05	9.61E+05	1.74E+06	0%	16%	14%	16%	13%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Aug	1.96E+05	3.40E+05	3.73E+05	6.43E+05	7.72E+05	48558.1	189280	418677	4.43E+05	8.01E+05	0%	21%	20%	22%	18%	-3%	-8%	-6%	-10%	-6%
Impacted	2037 Sep	1.69E+05	2.97E+05	3.26E+05	5.62E+05	6.73E+05	41799.9	162865	360400	3.82E+05	6.89E+05	0%	23%	22%	24%	19%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Oct	1.31E+05	2.40E+05	2.64E+05	4.53E+05	5.39E+05	32350.5	125991	278922	295413	5.34E+05	0%	28%	27%	29%	23%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Nov	1.35E+05	2.46E+05	2.71E+05	4.65E+05	5.54E+05	33417.6	130089	288118	305158	5.51E+05	0%	27%	26%	28%	23%	-4%	-8%	-6%	-10%	-6%
Impacted	2037 Dec	9.79E+04	1.92E+05	2.11E+05	3.61E+05	4.26E+05	24246.6	94346	209044	221412	400124	0%	36%	35%	37%	30%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jan	6.53E+04	9.78E+04	1.07E+05	1.84E+05	2.27E+05	16158.9	62847.4	139313	147558	266699	0%	14%	12%	14%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Feb	7.23E+04	1.07E+05	1.17E+05	2.02E+05	2.49E+05	17884.3	69528.3	154187	163315	295222	0%	14%	12%	14%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Mar	9.79E+04	1.48E+05	1.62E+05	2.79E+05	3.43E+05	24222.5	94128.4	208827	221195	399906	0%	14%	12%	15%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Apr	2.36E+05	3.55E+05	3.87E+05	6.68E+05	8.24E+05	58383.6	226777	5.03E+05	5.33E+05	9.64E+05	0%	14%	12%	15%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 May	8.16E+05	1.24E+06	1.35E+06	2.33E+06	2.87E+06	2.02E+05	7.83E+05	1.74E+06	1.84E+06	3.33E+06	0%	14%	13%	15%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jun	9.11E+05	1.37E+06	1.50E+06	2.58E+06	3.18E+06	2.25E+05	8.73E+05	1.94E+06	2.06E+06	3.72E+06	0%	14%	12%	15%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Jul	4.24E+05	6.41E+05	7.01E+05	1.21E+06	1.49E+06	104823	4.07E+05	9.04E+05	9.57E+05	1.73E+06	0%	14%	12%	15%	12%	-4%	-8%	-6%	-10%	-6%
Impacted	2038 Aug	1.96E+05	2.95E+05	3.22E+05	5.57E+05	6.86E+05	48363.4	187518	416914	4.42E+05	7.99E+05	0%	14%	12%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Sep	1.69E+05	2.53E+05	2.76E+05	4.77E+05	5.88E+05	41632.3	161347	358882	3.80E+05	6.88E+05	0%	14%	12%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Oct	1.31E+05	1.97E+05	2.16E+05	3.72E+05	4.58E+05	32220.6	124815	277746	294237	5.33E+05	0%	14%	12%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Nov	1.35E+05	2.03E+05	2.22E+05	3.82E+05	4.71E+05	33283.4	128874	286903	303943	5.50E+05	0%	14%	12%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2038 Dec	9.79E+04	1.48E+05	1.62E+05	2.79E+05	3.44E+05	24149.2	93464.1	208162	220530	399242	0%	14%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jan	6.53E+04	9.88E+04	1.08E+05	1.86E+05	2.29E+05	16096.8	62285.1	138751	146996	266137	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Feb	7.23E+04	1.07E+05	1.17E+05	2.02E+05	2.49E+05	17821.4	68957.9	153616	162745	294651	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Mar	9.79E+04	1.48E+05	1.61E+05	2.79E+05	3.43E+05	24145.2	93426.1	208124	220492	399204	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Apr	2.36E+05	3.54E+05	3.87E+05	6.68E+05	8.23E+05	58216.7	225259	5.02E+05	5.32E+05	9.63E+05	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 May	8.16E+05	1.24E+06	1.35E+06	2.33E+06	2.86E+06	2.01E+05	7.79E+05	1.73E+06	1.84E+06	3.33E+06	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jun	9.11E+05	1.37E+06	1.50E+06	2.58E+06	3.18E+06	2.25E+05	8.69E+05	1.94E+06	2.05E+06	3.71E+06	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Jul	4.24E+05	6.41E+05	7.00E+05	1.21E+06	1.49E+06	104629	4.05E+05	9.02E+05	9.55E+05	1.73E+06	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Aug	1.96E+05	3.04E+05	3.33E+05	5.75E+05	7.04E+05	48290.3	186844	416240	4.41E+05	7.98E+05	0%	14%	12%	14%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Sep	1.69E+05	3.12E+05	3.43E+05	5.88E+05	6.99E+05	41583.4	160892	358428	3.80E+05	6.88E+05	0%	16%	15%	17%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Oct	1.31E+05	2.52E+05	2.77E+05	4.76E+05	5.62E+05	32193.6	124561	277491	293982	5.32E+05	0%	17%	15%	18%	14%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Nov	1.35E+05	2.59E+05	2.85E+05	4.89E+05	5.78E+05	33266.7	128711	286740	303781	5.50E+05	0%	17%	15%	18%	14%	-4%	-9%	-6%	-10%	-6%
Impacted	2039 Dec	9.79E+04	2.01E+05	2.21E+05	3.79E+05	4.43E+05	24145.2	93418.8	208117	220485	399197	0%	18%	16%	19%	15%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jan	6.53E+04	1.49E+05	1.65E+05	2.81E+05	3.24E+05	16096.8	62278.6	138744	146990	266131	0%	18%	16%	19%	15%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Feb	6.98E+04	1.56E+05	1.72E+05	2.94E+05	3.40E+05	17206.9	66573.1	148312	157126	284484	0%	18%	16%	19%	15%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Mar	9.79E+04	2.00E+05	2.20E+05	3.77E+05	4.42E+05	24145.2	93416.3	208114	220483	399194	0%	16%	15%	17%	13%	-4%	-9%	-6%	-10%	-6%

		Runoff coefficient 0.41																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2040 Apr	2.36E+05	4.17E+05	4.58E+05	7.87E+05	9.42E+05	58216.7	225235	5.02E+05	5.32E+05	9.63E+05	0%	14%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 May	8.16E+05	1.33E+06	1.46E+06	2.51E+06	3.05E+06	2.01E+05	7.78E+05	1.73E+06	1.84E+06	3.33E+06	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jun	9.11E+05	1.48E+06	1.62E+06	2.79E+06	3.39E+06	2.25E+05	8.69E+05	1.94E+06	2.05E+06	3.71E+06	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Jul	4.24E+05	7.11E+05	7.80E+05	1.34E+06	1.62E+06	104629	4.05E+05	9.02E+05	9.55E+05	1.73E+06	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Aug	1.96E+05	3.52E+05	3.86E+05	6.65E+05	7.94E+05	48290.3	186824	416221	4.41E+05	7.98E+05	0%	14%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Sep	1.69E+05	3.10E+05	3.41E+05	5.85E+05	6.96E+05	41583.4	160875	358411	3.80E+05	6.87E+05	0%	15%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Oct	1.31E+05	2.51E+05	2.76E+05	4.73E+05	5.59E+05	32193.6	124547	277478	293969	5.32E+05	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Nov	1.35E+05	2.58E+05	2.84E+05	4.86E+05	5.75E+05	33266.7	128698	286726	303767	5.50E+05	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2040 Dec	9.79E+04	2.00E+05	2.20E+05	3.77E+05	4.41E+05	24145.2	93409	208107	220475	399187	0%	16%	15%	17%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jan	6.53E+04	1.48E+05	1.64E+05	2.80E+05	3.23E+05	16096.8	62271.4	138737	146982	266123	0%	18%	17%	19%	15%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Feb	7.23E+04	1.59E+05	1.76E+05	3.00E+05	3.48E+05	17821.4	68941.4	153600	162729	294635	0%	18%	16%	19%	14%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Mar	9.79E+04	1.99E+05	2.19E+05	3.75E+05	4.40E+05	24145.2	93401.9	208100	220468	399180	0%	16%	15%	17%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Apr	2.36E+05	4.14E+05	4.55E+05	7.82E+05	9.37E+05	58216.7	225196	5.02E+05	5.32E+05	9.62E+05	0%	14%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 May	8.16E+05	1.32E+06	1.45E+06	2.49E+06	3.03E+06	2.01E+05	7.78E+05	1.73E+06	1.84E+06	3.33E+06	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jun	9.11E+05	1.47E+06	1.61E+06	2.77E+06	3.37E+06	2.25E+05	8.69E+05	1.94E+06	2.05E+06	3.71E+06	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Jul	4.24E+05	7.07E+05	7.74E+05	1.33E+06	1.61E+06	104629	4.05E+05	9.02E+05	9.55E+05	1.73E+06	0%	13%	12%	14%	11%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Aug	1.96E+05	3.49E+05	3.84E+05	6.61E+05	7.90E+05	48290.3	186777	416173	4.41E+05	7.98E+05	0%	14%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Sep	1.69E+05	3.08E+05	3.38E+05	5.82E+05	6.93E+05	41583.4	160831	358366	3.80E+05	6.87E+05	0%	15%	13%	15%	12%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Oct	1.31E+05	2.49E+05	2.74E+05	4.70E+05	5.56E+05	32193.6	124510	277441	293932	5.32E+05	0%	15%	14%	16%	13%	-4%	-9%	-6%	-10%	-6%
Impacted	2041 Nov	1.35E+05	2.56E+05	2.82E+05	4.83E+05	5.72E+05	33266.7	128657	286686	303726	5.50E+05	0%	15%	14%	16%	13%	-4%	-9%	-6%	-11%	-6%
Impacted	2041 Dec	9.79E+04	1.99E+05	2.19E+05	3.75E+05	4.39E+05	24145.2	93377.4	208076	220444	399155	0%	16%	15%	17%	13%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Jan	6.53E+04	1.48E+05	1.63E+05	2.79E+05	3.22E+05	16096.8	62250.7	138716	146962	266103	0%	57%	57%	58%	47%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Feb	7.23E+04	1.58E+05	1.74E+05	2.99E+05	3.46E+05	17821.4	68920.5	153579	162708	294614	0%	52%	51%	53%	43%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Mar	9.79E+04	1.97E+05	2.17E+05	3.73E+05	4.37E+05	24145.2	93376.1	208074	220442	399154	0%	40%	39%	41%	33%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Apr	2.36E+05	4.11E+05	4.51E+05	7.75E+05	9.31E+05	58216.7	225140	5.02E+05	5.32E+05	9.62E+05	0%	21%	20%	22%	18%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 May	8.16E+05	1.31E+06	1.43E+06	2.47E+06	3.00E+06	2.01E+05	7.78E+05	1.73E+06	1.84E+06	3.33E+06	0%	12%	10%	12%	10%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Jun	9.11E+05	1.45E+06	1.59E+06	2.74E+06	3.34E+06	2.25E+05	8.68E+05	1.94E+06	2.05E+06	3.71E+06	0%	11%	10%	12%	9%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Jul	4.24E+05	6.99E+05	7.65E+05	1.32E+06	1.60E+06	104629	4.05E+05	9.02E+05	9.55E+05	1.73E+06	0%	15%	13%	15%	12%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Aug	1.96E+05	3.46E+05	3.79E+05	6.53E+05	7.82E+05	48290.3	186752	416148	4.41E+05	7.98E+05	0%	23%	22%	24%	19%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Sep	1.69E+05	3.04E+05	3.34E+05	5.75E+05	6.86E+05	41583.4	160814	358350	3.80E+05	6.87E+05	0%	26%	24%	27%	21%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Oct	1.31E+05	2.46E+05	2.71E+05	4.65E+05	5.51E+05	32193.6	124502	277432	293923	5.32E+05	0%	31%	30%	32%	26%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Nov	1.35E+05	2.53E+05	2.78E+05	4.78E+05	5.66E+05	33266.7	128652	286680	303721	5.50E+05	0%	31%	30%	32%	25%	-4%	-9%	-6%	-11%	-6%
Impacted	2042 Dec	9.79E+04	1.96E+05	2.16E+05	3.70E+05	4.35E+05	24145.2	93376.1	208074	220442	399154	0%	39%	39%	41%	33%	-4%	-9%	-6%	-11%	-6%
Impacted	2043 Jan	6.53E+04	1.56E+05	1.73E+05	2.96E+05	3.39E+05	16096.8	65294.5	141760	150005	269147	0%	4%	1%	5%	4%	-4%	-4%	-4%	-9%	-5%
Impacted	2043 Feb	7.23E+04	1.65E+05	1.82E+05	3.11E+05	3.59E+05	17821.4	71964.2	156622	165751	297657	0%	4%	1%	5%	4%	-4%	-5%	-5%	-9%	-5%
Impacted	2043 Mar	9.79E+04	1.94E+05	2.14E+05	3.67E+05	4.32E+05	24145.2	96419.9	211118	223486	402198	0%	3%	1%	5%	3%	-4%	-6%	-5%	-9%	-5%
Impacted	2043 Apr	2.36E+05	3.55E+05	3.88E+05	6.71E+05	8.26E+05	58216.7	228184	5.05E+05	5.35E+05	9.65E+05	0%	3%	1%	3%	3%	-4%	-8%	-6%	-10%	-6%
Impacted	2043 May	8.16E+05	1.03E+06	1.12E+06	1.94E+06	2.48E+06	2.01E+05	7.81E+05	1.74E+06	1.84E+06	3.33E+06	0%	2%	1%	3%	2%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jun	9.11E+05	1.14E+06	1.24E+06	2.15E+06	2.75E+06	2.25E+05	8.71E+05	1.94E+06	2.05E+06	3.72E+06	0%	2%	1%	3%	2%	-4%	-9%	-6%	-10%	-6%
Impacted	2043 Jul	4.24E+05	5.74E+05	6.25E+05	1.08E+06	1.36E+06	104629	4.17E+05	9.14E+05	9.67E+05	1.74E+06	0%	2%	1%	3%	3%	-4%	-6%	-5%	-9%	-5%
Impacted	2043 Aug	1.96E+05	3.08E+05	3.37E+05	5.82E+05	7.11E+05	48290.3	197314	426711	4.51E+05	8.09E+05	0%	3%	1%	4%	3%	-4%	-4%	-4%	-8%	-5%
Impacted	2043 Sep	1.69E+05	2.77E+05	3.03E+05	5.23E+05	6.34E+05	41583.4	170986	368521	389822	6.98E+05	0%	3%	1%	4%	3%	-4%	-3%	-4%	-8%	-5%
Impacted	2043 Oct	1.31E+05	2.32E+05	2.55E+05	4.39E+05	5.25E+05	32193.6	133569	286500	302991	5.41E+05	0%	3%	1%	4%	3%	-4%	-2%	-3%	-8%	-4%
Impacted	2043 Nov	1.35E+05	2.38E+05	2.61E+05	4.49E+05	5.37E+05	33266.7	138372	296400	313441	5.60E+05	0%	3%	1%	4%	3%	-4%	-2%	-3%	-8%	-4%
Impacted	2043 Dec	9.79E+04	1.94E+05	2.14E+05	3.67E+05	4.32E+05	24145.2	101271	215969	228338	407049	0%	3%	1%	5%	4%	-4%	-1%	-3%	-7%	-4%
Impacted	2044 Jan	6.53E+04	1.56E+05	1.73E+05	2.96E+05	3.39E+05	16096.8	68444.5	144910	153155	272296	0%	4%	2%	6%	4%	-4%	0%	-2%	-7%	-4%
Impacted	2044 Feb	6.98E+04	1.62E+05	1.79E+05	3.06E+05	3.51E+05	17206.9	72782.8	154522	163336	290694	0%	4%	1%	5%	4%	-4%	0%	-2%	-7%	-4%
Impacted	2044 Mar	9.79E+04	1.94E+05	2.14E+05	3.67E+05	4.32E+05	24145.2	100535	215234	227602	406314	0%	4%	1%	5%	4%	-4%	-2%	-3%	-8%	-4%
Impacted	2044 Apr	2.36E+05	3.55E+05	3.88E+05	6.71E+05	8.26E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	3%	1%	4%	3%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 May	8.16E+05	1.03E+06	1.12E+06	1.94E+06	2.48E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	2%	1%	3%	2%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Jun	9.11E+05	1.14E+06	1.24E+06	2.16E+06	2.76E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	2%	1%	3%	2%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Jul	4.24E+05	6.24E+05	6.81E+05	1.18E+06	1.46E+06	104629	4.26E+05	9.23E+05	9.77E+05	1.75E+06	0%	3%	1%	3%	3%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Aug	1.96E+05	2.88E+05	3.14E+05	5.44E+05	6.73E+05	48290.3	197314	426711	4.51E+05	8.09E+05	0%	3%	1%	3%	3%	-4%	-4%	-4%	-8%	-5%
Impacted	2044 Sep	1.69E+05	2.48E+05	2.71E+05	4.68E+05	5.80E+05	41583.4	170986	368521	389822	6.98E+05	0%	3%	1%	3%	3%	-4%	-3%	-4%	-8%	-5%
Impacted	2044 Oct	1.31E+05	1.92E+05	2.10E+05	3.63E+05	4.49E+05	32193.6	133569	286500	302991	5.41E+05	0%	3%	1%	3%	3%	-4%	-2%	-3%	-8%	-4%
Impacted	2044 Nov	1.35E+05	1.99E+05	2.17E+05	3.75E+05	4.64E+05	33266.7	138372	296400	313441	5.60E+05	0%	3%	1%	3%	3%	-4%	-2%	-3%	-8%	-4%
Impacted	2044 Dec	9.79E+04	1.44E+05	1.57E+05	2.72E+05	3.37E+05	24145.2	101271	215969	228338	407049	0%	3%	1%	3%	3%	-4%	-1%	-3%	-7%	-4%
Impacted	2045 Jan	6.53E+04	9.61E+04	1.05E+05	1.81E+05	2.24E+05	16096.8	68444.5	144910	153155	272296	0%	2%	1%	3%	3%	-4%	0%	-2%	-7%	-4%
Impacted	2045 Feb	7.23E+04	1.06E+05	1.16E+05	2.01E+05	2.48E+05	17821.4	75273.5	159932	169060	300967	0%	2%	1%	3%	3%	-4%	-1%	-3%	-7%	-4%
Impacted	2045 Mar	9.79E+04	1.44E+05	1.57E+05	2.72E+05	3.36E+05	24145.2	100535	215234	227602	406314	0%	2%	1%	3%	3%	-4%	-2%	-3%	-8%	-4%
Impacted	2045 Apr	2.36E+05	3.47E+05	3.79E+05	6.56E+05	8.11E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	2%	1%	3%	3%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 May	8.16E+05	1.20E+06	1.31E+06	2.27E+06	2.81E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	2%	1%	3%	3%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Jun	9.11E+05	1.34E+06	1.46E+06	2.53E+06	3.13E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	2%	1%	3%	3%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Jul	4.24E+05	6.24E+05	6.81E+05	1.18E+06	1.46E+06	104629	4.26E+05	9.23E+05	9.77E+05	1.75E+06	0%	2%	1%	3%	3%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Aug	1.96E+05	2.88E+05	3.14E+05	5.44E+05	6.73E+05	48290.3	197314	426711	4.51E+05	8.09E+05	0%	2%	1%	3%	3%	-4%	-4%	-4%	-8%	-5%
Impacted	2045 Sep	1.69E+05	2.48E+05	2.71E+05	4.68E+05	5.80E+05	41583.4	170986	368521	3.90E+05	6.98E+05	0%	2%	1%	3%	3%	-4%	-3%	-4%	-8%	-5%
Impacted	2045 Oct	1.31E+05	1.92E+05	2.10E+05	3.63E+05	4.49E+05	32193.6	133569	286500	302991	5.41E+05	0%	2%	1%	3%	3%	-4%	-2%	-3%	-8%	-4%
Impacted	2045 Nov	1.35E+05	2.05E+05	2.24E+05	3.87E+05	4.76E+05	33266.7	138372	296400	313441	5.60E+05	0%	3%	1%	3%	3%	-4%	-2%	-3%	-8%	-4%
Impacted	2045 Dec	9.79E+04	1.53E+05	1.67E+05	2.88E+05	3.53E+05	24145.2	101271	215969	228338	407049	0%	3%	1%	4%	3%	-4%	-1%	-3%	-7%	-4%
Impacted	2046 Jan	6.53E+04	1.01E+05	1.11E+05	1.91E+05	2.34E+05	16096.8	68444.5	144910	153155	272296	0%	3%	1%	3%	3%	-4%	0%	-2%	-7%	-4%
Impacted	2046 Feb	7.23E+04	1.11E+05	1.21E+05	2.10E+05	2.57E+05	17821.4	75273.5	159932	169060	300967	0%	2%	1%	3%	3%	-4%	-1%	-3%	-7%	-4%
Impacted	2046 Mar	9.79E+04	1.48E+05	1.62E+05	2.80E+05	3.45E+05	24145.2	100535	215234	227602	406314	0%	2%	1%	3%	3%	-4%	-2%	-3%	-8%	-4%
Impacted	2046 Apr	2.36E+05	3.61E+05	3.94E+05	6.81E+05	8.37E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	2%	1%	3%	3%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 May	8.16E+05	1.27E+06	1.38E+06	2.39E+06	2.93E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	3%	1%	3%	3%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Jun	9.11E+05	1.41E+06	1.54E+06	2.66E+06	3.26E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	3%	1%	3%	3%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Jul	4.24E+05	6.56E+05	7.17E+05	1.24E+06	1.52E+06	104629	4.26E+05	9.23E+05	9.77E+05	1.75E+06	0%	2%	1%	3%	3%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	2%	1%	3%	3%	-4%	-4%	-4%	-8%	-5%
Impacted	2046 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	3.90E+05	6.98E+05	0%	3%	1%	3%	3%	-4%	-3%	-4%	-8%	-5%
Impacted	2046 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	3%	1%	3%	3%	-4%	-2%	-3%	-8%	-4%
Impacted	2046 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	3%	1%	3%	3%	-4%	-2%	-3%	-8%	-4%
Impacted	2046 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	3%	1%	3%	3%	-4%	-1%	-3%	-7%	-4%
Impacted	2047 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2047 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2047 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2047 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2047 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2047 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2047 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2047 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%

		Runoff coefficient 0.41																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2048 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2048 Feb	6.98E+04	1.10E+05	1.20E+05	2.08E+05	2.54E+05	17206.9	72782.8	154522	163469	290826	0%	10%	8%	10%	8%	-4%	0%	-2%	-7%	-4%
Impacted	2048 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2048 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2048 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2048 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2048 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2048 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2048 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2049 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2049 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2049 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2049 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2049 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2049 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2049 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2049 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2050 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2050 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2050 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2050 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	4.27E+05	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2050 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	3.90E+05	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2050 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2050 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2050 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2051 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2051 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2051 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2051 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2051 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2051 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2051 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2051 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2052 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2052 Feb	6.98E+04	1.10E+05	1.20E+05	2.08E+05	2.54E+05	17206.9	72782.8	154522	163469	290826	0%	10%	8%	10%	8%	-4%	0%	-2%	-7%	-4%
Impacted	2052 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2052 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2052 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2052 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2052 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2052 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2053 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2053 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2053 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2053 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2053 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2053 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2053 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2053 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2054 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2054 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2054 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2054 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2054 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2054 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2054 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2054 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2055 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2055 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2055 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2055 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2055 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	4.27E+05	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2055 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	3.90E+05	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2055 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2055 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2055 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2056 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2056 Feb	6.98E+04	1.10E+05	1.20E+05	2.08E+05	2.54E+05	17206.9	72782.8	154522	163469	290826	0%	10%	8%	10%	8%	-4%	0%	-2%	-7%	-4%
Impacted	2056 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2056 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2056 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2056 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2056 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2056 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2057 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2057 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2057 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2057 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2057 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2057 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2057 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2057 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2058 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2058 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2058 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2058 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	4.27E+05	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2058 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	3.90E+05	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2058 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2058 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2058 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2059 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2059 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2059 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2059 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2059 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2059 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2059 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2059 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2060 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2060 Feb	6.98E+04	1.10E+05	1.20E+05	2.08E+05	2.54E+05	17206.9	72782.8	154522	163469	290826	0%	10%	8%	10%	8%	-4%	0%	-2%	-7%	-4%
Impacted	2060 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2060 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2060 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2060 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2060 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2060 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2061 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2061 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2061 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2061 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2061 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2061 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2061 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2061 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2062 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2062 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2062 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2062 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2062 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2062 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2062 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2062 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2063 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2063 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2063 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2063 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2063 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	4.27E+05	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2063 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2063 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2063 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2063 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2064 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2064 Feb	6.98E+04	1.10E+05	1.20E+05	2.08E+05	2.54E+05	17206.9	72782.8	154522	163469	290826	0%	10%	8%	10%	8%	-4%	0%	-2%	-7%	-4%
Impacted	2064 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2064 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2064 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2064 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2064 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2064 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2065 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2065 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2065 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2065 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2065 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2065 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2065 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2065 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2066 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2066 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2066 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2066 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2066 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2066 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2066 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2066 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2067 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2067 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2067 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2067 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2067 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2067 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2067 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2067 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2068 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2068 Feb	6.98E+04	1.10E+05	1.20E+05	2.08E+05	2.54E+05	17206.9	72782.8	154522	163469	290826	0%	10%	8%	10%	8%	-4%	0%	-2%	-7%	-4%
Impacted	2068 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2068 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2068 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2068 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2068 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2068 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2069 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2069 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2069 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2069 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2069 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2069 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2069 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2069 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2070 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2070 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2070 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2070 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2070 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2070 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2070 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2070 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2071 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2071 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2071 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%

		Runoff coefficient 0.41																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2071 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2071 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2071 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2071 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2071 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2071 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2072 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2072 Feb	6.98E+04	1.10E+05	1.20E+05	2.08E+05	2.54E+05	17206.9	72782.8	154522	163469	290826	0%	10%	8%	10%	8%	-4%	0%	-2%	-7%	-4%
Impacted	2072 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2072 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2072 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2072 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2072 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2072 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2073 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2073 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2073 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2073 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	4.27E+05	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2073 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2073 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2073 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2073 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2074 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2074 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2074 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2074 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2074 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2074 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2074 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2074 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2075 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2075 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2075 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2075 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2075 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2075 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2075 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2075 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2076 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2076 Feb	6.98E+04	1.10E+05	1.20E+05	2.08E+05	2.54E+05	17206.9	72782.8	154522	163469	290826	0%	10%	8%	10%	8%	-4%	0%	-2%	-7%	-4%
Impacted	2076 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2076 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2076 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2076 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2076 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2076 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%

		Runoff coefficient 0.41																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2079 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2079 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2079 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2079 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2079 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2079 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2079 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2079 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2080 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2080 Feb	6.98E+04	1.10E+05	1.20E+05	2.08E+05	2.54E+05	17206.9	72782.8	154522	163469	290826	0%	10%	8%	10%	8%	-4%	0%	-2%	-7%	-4%
Impacted	2080 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2080 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2080 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2080 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2080 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2080 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2081 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2081 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2081 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2081 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2081 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2081 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2081 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2081 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2082 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2082 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2082 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2082 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	4.27E+05	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2082 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2082 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2082 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2082 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2083 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2083 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2083 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2083 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2083 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2083 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2083 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2083 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2084 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2084 Feb	6.98E+04	1.10E+05	1.20E+05	2.08E+05	2.54E+05	17206.9	72782.8	154522	163469	290826	0%	10%	8%	10%	8%	-4%	0%	-2%	-7%	-4%
Impacted	2084 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2084 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2084 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	4.27E+05	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2084 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	3.90E+05	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%	
Impacted	2084 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2084 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2084 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2085 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2085 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2085 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2085 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2085 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2085 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2085 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2085 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2086 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2086 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2086 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2086 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2086 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2086 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2086 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2086 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2086 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2087 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2087 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2087 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2087 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2087 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2087 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2087 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2087 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2088 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2088 Feb	6.98E+04	1.10E+05	1.20E+05	2.08E+05	2.54E+05	17206.9	72782.8	154522	163469	290826	0%	10%	8%	10%	8%	-4%	0%	-2%	-7%	-4%
Impacted	2088 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2088 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2088 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2088 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2088 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2088 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2089 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2089 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2089 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2089 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	4.27E+05	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2089 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2089 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2089 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2089 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2090 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2090 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2090 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2090 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2090 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2090 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2090 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2090 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2091 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2091 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2091 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2091 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2091 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2091 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2091 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2091 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2092 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2092 Feb	6.98E+04	1.10E+05	1.20E+05	2.08E+05	2.54E+05	17206.9	72782.8	154522	163469	290826	0%	10%	8%	10%	8%	-4%	0%	-2%	-7%	-4%
Impacted	2092 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2092 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2092 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2092 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2092 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2092 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2093 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2093 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2093 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2093 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	4.27E+05	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2093 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	3.90E+05	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2093 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2093 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2093 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2094 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2094 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2094 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2094 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%

		Runoff coefficient 0.41																			
		1 in 10 dry years																			
		Monthly Flow rates										% Difference from Baseline									
		BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01	BL03	BC07	BL02	BC03	BC01	GC13	GC10	GC04	GC02	GC01
		m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon	m3/mon										
Impacted	2094 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2094 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2094 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2094 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2094 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2095 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2095 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2095 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2095 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2095 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2095 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2095 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2095 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2096 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2096 Feb	6.98E+04	1.10E+05	1.20E+05	2.08E+05	2.54E+05	17206.9	72782.8	154522	163469	290826	0%	10%	8%	10%	8%	-4%	0%	-2%	-7%	-4%
Impacted	2096 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2096 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	4.27E+05	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2096 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	3.90E+05	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2096 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2096 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2096 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2097 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2097 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2097 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2097 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2097 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2097 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2097 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2097 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2098 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2098 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2098 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2098 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2098 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2098 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2098 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2098 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%
Impacted	2099 Jan	6.53E+04	1.04E+05	1.13E+05	1.96E+05	2.39E+05	16096.8	68444.5	144910	153280	272421	0%	11%	9%	11%	9%	-4%	0%	-2%	-7%	-4%
Impacted	2099 Feb	7.23E+04	1.14E+05	1.25E+05	2.15E+05	2.63E+05	17821.4	75273.5	159932	169198	301104	0%	10%	8%	10%	8%	-4%	-1%	-3%	-7%	-4%
Impacted	2099 Mar	9.79E+04	1.52E+05	1.66E+05	2.88E+05	3.52E+05	24145.2	100535	215234	227788	406500	0%	8%	7%	9%	7%	-4%	-2%	-3%	-8%	-4%
Impacted	2099 Apr	2.36E+05	3.70E+05	4.04E+05	6.98E+05	8.54E+05	58216.7	238590	5.15E+05	5.45E+05	9.76E+05	0%	9%	7%	10%	8%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 May	8.16E+05	1.30E+06	1.42E+06	2.45E+06	2.99E+06	2.01E+05	8.21E+05	1.78E+06	1.88E+06	3.37E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Jun	9.11E+05	1.45E+06	1.58E+06	2.73E+06	3.33E+06	2.25E+05	9.15E+05	1.98E+06	2.10E+06	3.76E+06	0%	11%	9%	11%	9%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Jul	4.24E+05	6.65E+05	7.27E+05	1.26E+06	1.54E+06	104629	4.26E+05	9.23E+05	9.78E+05	1.75E+06	0%	9%	7%	10%	8%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Aug	1.96E+05	3.01E+05	3.28E+05	5.68E+05	6.97E+05	48290.3	197314	426711	4.52E+05	8.09E+05	0%	7%	5%	8%	6%	-4%	-4%	-4%	-8%	-5%
Impacted	2099 Sep	1.69E+05	2.63E+05	2.87E+05	4.96E+05	6.07E+05	41583.4	170986	368521	390143	6.98E+05	0%	8%	7%	9%	7%	-4%	-3%	-4%	-8%	-5%
Impacted	2099 Oct	1.31E+05	2.06E+05	2.25E+05	3.89E+05	4.75E+05	32193.6	133569	286500	303240	5.42E+05	0%	10%	8%	11%	9%	-4%	-2%	-3%	-8%	-4%
Impacted	2099 Nov	1.35E+05	2.15E+05	2.36E+05	4.07E+05	4.96E+05	33266.7	138372	296400	313698	5.60E+05	0%	11%	10%	12%	10%	-4%	-2%	-3%	-8%	-4%
Impacted	2099 Dec	9.79E+04	1.56E+05	1.71E+05	2.95E+05	3.60E+05	24145.2	101271	215969	228524	407236	0%	11%	10%	12%	10%	-4%	-1%	-3%	-7%	-4%

APPENDIX 5.15-3: PREDICTED CHANGES TO BASEFLOWS

Creek Name	Label	Catchment Area (m^2)	Estimated Baseflow	
			(m^3/day)	(L/s)
Blairmore Creek	BL-04	8,967,750	3,284	38
Blairmore Creek	BL-03	15,221,400	5,574	65
Blairmore Creek	BL-02	24,142,830	8,841	102
Blairmore Creek Tributary	UNC-01	6,739,410	2,468	29
Blairmore Creek	BL-01	48,053,240	17,597	204
Gold Creek	G2	32,910,700	12,052	139
Gold Creek	GC-01	63,089,700	23,103	267
Daisy Creek	D1 *	64,616,500	23,662	274

Source: Baseflows_Targets_GW_Model_1CM029.005_vm_20150923.xlsx

Note:

* D1 is a control point used to report baseflow estimates of the groundwater model; it is not a gauging station.

Table 7: Predicted Changes to the Baseflows of Blairmore, Gold and Daisy Creek for EOM Condition

Watershed	Station	Baseflow at Baseline (m^3/day)	Best Estimate Relative Difference at EOM (%)
Blairmore Creek	BL-04	3,271	0 %
	BL-03	5,822	0%
	BL-02	8,781	-14 %
	BL-01	16,396	-1 %
Gold Creek	G2	11,424	-9 %
	GC-01	20,976	-7 %
Daisy Creek	D1	22,190	0 %

Source: Relative_Diff_Baseflows_CtrPoint_For_SW-Balance _GF_rev5.xlsb

Notes:

* The EOM period is defined by a scenario where the pit is fully developed and drawdown at its maximum (worst case); surface water management system is constructed and active.

Table 8: Calculated Mine Contributions to Creek Baseflows under EOM Condition

Watershed	Baseflow (m^3/day)	Contribution to Baseflow (%) from:			
		Back-Ground *Not affected*	Rock Disposal Areas	Pit Lake and Saturated Rock Fills	Sediment Pond and Ditches
Blairmore Creek (at BL-01)	16,396	76.8%	8.0 %	13.3 %	1.9 %
Gold Creek (at GC-01)	20,976	97.6%	1.9 %	0.0 %	0.5 %
Daisy Creek (at D1)	22,190	99.9%	0.1 %	0.0 %	-

Source: Relative_Diff_Baseflows_CtrPoint_For_SW-Balance _GF_rev5.xlsb

Notes:

Calculated contributions are expressed in percentages of the total calculated flow reporting to each station. Where (-) is indicated, the corresponding source does not contribute to baseflow.

APPENDIX 5.16-1: ADDENDUM 5, CEAR #69, AER-R1-208

207. Addendum 2, Appendix 1E, Section 3.2, Page 6 Addendum 2, Appendix 1E, Table 3.3-1, Page 9 Addendum 2, Appendix 1E, Section 3.3.4, Page 11 Addendum 2, Appendix 1E, Section 3.4, Page13 Addendum 2, Appendix 1E, Table 3.4-1, Page 15 CR6, January 2017 Addendum 1, Appendix A3, Instream Flow Assessment

In the above sections Benga provided either a simple computation that showed that the overall allocations on the Crowsnest River do not exceed 55% or mentioned that the Water Conservation Objective (WCO) on the Crowsnest River is met. Benga did not demonstrate how the Instream Objective (IO) factors into determining if the WCO will be met. Also, there is no indication that Benga attempted to obtain naturalized flows from AEP to compute the WCO on a weekly or monthly time step including the portion of the IO. This work is required to be completed using the full criteria of the WCO, which is 45% of natural flow or 110% of the IO, whichever is greater.

Appendix A3 – Instream Flow Assessment (of CR6) mentions that the Instream Flow Needs (IFN) will be met, but does not propose an IFN with respect to flows in either Blairmore or Gold Creek.

a) Present a WCO analysis on a weekly time step showing the current performance of the WCO i.e. without the proposed transfers and reserved allocation in place. Every year where data exists at Frank, present the percentage of time that WCO is not being met.

Response:

The three allocations that have been applied for (described in detail in Addendum 2, Appendix 1E, Section 3), include the following applications:

York Creek temporary transfer:

- this licence has the highest priority (Priority #1 – discussed in more detail in the response to SIR 208) of all water licences in the Crowsnest River System between Crowsnest Lake and the Oldman River Dam. The total volume requested for transfer is 250,400 m^3 per year. This licence pre-dates any WCO objectives that were later adopted and is therefore, not subject to the WCO objective;

- the York Creek transfer will allow water to remain in the river for a longer time from the current location in York Creek (Addendum 2, Appendix 1E, Figure 1-1) to the confluence of Gold Creek with the Crowsnest River, an additional 7.4 km.

Devon Licence transfer:

- this licence has a priority of #3 in the Crowsnest River System between Crowsnest Lake and the Oldman River Dam. The total volume requested for transfer is 123,350 m^3 per year. This licence also pre-dates any WCO objectives that were later adopted and is therefore, not subject to the WCO objective.

- the Devon transfer will allow water to remain in the river for a longer time from the current location on the Crowsnest River (Addendum 2, Appendix 1E, Figure 1-1) to the confluence of Gold Creek with the Crowsnest River, an additional 16.5 km.

- the impact of these transfers result in more water staying in the river longer, which is positive to the environment and downstream users.

Industrial Reserve new allocation:

- this licence will be the newest allocation and will have the lowest priority (Priority #16) in the Crowsnest River System between Crowsnest Lake and the Oldman River Dam. The total volume requested for transfer is 185,025 m^3 per year. This licence will be subject to WCO objectives and will be the first licence to be shut down or restricted if the WCO objectives can't be met.

- this new licence can not have any impact on any new licensees or the WCO (either as the 45% of natural flow or as the IO plus 10%).

Since the two transfers are senior priorities and pre-date the WCO objectives, the WCO does not apply to them in the current location and form and therefore will not have any different effect on the WCO at Frank. The new licence will be subject to the WCO and since it will be the most junior licence above the Oldman Dam, will be the first to be shut down to achieve the WCO.

It is not productive to present an analysis of the naturalized flow without the requested transfers in place as the transferred licences are part of the calculated naturalized flows because they currently exist. The analysis of the flow before and after the transfers at Frank would be identical, or at the least present additional river flow due to the use of storage in the new location.

Since new licences are all subject to WCO being met, the new licence applied for can not have any impact on the WCO being met, just risk to the licence holder of being shut down. None of the licenses will have any impact on the WCO at Frank being met by being transferred or by new operations at Grassy Mountain. The potential impacts to Gold Creek, Blairmore Creek and the Crowsnest River are discussed in Addendum 2, Appendix 1E, Section 3.

b) Show the potential impact of each of the three allocations (separately) on the performance of the Crowsnest River WCO using weekly time steps. Show the potential impact of the three allocations combined, on the performance of the WCO using weekly time steps. Provide a conclusion on the potential impacts to the Crowsnest River due to all three allocations being requested.

Response:

Please see the response to SIR 207 a.

In Addendum 2, Appendix 1E, Table 3.3-2 compared the total licenced water allocations in the Crowsnest River (CNR) watershed to the total average flows in the CNR, to evaluate the percent of water that could be taken out of the CNR compared to the total volume. This is an extremely conservative calculation, but at no time do the flows get close to the WCO (either as the 45% of natural flow or as the IO plus 10%). An example of this conservatism is one licence for the Allison Creek Fish Hatchery (Licence # 00032258-00-00 - SE-27-008-05-W5M) which has return flow of 5,063,518 m^3 in the CNR watershed. Table 3.3-2 has been reproduced as Table 207-1, with the Allison Creek return flows removed. Using the new and less conservative assumptions, the maximum volume of water taken from the CNR was 11.6% at the Node 1 (Addendum 2, Appendix 1E, Figure 1-1) which is still extremely conservative. The Allison Creek allocation is actually located upstream of Node 1, and if the additional volume of water from the return flows were added to Node 1, the maximum percentage of water removed from Node 1 would be reduced to 0.1%.

Benga's conclusions remain the same as outlined in Addendum 2, Appendix 1E, Section 3, there will be no impact to the environment and to downstream users. It is very unlikely that the WCO objectives would be exceeded resulting in reduced allocations being available to junior licence holders. There have been no occasions where junior licences (or any licences) were required to stop or reduce withdrawals which supports the conclusion, since the Oldman Dam was operational in 1992.

Table 207-1 Crowsnest River -Flows Compared to Licenced Water Volumes (Less Allison Creek Return Flow)

Point of Measurement (shown on Figure 1-1)	Drainage Basin Area (km^2)	Avg. Annual Flows in Crowsnest River (m^3)	% of Total Licenced Volume to Volume in the Crowsnest River[1]	% of Total Licenced Volume Netting out Return Flow from Allison Creek [2]
Total Flow to 1	88.24	28,501,520	29.3%	11.6%
Total Flow to 2	283.73	91,644,790	9.1%	3.6%
Total Flow to 3	423.45	136,774,350	6.1%	2.4%

1 Total allocation in Crowsnest River (CNR) watershed - 8,359,926 m^3 (sourced from approval viewer in June 2016)

2 Return flow from Allison Creek Fish Hatchery (Licence # 00032258-00-00 - SE-27-008-05-W5M) alone is 5,063518 m^3 in the CNR watershed. Total volume of licenced allocation in CNR watershed minus Allison Creek is 5,063518 m^3 . To make the flow comparison more realistic, the Allison Creek return flows have been removed, remaining allocation would be 3,296,409 m^3 .

c) Propose IFN flows for both Gold and Blairmore Creek.

Response:

Addendum 1, Aquatic Ecology Consultant Report (CR#6), Appendix 3 provides an Instream Flow Assessment (IFA) to evaluate the potential for flow-related effects on westslope cutthroat trout (WSCT) and their habitat in Gold Creek and Blairmore Creek. Model predictions were made for baseline and all Project phases of hydraulic conditions important to WSCT (i.e., stream depth, width, water velocity, substrate) and the Area Weighted Suitability (AWS) of habitat calculated by applying WSCT life-stage specific Habitat Suitability Curves to these hydraulic conditions. The intent of the IFA was to assess this potential impact of changes in flow not to provide an IFN number.

208. Addendum 2, Appendix 1E, Section 3.2, Page 6

Addendum 2, Appendix 1E, Table 3.3-1, Page 9

Addendum 2, Appendix 1E, Table 3.4-1, Page 15

Benga states that there are no users that maybe affected on either Gold or Blairmore Creek, however the statement that no user will be impacted downstream on the Crowsnest River is not well understood and further information and analysis is required to support this claim. Based on average flows in Gold and Blairmore creek, an impact of 5% reduction in Gold Creek and 8% higher flows in Blairmore indicate an overall reduction of volume of approximately 500,000 m3. Furthermore, the transferred allocations will have an impact due to increase in water usage/diverted. Benga's proposed water use from both transfers will be greater than water use previously reported by Devon or the Municipality of Crowsnest Pass under their licences at their original points of diversion.

a) Provide a map that clearly identifies and separates the location of the junior and senior licensees on Crowsnest River.

Response:

Figure 208-1 identifies the location of each licence on the Crowsnest River and identifies the priority of each licence as well. Table 208-1 lists the current water licences between Crowsnest Lake and the Oldman River Dam. The dates of each licences (which are the priority) and some other details for each licence, including volume are provided. No public information was found to indicate actual current and past water use by any of the listed licences.

Table 208-1 Surface Water Licences on Crowsnest River between Crowsnest Lake and Oldman River Dam									
APPROVAL ID	**PRIORITY [1]**		**LICENCE**	**POINT OF DIVERSION [2]**	**SOURCE [3]**	**VOLUME[4]**	**DIVERSION RATE [5]**	**TYPE**	**PURPOSE [6]**
45622	1	1910-09-19-001	MUNICIPALITY OF CROWSNEST PASS	NW-34-007-04-5	York Creek	308,380	.105	SW	Municipal
44947	2	1924-02-05-001	ALBERTA INFRASTRUCTURE, CALGARY	SE-07-008-04-5	Crowsnest River	0		SW	Commercial
39493	3	1961-12-14-002	DEVON CANADA CORPORATION	NE-02-008-05-5	Crowsnest River	123,350	.017	SW	Industrial
35946	4	1978-09-11-001	MUNICIPAL DISTRICT OF PINCHER CREEK NO. 9	NE-26-007-02-5	Crowsnest River	24,670	.015	SW	Municipal
35850	5	1980-11-27-002	MUNICIPALITY OF CROWSNEST PASS	SW-10-008-05-5	Crowsnest River	103,610	.019	SW	Municipal
35136	6	1981-05-26-001	GLEN GRAVEL (GLEN RANCHING LTD.)	NE-27-007-02-5	Crowsnest River	61,670	.03	SW	Commercial
35946	7	1983-08-23-001	MUNICIPAL DISTRICT OF PINCHER CREEK NO. 9	NE-26-007-02-5	Crowsnest River	24,670	.015	SW	Municipal
29743	8	1985-03-26-001	WILLIAM & SHIRLEY SARA	NW-17-007-02-5	Crowsnest River	16,040	.014	SW	Irrigation
35946	9	1985-08-09-001	MUNICIPAL DISTRICT OF PINCHER CREEK NO. 9	NE-26-007-02-5	Crowsnest River	49,340	.015	SW	Municipal
34586	10	1987-03-19-010	CERVO, EDWARD	NW-11-007-03-5	Crowsnest River	32,070	.027	SW	Irrigation
26653	11	1990-11-22-001	GREEN, LEONARD	SE-13-007-03-5	Crowsnest River	27,130	.018	SW	Irrigation
24892	12	1993-04-29-002	DARRYL & KATHY ALLSOP	SE-13-007-03-5	Crowsnest River	2,460	.009	SW	Irrigation
31356	13	1994-05-13-002	DUNN CREEK RESOURCES LTD.	SE-28-007-02-5	Crowsnest River	4,930	.006	SW	Commercial

Table 208-1 Surface Water Licences on Crowsnest River between Crowsnest Lake and Oldman River Dam

APPROVAL ID	PRIORITY [1]		LICENCE	POINT OF DIVERSION [2]	SOURCE [3]	VOLUME[4]	DIVERSION RATE [5]	TYPE	PURPOSE [6]
156043	14	1999-01-28-002	CARMEN & NANCY RINKE	NW-20-007-02-5	Crowsnest River	8,641.98	.016	SW	Irrigation
212433	15	2003-12-18-003	DAVIS, JEFF	NW-21-007-03-5	Crowsnest River	1,036.06	.001	SW	Management of Fish

NOTES:

(1) Priority - first in time first in right, based on the date of a complete application (YYYY-MM-DD-00X); e.g. 1958-11-03-001 = 1958(year), 11(month), 03(day), 001(database generated)

(2) Point of Diversion - the legal land location of the works; e.g. 12 or NE 08-007-06-4 = 12 or NE (legal subdivision and/or quarter section), 08 (section), 007(township), 06(range), 4(meridian)

(3) Source - Refer to the licence document for the approved source

(4) Volume - maximum annual quantity that may be diverted; units are in cubic metres

(5) Diversion Rate - maximum instantaneous diversion rate; units for surface water diversion rate are cubic metres/second; units for an aquifer diversion rate are cubic metres/day

(6) Purpose - purposes are grouped into a classification system within a database. Refer to the licence document for approved purpose

Total volume of allocations - 787,998 cubic metres

Total volume of allocations minus licence transfers to Benga - 356,268 cubic metres

b) Discuss how changes in flow in Blairmore and Gold Creeks will affect junior licensees downstream on the Crowsnest River. Include in your response the increase in probability, as applicable, of junior licensees not able to divert (due to WCO/IO not being met).

Response:

The flows in Blairmore Creek are predicted to increase by 8% and flows in Gold Creek are predicted to decrease by 5%. These changes were calculated after the water supply volumes and Water Act Licence applications for the project were incorporated. There will be more water in the Crowsnest River from Blairmore Creek to Gold Creek as a result of this. This will benefit downstream users regardless of priority. The two transfers that have been applied for will also keep water in the CNR longer as described in detail in Addendum 2, Appendix 1E, Section 3. Any licensee is entitled to make a priority call if the IO listed on their license prevents them from diverting water. Junior licences downstream from the new licence applied for by Benga will be able to make a call on Benga's new licence and therefore will not be affected. Some of the details include:

- York Creek temporary transfer – this licence has the highest priority (Priority #1) of all water licences in the Crowsnest River System between Crowsnest Lake and the Oldman River Dam. The total volume requested for transfer is 250,400 m^3 per year. The York Creek transfer will allow water to remain in the system from the current location in York Creek (Addendum 2, Appendix 1E, Figure 1-1) to the confluence of Gold Creek with the Crowsnest River, an additional 7.4 km. In Addendum 2, Appendix 1E, Table 3.4-1, impacts to downstream users and the environment were presented based on the proposed transfer of the York Creek licence. The Municipality of Crowsnest is the current holder of the licence and has shown in its assessment of good standing that they are, or can be, fully capable of making full use of their licence if it remains where it is without the temporary transfer and will make full use of the licence when it reverts to their use in 25 years. The temporary transfer in itself has no effect on water availability downstream.

- Devon Licence transfer – this licence has a priority of #3 in the Crowsnest River System between Crowsnest Lake and the Oldman River Dam. The total volume requested for transfer is 123,350 m^3 per year. The Devon transfer will allow water to remain in the system from the current location on the Crowsnest River (Addendum 2, Appendix 1E, Figure 1-1) to the confluence of Gold Creek with the Crowsnest River, an additional 16.5 km. In Table 3.3-1, impacts to downstream users and the environment were presented based on the proposed transfer of the Devon licence. The Devon licence was shown in its good standing assessment to be capable of diverting its full diversion rate and volume at the time of the application for transfer. Although Devon had not historically used its full allocation, it was possible at any time for it to do so, and therefore downstream licencees should have been prepared for that to occur and were aware of that potential at the time they applied for their licences. The transfer of the Devon licence does not represent any additional risk to downstream licensees.

More water will remain in the CNR longer and will benefit downstream users because Benga will use water storage ponds where Devon had no storage and used water directly from the

Crowsnest River even during the lowest flows when it was most critical for other licensees to meet IO flows.

There are 15 existing licences on the mainstem of the CNR. The locations and priorities are shown on Figure 208-1 and listed on Table 208-1. The priority system was created and allows for a "first in time, first in right". As such the senior, highest priority licences will be allowed to with draw water before junior licences in times of water shortages. The system was created to allow this and all licencees are aware of this. The junior licences were always at risk when the Devon and York Creek licences were at their original locations because both licences were in good standing and capable of fully utilizing their allocations at any time, thus juniors downstream should have been prepared operationally in any year to expect the same flow at their diversion points as will occur with the transfers in place, or are better off due to the storage at Grassy that is available in low stream flow periods. There have been no occasions where junior licences (or any licences) were required to stop or reduce withdrawals since the Oldman Dam was operational.

Operationally, Benga will capture water from the site during high flow/runoff period and will store this water in ponds for use for the project. Water will be released regularly when water quality is acceptable. Capture water and store it during periods of high precipitation will reduce the need to remove water from the system during lower flow periods.

c) Discuss how changes in flow in Blairmore and Gold Creeks will affect senior licensees downstream on the Crowsnest River. Include in your response, the increase in probability, as applicable, of senior licensees with WCO or IO conditions calling priority.

Response:

This has been addressed in the response to SIR 208 b).

APPROVAL ID	PRIORITY [1]		LICENSE	POINT OF DIVERSION [2]	SOURCE [3]	VOLUME [4]	DIVERSION RATE [5]	TYPE	PURPOSE [6]
45622	1	1910-09-19-001	MUNICIPALITY OF CROWSNEST PASS	NW-34-007-04-5	York Creek	308380	.105	SW	Municipal
44947	2	1924-02-05-001	ALBERTA INFRASTRUCTURE, CALGARY	SE-07-008-04-5	Crowsnest River	0		SW	Commercial
39493	3	1961-12-14-002	DEVON CANADA CORPORATION	NE-02-008-05-5	Crowsnest River	123350	.017	SW	Industrial
35946	4	1978-09-11-001	MUNICIPAL DISTRICT OF PINCHER CREEK NO. 9	NE-26-007-02-5	Crowsnest River	24670	.015	SW	Municipal
35850	5	1980-11-27-002	MUNICIPALITY OF CROWSNEST PASS	SW-10-008-05-5	Crowsnest River	103610	.019	SW	Municipal
35136	6	1981-05-26-001	GLEN GRAVEL (GLEN RANCHING LTD.)	NE-27-007-02-5	Crowsnest River	61670	.03	SW	Commercial
35946	7	1983-08-23-001	MUNICIPAL DISTRICT OF PINCHER CREEK NO. 9	NE-26-007-02-5	Crowsnest River	24670	.015	SW	Municipal
29743	8	1985-03-26-001	WILLIAM & SHIRLEY SARA	NW-17-007-02-5	Crowsnest River	16040	.014	SW	Irrigation
35946	9	1985-08-09-001	MUNICIPAL DISTRICT OF PINCHER CREEK NO. 9	NE-26-007-02-5	Crowsnest River	49340	.015	SW	Municipal
34586	10	1987-03-19-010	CERVO, EDWARD	NW-11-007-03-5	Crowsnest River	32070	.027	SW	Irrigation
26653	11	1990-11-22-001	GREEN, LEONARD	SE-13-007-03-5	Crowsnest River	27130	.018	SW	Irrigation
24892	12	1993-04-29-002	DARRYL & KATHY ALLSOP	SE-13-007-03-5	Crowsnest River	2460	.009	SW	Irrigation
31356	13	1994-05-13-002	DUNN CREEK RESOURCES LTD.	SE-28-007-02-5	Crowsnest River	4930	.006	SW	Commercial
156043	14	1999-01-28-002	CARMEN & NANCY RINKE	NW-20-007-02-5	Crowsnest River	8641.98	.016	SW	Irrigation
212433	15	2003-12-18-003	DAVIS, JEFF	NW-21-007-03-5	Crowsnest River	1036.06	.001	SW	Management of Fish

NOTES:

(1) Priority - first in time first in right, based on the date of a complete application (YYYY-MM-DD-00X); e.g. 1958-11-03-001 = 1958(year), 11(month), 03(day), 001(database generated)

(2) Point of Diversion - the legal land location of the works; e.g. 12 or NE 08-007-06-4 = 12 or NE (legal subdivision and/or quarter section), 08 (section), 007(township), 06(range), 4(meridian)

(3) Source - Refer to the licence document for the approved source

(4) Volume - maximum annual quantity that may be diverted; units are in cubic metres

(5) Diversion Rate - maximum instaneous diversion rate; units for surface water diversion rate are cubic metres/second; units for an aquifer diversion rate are cubic metres/day

(6) Purpose - purposes are grouped into a classification system within a database. Refer to the licence document for approved purpose

Total volume of allocations - 787,998 cubic metres

Total volume of allocations minus licence transfers to Benga - 356,268 cubic metres

R5 W5M | R4 W5M | R4 W5M | R3 W5M | R2 W5M | R1 W5M | R30 W4M | R29 W4M

T9 | T8 | T7

Forestry Trunk Road

M.D. of Ranchland No.66

Fence-line WA Boundary

35850
Priority 5
103610 m³

Coleman

Sentinel

Savanna

Crowsnest Lake

M.D. of Crowsnest Pass

44947
Priority 2
0 m³

39493
Priority 3
123350 m³

Blairmore

Frank

45622
Priority 1
308380 m³

212433
Priority 15
1036 m³

Bellevue

Hillcrest Mines

34586
Priority 10
32070 m³

Burmis
29005

24892
Priority 12
2460 m³

26653
Priority 11
27130 m³

156043
Priority 14
8642 m³

35136
Priority 6
61670 m³

35946
Priority 4
24670 m³

35946
Priority 9
49340 m³

35946
Priority 7
24670 m³

31356
Priority 13
4930 m³

29743
Priority 8
16040 m³

M.D. of Pincher Creek No.9

Ross Lake

Hudson Bay Lake

Lee Lake

Lundbreck

Cowley

Oldman Dam

Todd Creek

CPR

40 | 22 | 3A | 3 | 507 | 510 | 785

LEGEND

- Diversion Licence
- Diversion Licence (Historical Location)
- Railway
- Powerline
- Resource/Recreation/Winter Road
- Road
- Highway
- Existing Access Road
- Existing Powerline
- CHPP Facilities
- Proposed Water Pipeline/ Service Road
- Railway Loop
- Proposed Helipad Access
- Access Road
- Rail Loadout
- Proposed Haul Road
- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Coal Handling Processing Plant and Infrastructure
- Covered Conveyor, Access Road and Powerline ROW
- Proposed Golf Course Area
- Undisturbed Area
- Legacy Mine Disturbance
- Gold Creek Catchment
- Blairmore Creek Catchment
- Aboriginal Land
- Oldman Dam
- Gold Creek Catchment
- Blairmore Creek Catchment

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

SURFACE WATER LICENCES AND PRIORITIES ON CROWSNEST RIVER ABOVE OLDMAN RIVER DAM

AltaLIS, 2018; MEMS, 2018; NRCAN, 2015; SRK, 2017

Projection/Datum: UTM Zone 11 Nad 83

0 4 8 Kilometres

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DATE: FEBRUARY 27, 2018

FIGURE 208-1

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APPENDIX 5.16-2: ADDENDUM 8, CEAR #89, AER-R2-6, AND AER-R2-7

6. Volume 1, C.5.3.3, Page C-93 Appendix E, Section 1.0, Page 1 Volume 3, Appendix 10B, Water and Load Balance Model Report, Section 2.4.1, Page 5 SIR Responses 1, Section D.2.2, SIR 206, Page 285 Addendum 7, SIR 206, Pdf Page 7

Benga affirms that water will be returned to the creeks. In Volume 3, Benga states that water in the settling ponds will be released to the creeks if water quality is acceptable. If not, then water will be discharged to the saturated zones for further treatment. Return flows to Blairmore Creek and Gold Creek are very important to minimize potential impacts to the streams, and will also be a mandatory requirement of the York Creek transfer and the most junior licence during times when Water Conservation Objectives (WCOs) are not being met.

In SIR 206, Addendum 7, Benga provided a spreadsheet with expected releases at each return location in Gold and Blairmore Creeks. Based on the data submitted it is expected that returns to Gold Creek will be zero during operations and small after the reclamation. It is not clear how Benga will deal with the York Creek and Crown Reservation licences, which may require return flows. The York Creek licence transfer may require return flows in the new licence, in keeping with the conditions of the original licence,; The Crown Reservation licence will be the most junior licence meaning that during times when IOs or WCOs are not being met Benga will need to release up to the estimated natural flow to the respective waterbody, which may include Gold Creek.
a) Considering Benga's proposal for water management and returns (or lack thereof) to Gold and Blairmore Creek, how will Benga satisfy requirements to return water to both creeks due to licence requirements such as returning flows during times when WCOs are not being met.

Response:

Benga will release water from the mine through the planned sedimentation/release ponds. These release ponds will be constructed on both Blairmore and Gold Creeks. These were provided in the response to the AER-R1-IR 206 (Table 206-1), and an updated version has been provided in as Table AER-R2-6-1.

The source of the water directed to the sedimentation ponds will be from surface runoff and groundwater interception from the pit and will not be exposed to selenium enrichment, so they do not require selenium management efforts. This water may contain suspended solids that will require removal prior to release to the environment. The six settling/release ponds will treat and release water back into the environment. Water from the pit areas can be sent to specific ponds to be released to either Gold or Blairmore Creeks, so flows can be augmented to either creek as needed.

Table AER-R2-6-1: Sedimentation/Release Ponds with Location of Releases

Pond Name	Mine Year Constructed	Return Flow Creek	Planned Pond Operation and Release
Plant Site Sedimentation Pond	Year 0	Blairmore Creek	Surface water collected around the site infrastructure (coal wash plant, office buildings, maintenance shop) is directed

			here. All water discharges to Blairmore Creek all the time.
Loadout Sedimentation Pond	Year 0	Blairmore Creek	Surface water collected around the coal loadout, rail loop and infrastructure is directed here. All water discharges to Blairmore Creek all the time.
West Sedimentation Pond	Year 2	Blairmore Creek	Water collected at the western active mine faces is directed here and discharges to Blairmore Creek (includes water being forwarded from SWSP)
East Sedimentation Pond	Year 6	Gold Creek	Water collected at the mine face (surface runoff and gw) is directed to this pond prior to release to Gold Creek. Prior to Year 6 the Pond does not exist and all natural drainage reports to Gold Creek.
Northeast Sedimentation Pond	Year 14	Gold Creek	Water collected at the mine face (surface runoff and gw) is directed to this pond prior to release to Gold Creek. Prior to Year 14 the Pond does not exist and all natural drainage reports to Gold Creek.

Within the surface water management plan, Benga will store significant volumes of water on site and will be able to, and plan to release water to Blairmore and Gold Creeks. Achieving the WCO will be possible as a result of this excess storage of water and ability to release it to either creek.

7. Addendum 2, Appendix 1E, Section 3.2, Page 6 Addendum 2, Appendix 1E, Table 3.3-1, Page 9 Addendum 2, Appendix 1E, Section 3.3.4, Page 11 Addendum 2, Appendix 1E, Section 3.4, Page13 Addendum 2, Appendix 1E, Table 3.4-1, Page 15 CR6, January 2017 Addendum 1, Appendix A3, Instream Flow Assessment SIR Responses 1, Section D.2.2, SIR 207, Page 287 Addendum 7, SIR 207, Pdf Pages 8 to 10

In response to SIR 207, Benga has provided the initial steps of the requested analysis to show the current performance of the Crowsnest River's Water Conservation Objective (WCO). However, Benga has not provided the impacts that the proposed transfers and the new licence may have on the ongoing performance of the WCO, acknowledging that there will be an increase in water use from the original licences.
Benga indicates that the two senior licences pre-date the concept of WCOs and as such are not subject to WCO's. The Approved Water Management plan established a WCO on the watercourses in question and under the Matters and Factors that a Director must consider, the historical performance of the WCO and its potential performance after the transfers are critical considerations for the approval and conditions of the transfer, including but not limited to the decision to withhold 10% of the transferred volume. This analysis is required for AER's consideration of the Matters and Factors listed in the Approved Water Management Plan for the South Saskatchewan River Basin. The WCO analysis should include any existing Instream Objectives (IO) and should be completed using the full criteria of the WCO, which is 45% of natural flow or 110% of the IO, whichever is greater.
As for the new licence application, Benga affirms that "this licence will be subject to WCO objectives and will be the first licence to be shut down or restricted if the WCO objectives can't be met". While the AER agrees with this assertion, it is not clear if Benga understands that the risk to the licensee will extend not only to "*being shut down*" but also to be required to return up to the natural flow contributions of the creeks to the Crowsnest River. Since Benga's proposed diversion is based on impoundment of runoff and is not a direct diversion from the creeks, the appropriate response to WCO/IO conditions not being met will be to facilitate return flows.

a) Show the potential impact of each of the two transfer allocations (separately) on the performance of the Crowsnest River and Gold Creek WCO using weekly time steps. Show the potential impact of the two allocations combined, on the performance of the WCO using weekly time steps. Provide a conclusion on the potential impacts to the Crowsnest River and Gold Creek due to the transfers requested.

Response:

AER-R2-7-1 shows the naturalized flow data of the Crowsnest River at Frank from AEP averaged on a weekly basis. Also shown are the WCO flows which were made from the AEP data on IO and have had 10% added to create a WCO. The naturalized flows are also shown minus the consumptive diversions of the two transfers where the transfers are taken continuously over the year. AER-R2-7-1 and the supporting overview (below) demonstrates that the licences to be transferred have impacts so small they are difficult to identify in the naturalized flow when combined, if shown separately they would be even more difficult to identify.

1. **York Creek Licence**
    - 250 acre ft. total diversion
    - 223 acre ft. return flow
    - 27 acre ft. consumption
      = 91.3 m3/day

2. **Devon Licence**
    - 100 acre ft. total diversion
    - 100 acre ft. consumption
      = 338 m3/day

    Total diversion of #1 and #2: 91.3 m3/day + 338 m3/day = 0.005 m3/s

    Lowest WCO (calculated as IO + 10%) week is 1.46 m3/s in February.
    Lowest naturalized flow (averaged cross all years) week is 1.32 m3/s in March.

    Two licences diversion total = 0.005 m3/s
    = 0.34% of lowest WCO
    = 0.38% of lowest naturalized flow

    Note: neither is subject to WCO on licence.

3. **New Licence**
    - 150 acre ft. compared to two licences at 123 acre ft; therefore, ~0.4% of naturalized flow.

The conclusion on the potential impacts to the Crowsnest River is that the licence diversions are within the margin of error in creating the data for the naturalized flow at Frank and have a negligible effect on the WCO for the river.

The effect of moving the transfers further downstream on the Crowsnest River and York Creek for substantial distances will be to increase the flows and improve the current WCO performance. Downstream of the Gold Creek confluence the effect of the transfers on the Crowsnest River will be no change to the current licenced condition. The "in good standing" process has shown that the licences to be transferred could be used to their full extent at their current upstream locations. The infrastructure design, water use, and right of way to fully utilize the York Creek licence is in place at its current location. The Devon site is still zoned as industrial and available for redevelopment and water use if the transfer does not proceed.

While a review of the recent historical use of the licences to be transferred may indicate the transfers will increase the use of water from the Crowsnest River over recent water use patterns, that information must also be balanced with the decisions that have been made to transfer the licences downstream instead of developing them to their full use at the current locations. Both transferors recognize the value of the water allocations and can develop full use of the water at their existing locations. The Crowsnest River flow and its WCO is therefore improved in upstream reaches and neutral in effect downstream by the transfers.

On Gold Creek, the transfers will be used to offset water diverted from the natural landscape flow into the mine footprint. More water will flow into the storages than would naturally run off the landscape into Gold Creek because the vegetation will be removed and vegetative use will decline within the mine site. The stored water will be available to release to Gold Creek and at any time the Gold Creek WCO may otherwise (naturally) not be met.

b) Provide details on how Benga will ensure that the return flows are equal to or greater than the natural flow contributions of Blairmore Creek and Gold Creek to the Crowsnest River when WCO or IOs are not being met, especially for the junior licence (Crown Reservation).

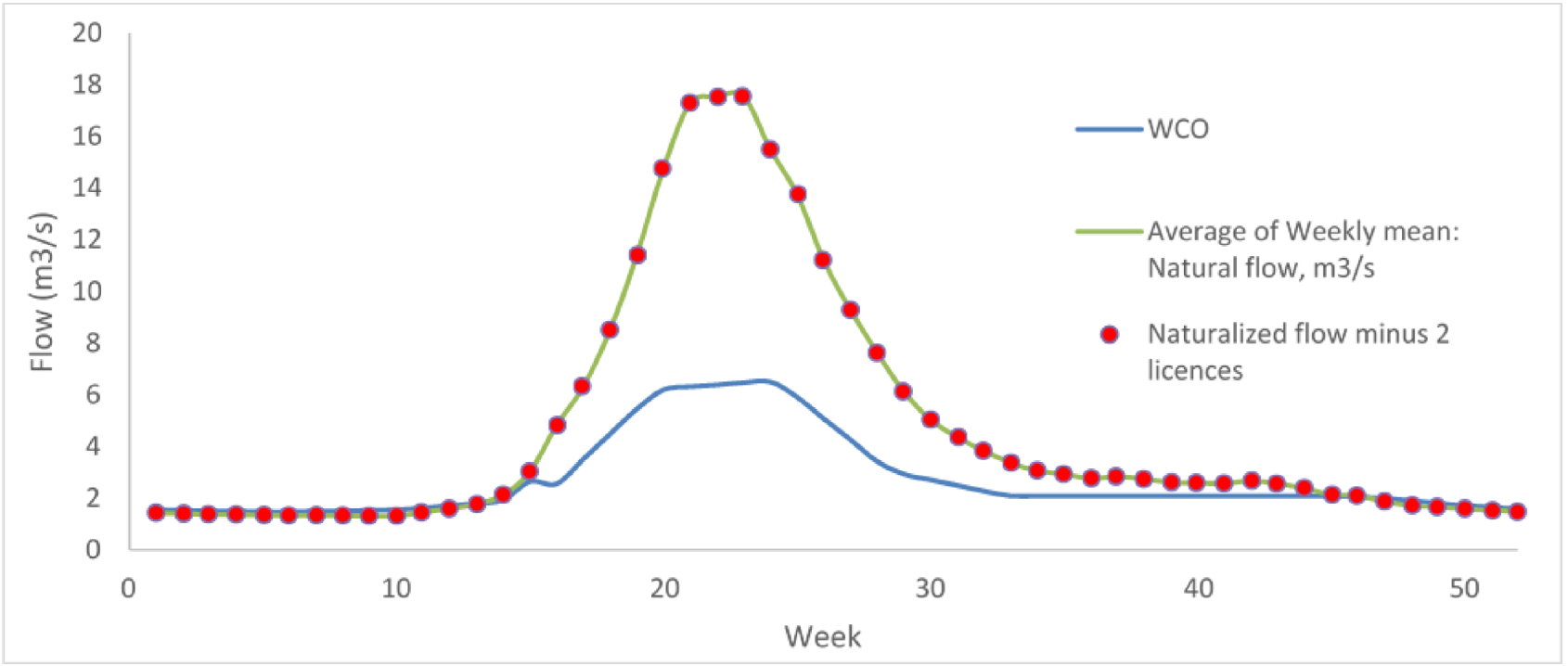
Response:

As stated in the response to SIR #6, Benga will store significant volumes of water on site, within the surface water management plan and will be able to release water to either creek through direct and intensive water management. The WCO will be met through these means.

c) Appendix A3 – Instream Flow Assessment (of CR6) mentions that the Instream Flow Needs (IFN) will be met, but does not propose an IFN with respect to flows in either Blairmore Creek or Gold Creek. Propose Instream Objective flows for both Gold Creek and Blairmore Creek based on the Instream Flow Assessment.

Response:

Instream Flow Needs have been identified for Blairmore and Gold Creeks near the confluence with the Crowsnest River. All calculations were performed following the Alberta Desktop Method for Determining Environmental Flows (Instream Flow Needs). Data used are monthly average baseline flows estimated at downstream locations on Gold (Figure AER-R2-7-2) and Blairmore Creeks (Figure AER-R2-7-3) for the years 1975-2016.



RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

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COMPARISON OF NATURALIZED FLOWS AND WCO, WITH THE LICENSE TRANSFERS REMOVED

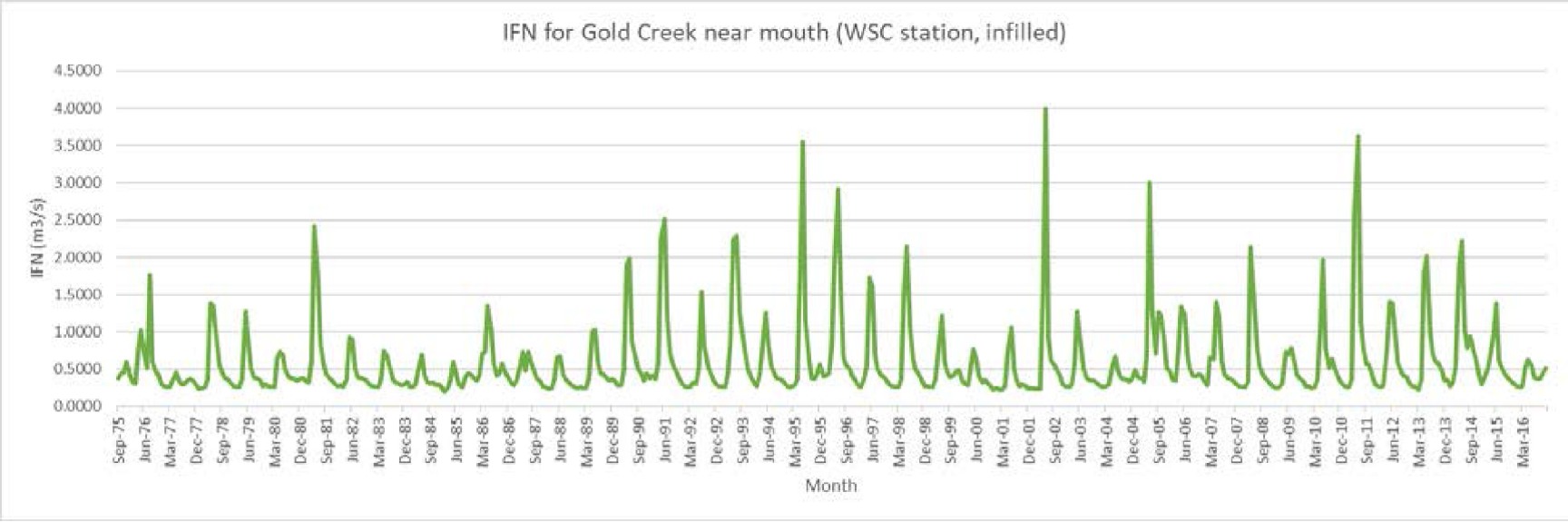
MEMS, 2018

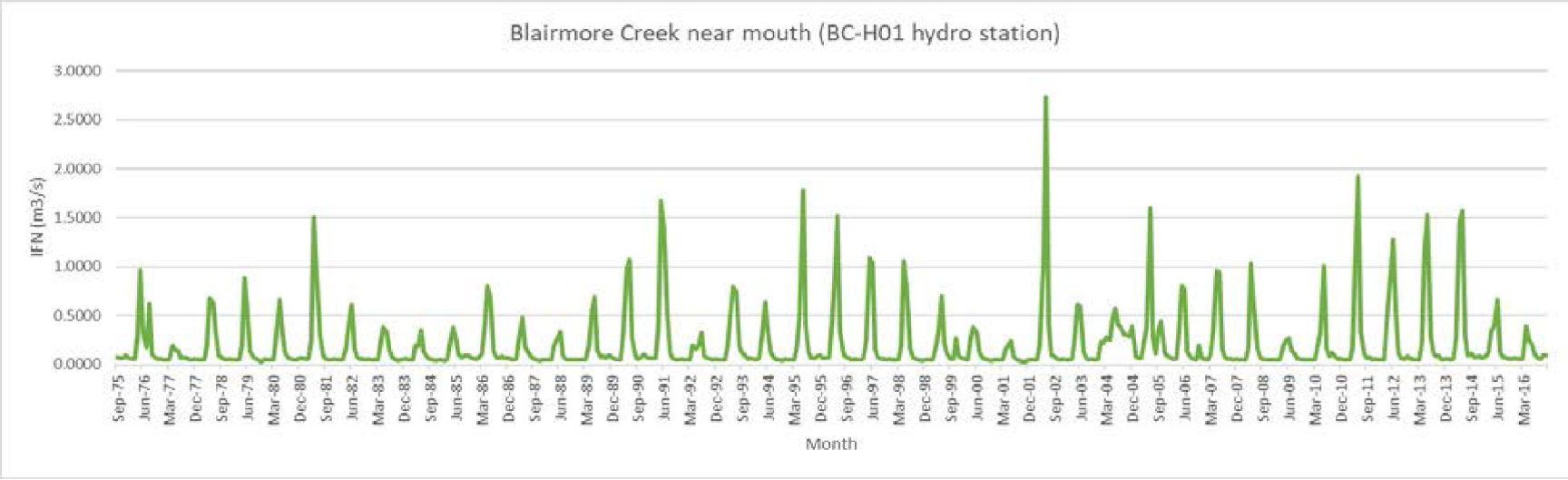
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FIGURE
AER-R2-7-1

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RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

IFN FOR GOLD CREEK

MEMS, 2018

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FIGURE
AER-R2-7-2

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APPENDIX 5.16-3: ADDENDUM 7, CEAR #72, UPDATED RESPONSE TO ADDENDUM 5, AER-R1-207

Addendum 7, CEAR #72, updated response to Addendum 5, AER-R1-207

207. Addendum 2, Appendix 1E, Section 3.2, Page 6

Addendum 2, Appendix 1E, Table 3.3-1, Page 9

Addendum 2, Appendix 1E, Section 3.3.4, Page 11

Addendum 2, Appendix 1E, Section 3.4, Page13

Addendum 2, Appendix 1E, Table 3.4-1, Page 15

CR6, January 2017 Addendum 1, Appendix A3, Instream Flow Assessment

In the above sections Benga provided either a simple computation that showed that the overall allocations on the Crowsnest River do not exceed 55% or mentioned that the Water Conservation Objective (WCO) on the Crowsnest River is met. Benga did not demonstrate how the Instream Objective (IO) factors into determining if the WCO will be met. Also, there is no indication that Benga attempted to obtain naturalized flows from AEP to compute the WCO on a weekly or monthly time step including the portion of the IO. This work is required to be completed using the full criteria of the WCO, which is 45% of natural flow or 110% of the IO, whichever is greater.

Appendix A3 – Instream Flow Assessment (of CR6) mentions that the Instream Flow Needs (IFN) will be met, but does not propose an IFN with respect to flows in either Blairmore or Gold Creek.

a) Present a WCO analysis on a weekly time step showing the current performance of the WCO i.e. without the proposed transfers and reserved allocation in place. Every year where data exists at Frank, present the percentage of time that WCO is not being met.

Response:

Benga requested and received information from AEP for naturalized flows at the WCO station "Crowsnest River at Frank". The information received was in the form of two pieces of data and a formula. The data is a set of naturalized flows at the WSC station "Crowsnest River at Frank" for the years 1928 to 2009, and a set of weekly flows calculated in 1995 using the old and outdated modified Tennant/Tessman minimum flow methodology referred to as an "IO" or Instream Objective. The formula was represented as either 45% of the natural flow or the IO plus 10% whichever is greater. This data was used to compute the WCO on a weekly time step.

The IO is substantially greater than 45% so a comparison calculation was prepared for the provided naturalized river flow data set and the frequency that the IO plus 10% would equal the natural flow. Normally the second step would be to subtract the licenced diversions, in a reasonable proportion to their typical pattern of use, from the naturalized river flow to see how often the new licenced diversion would be restricted.

The analysis from the AEP supplied data showed the calculated WCO often exceeded the natural river flow for much of the year, for all of the modelled years without even considering any of the existing licenced diversions. The data is graphically shown on Figure 207-1.

The results show the WCO exceeded the naturalized flow data numerous times every week of the year, without any withdrawals occurring. For example in the 81 years of flow data in week 9, the WCO requirement exceeds the natural flow in all 81 years. This data wasn't presented in the response to SIR #207a, as it was assumed there was an error in the data. The reason behind developing a WCO for a watercourse in Alberta was to identify a reasonable portion of a stream flow that must remain in the stream to protect the instream environment. (Water Act sec 1(1)(hhh)). A formula that frequently identifies more water than is naturally available in the stream most of the time suggests an error in either data or methodology. The issue was described to AEP, with a request for clarification of any potential data misalignment. No response was received on why the data produced a WCO requirement greater than the natural flow.

Benga investigated this further and found an updated method for calculating Instream Flow Needs, that was developed in 2011 and was available on the AEP website. The method commonly referred to as the "Alberta Method" was carefully constructed as a replacement for the previously used "modified Tennant/Tessman method" and its variations adopted from the USA in the 1970 to 2010 period. For comparison, the AEP naturalized flow for "Crowsnest River at Frank" was applied according to the AEP website instructions for calculating an Instream Flow Need. The result is shown on Figure 207-2. The analysis shows the minimum flow required for protecting the river environment (IFN) exceeds the natural flow in about 20 years out of the 81 years of data. During such occasions Benga would assume the risk to reduce production or to increase on-site water storage to use during these times.

The second step of subtracting the existing senior licence diversions from the naturalized flow data to predict the frequency that the new application may be restricted has not been attempted. Although there is a relatively small amount of licenced water use in the Crowsnest River basin, there is no reliable data on the frequency of water use by the existing small group of licencees. There is also the potential for compounding errors, since the naturalized flow data set provided by AEP was constructed also without actual water use reports to indicate the water use pattern and frequency of use of the existing licencees.

The impact on the three allocations that have been applied for is described below:

York Creek temporary transfer:

- This licence has the highest priority (Priority #1 – discussed in more detail in the response to SIR 208) of all water licences in the Crowsnest River System between Crowsnest Lake and the Oldman River Dam. The total volume requested for transfer is 250,400 m^3 per year. This licence pre-dates any WCO objectives that were later adopted and is therefore, not subject to the WCO objective.
- The York Creek transfer will allow water to remain in the river for a longer time from the current location in York Creek (Addendum 2, Appendix 1E, Figure 1-1) to the confluence of Gold Creek with the Crowsnest River, an additional 7.4 km.

Devon Licence transfer:

- This licence has a priority of #3 in the Crowsnest River System between Crowsnest Lake and the Oldman River Dam. The total volume requested for transfer is 123,350 m^3 per year. This licence also pre-dates any WCO objectives that were later adopted and is therefore, not subject to the WCO objective.
- The Devon transfer will allow water to remain in the river for a longer time from the current location on the Crowsnest River (Addendum 2, Appendix 1E, Figure 1-1) to the confluence of Gold Creek with the Crowsnest River, an additional 16.5 km.
- The impact of these transfers result in more water staying in the river longer, which is positive to the environment and downstream users.

Industrial Reserve new allocation:

- This licence will be the newest allocation and will have the lowest priority (Priority #16) in the Crowsnest River System between Crowsnest Lake and the Oldman River Dam. The total volume requested for allocation is 185,025 m^3 per year. This licence will be subject to WCO objectives and will be the first licence to be shut down or restricted if the WCO objectives can't be met.
- This new licence can not have any impact on any new licensees or the WCO (either as the 45% of natural flow or as the IO plus 10%).

Since the two transfers are senior priorities and pre-date the WCO objectives, the WCO does not apply to them in the current location and form and therefore will not have any different effect on the WCO at Frank. The new licence will be subject to the WCO and since it will be the most junior licence above the Oldman Dam, will be the first to be shut down to achieve the WCO.

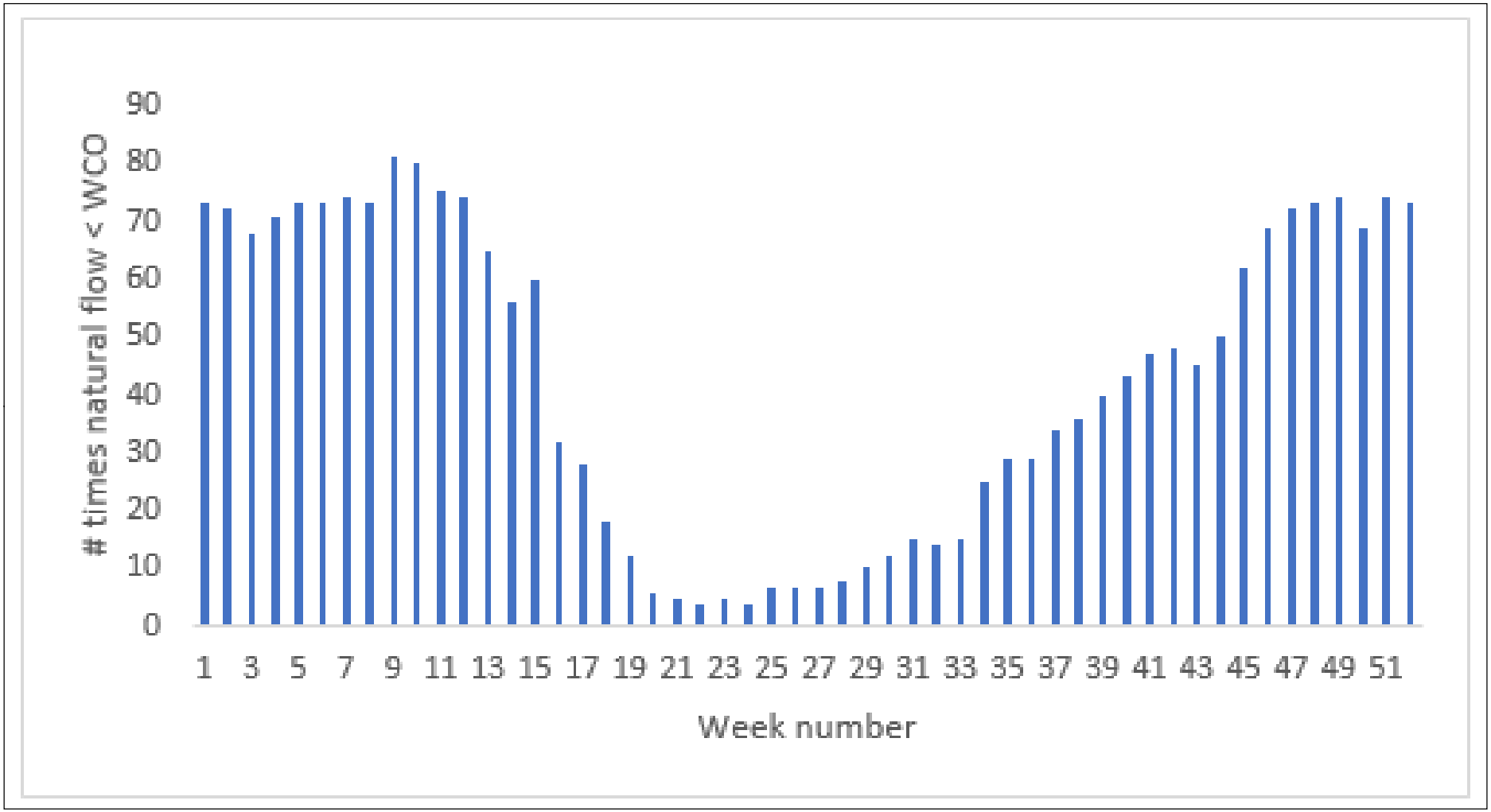
Since new licences are all subject to WCO being met, the new licence applied for can not have any impact on the WCO being met, just risk to the licence holder of being shut down. None of the licenses will have any impact on the WCO at Frank being met by being transferred or by new operations at Grassy Mountain. The potential impacts to Gold Creek, Blairmore Creek and the Crowsnest River are discussed in Addendum 2, Appendix 1E, Section 3.

From the table of Matters and Factors in the Water Management Plan for the SSRB one of the items in the Matters column is:

"Existing, potential and cumulative effects on any applicable instream objective and/or WCO"

The way previous licence applications have been managed to meet the requirement above is a condition has been added to the new licence stating the licencee must cease diversions when the WCO is not being met. To be comparable to other licences issued Benga expects the same condition will be placed on the new licence thus preventing any effects on the WCO.

It is assumed the issue of the WCO being identified as the IO plus 10% where the data used forces a calculated value greater than the natural flow most of the time will be resolved. A WCO of 45% of natural flow, or a WCO equal to the IFN are more practical and acceptable values.



RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

WEEKLY FLOWS IN CROWSNEST RIVER AT FRANK WITH COMPARISON OF NATURAL FLOWS TO WCO OBJECTIVE (1995 MODIFIED TENNANT/TESSMAN)

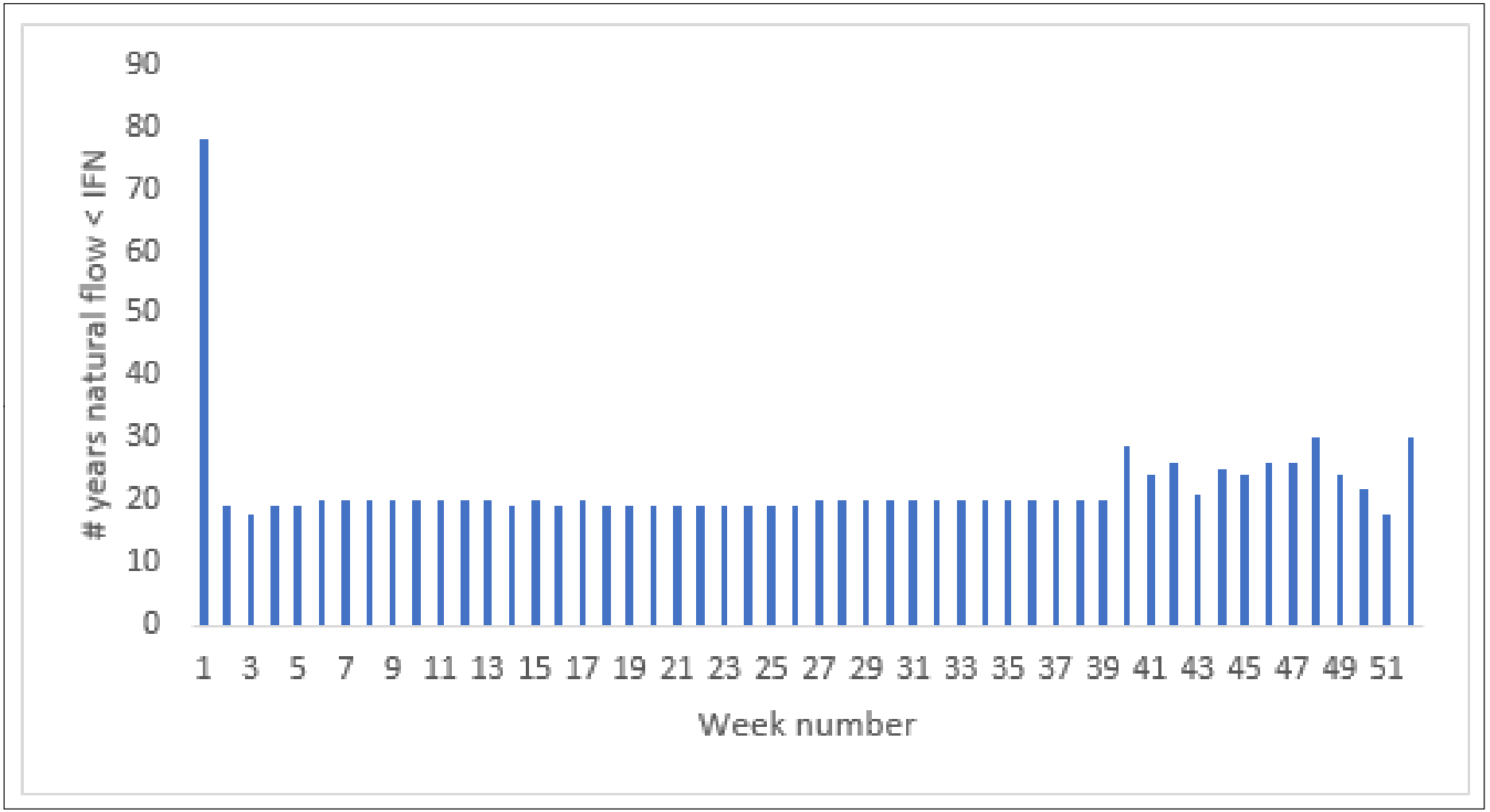
MEMS, 2018

MILLENNIUM EMS Solutions Ltd.

PROJECT:	14-00201
DRAWN BY:	MM
CHECKED BY:	MB
DATE:	MAY 22, 2018
FIGURE	207-1

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RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

WEEKLY FLOWS IN CROWSNEST RIVER AT FRANK WITH COMPARISON OF NATURAL FLOWS TO WCO OBJECTIVE (2011 ALBERTA METHOD)

MEMS, 2018

MILLENNIUM EMS Solutions Ltd.

PROJECT: 14-00201
DRAWN BY: MM
CHECKED BY: MB
DATE: MAY 22, 2018

FIGURE
207-2

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APPENDIX 5.39-1: DRAFT WILDLIFE MITIGATION AND MONITORING PLAN

Grassy Mountain Coal Project
Draft Wildlife Mitigation and Monitoring Plan

Benga Mining Limited

July 2019

(presented in Addendum 10, JRP IR-5.39, Appendix 5.39-1)

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1.0 INTRODUCTION

1.1 Purpose of Draft Plan

The following draft Wildlife Mitigation and Monitoring Plan (the Plan) has been developed for the Grassy Mountain Coal Project (the Project) to address Joint Review Panel (JRP) information request (IR) 5.39 (CEAR #215), which requested the following information:

a) *Based on the previous information provided by Benga, provide a draft Wildlife Mitigation and Monitoring Plan. Describe the components of the plan including, but not limited to:*
   i. *a clear statement of the mitigation and monitoring plan objective(s) and scope, spatial and temporal extent at each stage of the life of the Project;*
   ii. *a list of target species or surrogate species and habitat types to be monitored, including those identified by Indigenous groups;*
   iii. *an outline of mitigation measures for each species and habitat, including any proposed offsets;*
   iv. *identification of indicators that will be monitored to determine whether mitigation measures are effective and how identified indicators will be monitored;*
   v. *a description of the strategies and actions that will be implemented, adhering to the mitigation hierarchy of avoid, minimize, restore, and offset, to mitigate project and site- specific effects on wildlife species at risk and of cultural significance throughout the life of the Project that may occur through:*
      – *direct habitat loss;*
      – *indirect habitat loss;*
      – *habitat fragmentation and effects on wildlife movement; and*
      – *mortality;*
   vi. *identification and discussion of any Project-specific mitigation measures that may have a positive impact on wildlife including any details of proposed conservation offsets.*
   vii. *a description of uncertainties that may necessitate the use of adaptive management;*
   viii. *thresholds that monitoring results will be compared to that will trigger implementation of adaptive management or alternative mitigation measures;*
   ix. *a description of the adaptive management approach that will be used to assess and improve the effectiveness of mitigations; and*
   x. *to the extent possible, a description of how, when and where mitigation measures will be implemented including details on leading methodologies used and their supporting literature or research.*

The purpose of this Plan is to outline a process to mitigate potential Project effects on wildlife, assess mitigation effectiveness through monitoring and adapt mitigation as necessary and possible based on

monitoring results. The Plan also provides information on the roles and responsibilities of Benga's employees and contractors and how monitoring results will be communicated to appropriate stakeholders.

This draft Plan has been prepared using the most current information available regarding mitigation, monitoring and adaptive management related to the Project. Finalization of the draft Plan will occur following additional consultation with regulators, Aboriginal communities and stakeholders and is an anticipated requirement of the *Environmental Protection and Enhancement Act* (*EPEA*) approval condition, should the Project be approved. It is anticipated that this draft Plan will be periodically updated and reviewed as per expected *EPEA* approval conditions.

1.2 Limitations

The final version of this Plan will incorporate information that is not currently available, including the JRP Report, the Decision Statement, future stages of Project planning and feedback from Indigenous communities and stakeholders. Benga expects that finalization of this Plan will involve the following steps, which are not necessarily sequential, and which may result in changes to the structure of this document.

- receive the JRP Report and Minister's Decision Statement following the JRP Hearing;
- receive the Alberta *EPEA* approval with conditions;
- understand the current state of relevant provincial and federal regulations and relevant guidelines to be addressed in the Plan;
- continue engaging with regulators, Indigenous communities and stakeholders to develop more clarity around the indicators, metrics and thresholds or objectives to be used to evaluate mitigation effectiveness;
- finalize details of the Plan considering future stages of project planning and engineering, including technical, environmental and commercial details; and
- review the final Plan with regulators, Indigenous communities and stakeholders prior to finalization and submission to appropriate regulators as an anticipated condition of an *EPEA* approval.

2.0 REGULATIONS, APPROVALS AND GUIDELINES

This section of the Plan lists relevant provincial and federal regulations, guidelines, legislation, standards, and approval conditions relevant to wildlife mitigation and monitoring (Table 2.0-1). Copies of relevant approvals and documentation will be included in this report, once they become available.

Table 2.0-1 Wildlife Legislation, Regulation, Policy, Standards and Guidelines

Name	Type	Jurisdiction	Description
Species at Risk Act (SARA)	Act	Canada	Legal protection for at-risk wildlife species including species of special concern, and endangered, threatened, or extirpated species. Prohibits these species from being harmed or harassed and prohibits the destruction of their nests or dens.
Federal Recovery Strategies	Policy	Canada	Developed for species designated as threatened, endangered, or extirpated under Schedule 1 of SARA. Identifies critical habitat of Schedule 1 species. Currently, there are only three recovery strategies applicable to the Project's wildlife: • Recovery Strategy for the Olive-sided Flycatcher (*Contopus cooperi*) in Canada (Environment Canada 2016a) • Recovery Strategy for the Common Nighthawk (*Chordeiles minor*) in Canada (Environment Canada 2016b) • Proposed Recovery Strategy for Little Brown Myotis (*Myotis lucifugus*), Northern Myotis (*Myotis septentrionalis*), and Tri-colored Bat (*Perimyotis subflavus*) in Canada (Environment Canada 2015)
Federal Management Plan	Policy	Canada	Proposed Management Plan for the Short-eared Owl (*Asio flammeus*) in Canada (Environment Canada 2016c)
Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	-	Canada	Legally assesses and classifies wildlife species according to the framework of SARA. Determines national status of species, subspecies, and populations thought to be at risk.
Migratory Birds Convention Act	Act	Canada	Prohibits killing, harming, or disturbing migratory birds or deposition of harmful substances in areas frequented by migratory birds; also protects their eggs and nests.
Wildlife Act	Act	Alberta	Multiple sections protect wildlife by outlining rules in regards to hunting, taking, trapping, wounding, and/or killing wildlife.

Table 2.0-1 Wildlife Legislation, Regulation, Policy, Standards and Guidelines

Name	Type	Jurisdiction	Description
Water Act	Act	Alberta	Ensures that water quality, fish and wildlife habitat, and the rights of license users are not compromised.
Integrated Standards and Guidelines: Enhanced Approval Process	Guideline	Alberta	Outlines best management practices that industry can follow to avoid, limit, or mitigate negative effects on wildlife and the environment.
Recommended Land Use Guidelines: Key Wildlife and Biodiversity Zones	Guideline	Alberta	Assists industry in minimizing impacts on wildlife in KWBZ that generally provide high-quality wintering habitats for ungulates.
Recommended Land Use Guidelines: Mountain Goat/ Bighorn Sheep Ranges	Guideline	Alberta	Assists industry in minimizing impacts on mountain goats and mountain sheep.
Wildlife Sensitivity Maps	Guideline	Alberta	Identifies specific wildlife key areas that function in ensuring the continued survival of local and regional populations of wildlife or wildlife group.
Sensitive Species Inventory Guidelines	Guideline	Alberta	Pre-disturbance inventory protocols focused on wildlife that are or may be at risk of extirpation, require protection to prevent them from becoming at risk, or other species of management concern.

3.0 PLAN GOALS AND OBJECTIVES

The goals of the draft Plan link potential Project effects to mitigation, mitigation objectives to monitoring, and monitoring results to adaptive management actions. The specific goals and objectives of this Plan are summarized in Table 3.0-1.

Table 3.0-1 Summary of the Goals and Objectives for the Plan

Goals	Objectives
1. Reduce changes in wildlife habitat availability, movement, mortality risk, and abundance by applying mitigation to reduce potential effects.	a. Reduce direct habitat loss. b. Reduce indirect habitat loss (*i.e.*, sensory disturbance). c. Reduce changes in movement. d. Reduce changes in mortality risk (*i.e.*, clearing/removal of natural habitat, vehicle-wildlife collisions, increased access to the area, contamination of water). e. Reduce changes in wildlife abundance.

Table 3.0-1 Summary of the Goals and Objectives for the Plan

Goals	Objectives
2. Monitor effectiveness of mitigation designed to reduce changes in wildlife habitat availability, habitat connectivity and movement, mortality risk. and abundance.	a. Monitor recolonization of wildlife in reclaimed habitats to evaluate whether suitable wildlife habitat has been successfully achieved in the reclaimed landscape. b. Monitor wildlife occurrence, distribution and relative abundance in lands adjacent to the Project to evaluate the effectiveness of reducing sensory disturbance. c. Monitor the use of wildlife crossings (*i.e.*, underpasses and overpasses) and undisturbed vegetated buffers to evaluate the effectiveness in maintaining movement. d. Monitor the effectiveness of mitigation to reduce changes in mortality risk and determine the cause of Project-related wildlife mortality. e. Monitor the effectiveness of mitigation to reduce changes in wildlife abundance.
3. Adapt mitigation designed to reduce changes in wildlife habitat availability, habitat connectivity and movement, mortality risk, and abundance, as necessary, based on monitoring outcomes.	a. Adapt mitigation if recolonization of wildlife in reclaimed habitats is not meeting targets. b. Adapt mitigation to minimize sensory disturbance, as appropriate and possible, based on monitoring outcomes. c. Adapt mitigation if wildlife are not using wildlife crossings (*i.e.*, underpasses and overpasses) and undisturbed vegetated buffers as predicted. d. Adapt mitigation if Project-related wildlife mortality incidents are not meeting targets.

3.1 Spatial and Temporal Extent of Monitoring

Monitoring will occur slightly differently based on the different stages of the Project, relative to the activities that are occurring, and the lands that are disturbed:

- Construction - Monitoring will be focused on construction activities. There is no reclamation to monitor at that stage. Monitoring will focus on areas that are under active construction, and adjacent undisturbed areas that are determined to be appropriate as comparison monitoring plots, or for long-term trend analysis.
- Operations – Early in operations, progressive reclamation has not yet started and monitoring will proceed similarly to the construction stage. As progressive reclamation commences, reclamation monitoring will be added into the Plan. Monitoring will include active mine areas, reclaimed landscapes within the Project footprint, and adjacent undisturbed areas determined to be part of the comparison monitoring plots.

- Reclamation and Closure – Once mining has ceased and all lands have been reclaimed, monitoring of reclaimed landscapes will be the focus of the Plan. Monitoring will include all reclaimed landscapes within the Project footprint and adjacent undisturbed areas determined to be part of the comparison monitoring plots.

4.0 PLAN DEVELOPMENT AND CONSULTATION

4.1 Past Engagement

Benga received considerable input on existing land values and expectations for reclaimed lands through extensive past and ongoing public engagement and Indigenous consultation. Information gained during the environmental assessment process, subsequent consultations, and Traditional Ecological Knowledge (TEK) reports were used to identify issues relating to development and reclamation of the Project. Through the examination of the existing mining operations region, input from public engagement and Indigenous consultation and consideration of the Terms of Reference (AER, 2015), an issue screening process was completed. Examples of identified issues include:

- native plant species are important;
- commercial forest productivity needs to be re-established;
- forest communities need to be established such that all of their functions are returned;
- water quality and quantity is very important;
- fisheries habitat is important to protect and to re-establish;
- landform types and integration with adjacent undeveloped areas;
- reclamation performance in terms of ecological development and sustainability;
- end land uses – balancing the wants and needs of the various stakeholders (*e.g.*, golf course);
- wildlife habitat, health and population levels need to be protected and re-established;
- consideration should be given to creation of habitat suitable for bison to support possible re-establishment of a plains bison population in the area; and
- wildlife density on reclaimed lands needs to be planned and managed so as not to become higher than the natural carrying capacity.

Consultation commenced early in the regulatory process and will continue as the environmental assessment process advances. Consultation with Indigenous groups on the C&R Plan will be ongoing throughout the environmental assessment process and the construction, operations, and reclamation phases should the Project be approved.

4.2 Traditional Ecological Knowledge and Land Use

TEK and Traditional Land Use (TLU) reports were completed as part of the Project by Indigenous groups identified as potentially affected by the Project and are provided in Appendix 4.1-1: Updated Assessment on the Potential Effects of the Grassy Mountain Project on Indigenous Peoples (JRP IR-4.1).

Elders and technicians provided input on the key issues, themes, observations, wisdom, insights, traditional knowledge and land use through a series of site visits, workshops, meetings, and other communication events. Some of the recommendations and ideas expressed to date by Indigenous groups that were relevant to conservation and reclamation planning included:

- protect and harvest lodgepole pines and other plants of interest on a regular and ongoing basis;
- make efforts to relocate trees from areas of development for use on the reserves;
- protect and monitor water;
- impose no-go buffers around sacred sites of 100 m;
- maintain habitat for wildlife, including eagles' nests;
- ensure that effective reclamation involves reforestation of evergreen species to outcompete weeds;
- ensure efforts for research focus specifically in areas that have not been disturbed;
- provide adequate funding for ongoing project involvement and costs associated with Indigenous traditional environmental monitoring and harvesting vegetation throughout the Project;
- annual project review with Benga for the life of the Project;
- have an emergency preparedness plan in the event of leaks, spills or other disasters to address concerns regarding water quality and species dependent on clean water resources;
- consider including habitat suitable for the possible reintegration of bison into the area in the future;
- ensure new areas of development encompass previously disturbed areas; and
- consider socio-economic effects of the proposed Project.

Various TLU objectives were also identified in the reports. Some of the TLU principles that Benga will incorporate into the C&R and Closure Plans include:

- where possible, impact to significant vegetative communities will be managed or mitigated;
- on Benga private land, lodgepole pine and other significant plants will be made available to Indigenous groups for harvesting prior to clearing activities;

- wildlife habitat for traditionally important wildlife species will be re-established in areas of disturbance;
- reclamation, revegetation and reforestation efforts will be implemented to ensure weed species are outcompeted;
- water management plans will be implemented to manage surface and groundwater across the Project so that potential impacts to downstream users is mitigated;
- weed control efforts will be implemented throughout the life of the mine and during reclamation;
- where feasible, encourage biodiversity in the reclaimed landscape and re-establishment of native vegetation through direct placement of salvaged soil;
- local seed sources will be utilized for reforestation of native species and for the reestablishment of traditionally important plant species;
- wetlands, water bodies and grassy areas around waterbodies will be established; and
- previous disturbances across the Project area will be incorporated into the C&R plan for the mine resulting in improved biodiversity.

Benga is respectful of the spiritual aspects of TEK and TLU. Local stakeholders have identified the importance of harvesting lodgepole pine as well as other significant plants. Benga will engage with Indigenous groups prior to and during mine construction to offer opportunities for these species to be harvested, re-located or otherwise utilized.

4.3 Future Engagement

Indigenous consultation will be ongoing through the life of the mine. Input from Indigenous consultation was considered for species selection for revegetation plans and for terrain and vegetation planning to support vegetation and wildlife of importance to Indigenous groups. Since consultation will be ongoing, any additional species that may be identified will be considered.

Benga has committed to developing an Indigenous monitoring program in cooperation with nearby Indigenous communities to work in parallel with other western science-based monitoring plans. In addition, Benga will consult with Indigenous groups in developing the monitoring programs through a series of workshops. Benga has committed to providing Annual Reporting documents to Indigenous groups highlighting the results from the monitoring programs and seeking any input that would help Benga improve monitoring and the effectiveness of mitigation measures.

5.0 MITIGATION PROGRAM

The Project has the potential to affect wildlife through a number of effects mechanisms such as direct and indirect habitat loss, habitat fragmentation/connectivity, and changes in movement patterns, and

increased mortality risk. The proposed mitigation measures described in this section were designed to reduce or minimize the effects of the Project on wildlife and to monitor the effects of the Project to allow for effective adaptive management of mitigation measures over time to ensure that the Project-related effects on wildlife are avoided or minimized (Goal #1, Table 3.0-1). Benga has already committed to these mitigation measures and expects that they would become part of the anticipated *EPEA* approval for the Project. Table 5.0-1 summarizes the objectives and planned mitigation of the mitigation program, which are further described in Section 5.1. General wildlife mitigations apply to all VCs with additional species-specific mitigation as noted (Table 5.0-1).

Table 5.0-1 Wildlife Mitigation Program

Potential Project Effects	Mitigation Objectives	Valued Component	Mitigation
Change in habitat availability	Reduce direct habitat loss	General	Effects on wildlife habitat will mitigated with the following measures: • Implementing an effective conservation and reclamation plan that aims to establish suitable wildlife habitat. • Avoiding habitat destruction and alteration outside of the defined Project footprint to the extent possible. • Pre-disturbance surveys will be conducted along the edges of all areas to be cleared during Project development to determine the occurrence of any important wildlife habitat features. • In areas of suitable wildlife habitat (on the edge of the Project footprint boundary) appropriate setback distances (or buffer zones) will be considered. • Clearing and equipment use/storage/cleaning in undisturbed areas within and adjacent to the Project footprint will be avoided. • Where appropriate, vegetated buffer zones (100 m or minimum of 30 m; pending topographic constraints) will be maintained between Project infrastructure and wetlands, creeks, and streams to the extent possible. • Retain slash and large woody debris in salvaged soil to provide microsites for perches for migratory birds. • Ensuring reclaimed areas promote the re-establishment of woody species and are on a trajectory for reforestation. • Minimizing loss of mature and old-growth forest habitat and avoid complex, multi-story mixedwood forest where possible.
		Columbia spotted frog/	In addition to mitigations for wildlife in general (above), mitigations for effects on Columbia spotted frog and Western toad include: • Conducting monitoring to identify other habitable ponds and to identify habitat requirements and constraints.

Table 5.0-1 Wildlife Mitigation Program

Potential Project Effects	Mitigation Objectives	Valued Component	Mitigation
		Western toad	• Constructing trial breeding ponds. • Reclaiming upland habitat adjacent to reconstructed breeding ponds.
Change in habitat availability (*cont'd*)	Reduce direct habitat loss (*cont'd*)	Olive-sided flycatcher	For olive-sided flycatcher, additional (from those listed above for wildlife in general) relevant mitigations include: • Should Environment and Climate Change Canada (ECCC) have other requirements (*e.g.*, beneficial management practices), Benga will work with ECCC to ensure those mitigation measures are also implemented.
		Great gray owl	For great gray owl and other raptors, additional relevant mitigations include: • Retaining residual patches of essential habitat and habitat features within and adjacent to the mine footprint (*i.e.*, mature poplar trees, tall conifer trees) to provide perches, nest sites, and cover for security. • Minimizing loss of mature and old-growth forest habitat and avoid complex, multi-story mixedwood forest where possible. • Maintaining a 100 m buffer of undisturbed forest around Blairmore Creek, Gold Creek and other riparian corridors. • Planning vegetation clearing outside of the great gray owl nesting period (March 1 to April 30) characteristic of the region.
		Little brown myotis	Additional mitigation measures specific to little brown myotis and other bat species include: • Avoiding direct and indirect impacts to known, primary maternity roosts should any such roosts be located/identified. • Consulting with ECCC and AEP should hibernacula, fall swarming sites, or maternity roosts be observed during operations. • Implementing a reclamation plan to promote the re-establishment of woody species and wetland vegetation. • Preserving remnant forest patches within the development areas where feasible to provide habitat, habitat connectivity and roost sites for bat species. • Construction and placement of bat houses to provide additional roosting sites for bats.

Table 5.0-1 Wildlife Mitigation Program

Potential Project Effects	Mitigation Objectives	Valued Component	Mitigation
		Grizzly bear	Additional mitigations that are specifically targeted to grizzly bears and grizzly bear habitat will also support other carnivores and migratory birds, and include: • Maintaining a 100 m undisturbed forested buffer around Blairmore Creek and other riparian corridors. • Leaving patches of residual forest within and adjacent to the mine footprint to the extent possible. • Initiating reclamation early on in mine operations by seeding reclaimable areas with plant species favourable to grizzly bear forage, and by planting shrub and tree species that provide suitable security cover (*e.g.,* willow, alder, coniferous trees).
		Migratory birds	• Implementing an effective conservation and reclamation plan that promotes the development of habitats required for migratory birds. • Should Environment Canada have other requirements (*e.g.,* in beneficial management practices or species recovery strategies), Benga will work with Environment Canada to ensure those mitigation measures are also implemented
Change in habitat availability	Reduce indirect habitat loss (*i.e.,* sensory disturbance)	General	Sensory disturbances that may reduce habitat quality and effective habitat quantity will be mitigated by: • Retaining vegetation adjacent to high-activity linear corridors (*e.g.,* access roads, coal conveyor) to reduce noise and visual sensory disturbances to the extent possible. • Development of a visual impact mitigation plan that reduces stray and non-essential artificial lighting to minimize wildlife effects and that will comply with OH&S safety requirements. • Installing and maintaining a 15 m high berm to mitigate the potential effects of sensory disturbances (acoustic and visual) on effective habitat availability along the eastern edge of the south disposal area. • Mitigating Project-related noise (see Noise CR #2a).
Change in movement	Reduce changes in movement	General	Measures to mitigate effects on wildlife movement include: • Incorporating a minimum of six wildlife crossings (underpasses and overpasses) into the design of the 5.4 km long coal conveyor.

Table 5.0-1 Wildlife Mitigation Program

Potential Project Effects	Mitigation Objectives	Valued Component	Mitigation

			• Maintaining vegetated buffer zones (100 m or minimum of 30 m; depending on topographic constraints) between Project infrastructure and wetlands, creeks, and streams to the extent possible.
			• Ensuring that surface water management ponds and ditches located in undisturbed areas of the Project footprint will be designed to allow wildlife to move around or cross safely.
			• Road plowing and grading will be conducted in a manner that does not restrict wildlife from crossing access roads or accessing wildlife crossings.
			• Implementing an effective conservation and reclamation plan that aims to establish suitable wildlife habitat, including:
			  • Minimizing the overall disturbance footprint through the mine planning process.
			  • Preserving remnant forest patches in the development areas to provide essential habitat, habitat connectivity, and hide cover for wildlife species.
			  • Retaining slash and large woody debris in the replaced soil landscape.
			  • Planting native shrubs early in the reclamation process to initiate hiding cover.
			  • Establishing mixed wood forest stands and high density coniferous tree stands.
			  • Providing understory complexity in the reclaimed forests by planting native shrubs such as alder and willow to provide security cover for the carnivores and their prey.
			  • Maximizing the amount of ungulate habitat.
			  • Disrupting linear disturbances and sight lines by mounding surface soils and piling brush prior to final reclamation.
			• Limiting sight lines by maintaining mature forest stands or by planting high density coniferous stands to act as buffers between roads, project disturbance boundaries and the reclaimed mine areas.

		Little brown myotis	Effects on habitat connectivity and movement will be mitigated by: • Implementing a reclamation plan to promote the re-establishment of woody species and wetland vegetation.

Table 5.0-1 Wildlife Mitigation Program

Potential Project Effects	Mitigation Objectives	Valued Component	Mitigation
			• Preserving remnant forest patches within the development areas where feasible to provide habitat connectivity for bat species.
Change in mortality risk	Reduce changes in mortality risk (*i.e.*, clearing/removal of natural habitat, vehicle-wildlife collisions, increased access to the area, contamination of water)	General	Mitigations for effects on wildlife mortality risk include: • Timing vegetation site clearing activities are to occur outside the April 15 to August 31 restricted activity period to avoid disrupting nesting migratory and resident songbirds • Conducting pre-disturbance nesting surveys in the event that vegetation clearing must occur within the restricted activity period for birds. The surveys will be conducted by experienced avian biologists according to established sensitive species inventory guidelines (Government of Alberta 2013b). • Ensuring that surface water management ponds and ditches located in undisturbed areas of the Project footprint will be designed to allow wildlife to move around or cross safely. • Retaining slash and large woody debris in the salvaged soil to provide cover for security. • Controlling all access to the Mine Permit Area; no uncontrolled access will be permitted. Common operational practices will include: prohibiting use of snowmobiles and ATVs; prohibiting hunting, harassment, or feeding of wildlife; and implementing a strictly enforced zero tolerance policy on the use of firearms. • Designing water management ponds and drainage ditches, and pit lakes to minimize potential entrapment of wildlife. • Mitigating bird collisions with buildings by placing visual markers on windows, and collisions with the proposed power line will be mitigated by installing large 'floats' or other markers. • Enforcing speed limits (≤50 km/h) along the main access road and utility corridors, and placing signs at identified wildlife crossings to increase driver diligence to minimize wildlife-vehicle collisions. Vehicles will yield to all wildlife crossing the main access road.

Table 5.0-1 Wildlife Mitigation Program

Potential Project Effects	Mitigation Objectives	Valued Component	Mitigation
			• Developing and implementing a detailed Waste Management Plan prior to construction and operational activities to minimize the attraction of wildlife. Benga will follow the Best Management Practices for camps, fences, and barriers as described in Bear Smart: Best Management Practices for Camps (ASRD 2011), and ensure all waste is stored in wildlife-proof containers and disposed of properly. • Implementing an Emergency Spill Response Plan to limit the effects of accidental spills. Spills will be minimized by restricting fuel storage and filling to designated areas that are at least 100 m from wetlands and watercourses as well as Project drainage ditches, sediment control ponds, and pit lakes. • Storing all hazardous materials, including those used for blasting, in secure areas that are inaccessible to wildlife. In addition, proper handling and storage of industrial materials and debris within the Project footprint will be maintained to minimize potential risks to wildlife. • Developing procedures to clear blasting areas of large mammals or birds prior to blasting. • Developing a strategy to minimize changes in water quality upstream of the mine in conjunction with a water-quality monitoring program.
		Little brown myotis	Effects on mortality will be mitigated by: • Timing clearing outside of the summer breeding/rearing window (falls within the restricted activity period for migratory birds and resident birds and raptors). • Avoiding direct and indirect impacts to known, primary maternity roosts should any such roosts be located/identified.
		Grizzly bear	To mitigate effects on grizzly bear mortality (in addition to mitigations for wildlife in general): • Benga commits to supporting active bear management plans associated with the Project. If a site specific plan is required, it will be developed in consultation with AEP personnel as part of this Wildlife Mitigation and Monitoring Plan.

5.1 Wildlife Mitigation Measures

Benga will be implementing a number of best management practices, Project design features, and other wildlife mitigation measures to avoid or minimize effects on wildlife. These best management practices, design features, and mitigation measures are presented below in relation to each of the expected Project-wildlife interactions that were assessed.

5.1.1 Species at Risk

To prevent or minimize Project effects on federally-listed (SARA) species at risk, Benga will work in consultation with ECCC to develop species-specific mitigation and monitoring plans for species at risk known to occur in the WLSA. These species include olive-sided flycatcher, common nighthawk, short-eared owl, little brown myotis, American badger and Baird's sparrow. Critical habitat has not yet been identified for these species by ECCC; however, should this happen, mitigation plans will be updated to include critical habitat. Over the duration of the Project, other species at risk may be found in the WLSA or added to the SARA list of protected species. If this occurs, Benga will contact Environment Canada to determine mitigation requirements for these additional species.

At the time of the updated submission, federal recovery strategies exist for three species at risk in the WLSA – olive-sided flycatcher (Environment Canada, 2016a), common nighthawk (Environment Canada, 2016b), and little brown myotis (ECCC 2018). The short-term and long-term objectives outlined in these recovery strategies, and any future federal action plans that may be developed from these proposed recovery strategies, will form the basis for Project mitigation and monitoring plans for these three species. Additionally, a proposed federal management plan for short-eared owl was also released (Environment Canada, 2016c). Should recovery strategies, action plans, or management plans be developed by Environment Canada for any other species at risk found in the WLSA, the Project mitigation and monitoring plans will be updated accordingly.

5.1.2 Migratory Birds

Mitigation measures to prevent or minimize Project effects on migratory birds and their habitats are incorporated into Section 5.1.3 (habitat availability), Section 5.1.4 (habitat connectivity and movement), and Section 5.1.5 (mortality risk). Key measures include planning vegetation clearing outside of the breeding bird period (April 15 to August 31) characteristic of the region, conducting pre-disturbance nest searches, and implementing an effective conservation and reclamation plan (Appendix 2.6-1, JRP IR-2.6) that promotes the development of habitats required for migratory birds. Benga also acknowledges that ECCC encourages industry to develop Beneficial Management Practices guides to minimize potential Project-specific impacts on migratory birds and their habitat.

5.1.3 Habitat Availability

The majority of Project-related wildlife habitat loss will result from land clearing, surface mining, and construction of infrastructure and roads. In addition to direct physical loss of habitat, indirect habitat loss may arise from sensory disturbances (*e.g.*, artificial light and increased noise from equipment and blasting, and vehicles) that cause wildlife species to avoid the area and from dust accumulation on vegetation and in wetlands.

Many of the Project effects associated with wildlife habitat loss will be minimized through implementation of the Project's reclamation plan. The summary of the reclamation plan mitigation recommendations for wildlife and wildlife habitat reclamation include:

- Minimizing the overall disturbance footprint through the mine planning process to avoid critical breeding habitats, nesting and denning sites, and movement corridors to the extent possible;
- Preserving remnant forest patches within development areas where feasible to provide habitat, habitat connectivity and security cover for wildlife species;
- Protecting known essential raptor habitat features (*i.e.*, mature balsam poplar and aspen or conifers used for nesting) to the extent possible;
- Maximizing the direct placement of salvaged soil to enhance native plant development;
- Retaining slash and large woody debris in salvaged soil to provide microsites for native plant and to provide security cover for wildlife;
- Establishing a variety of vegetation species and communities suitable for wildlife, and encouraging structural complexity within reclaimed forests;
- Encouraging understory complexity in reclaimed forests by planting native shrubs such as alder and willow;
- Ensuring that core security areas are provided for wildlife;
- Providing a water management program that ensures surface water quality is maintained; and
- Limiting sight lines by maintaining mature forest stands as buffers between roads and reclamation areas.

To support the reclamation plan mitigation measures, the following will be implemented to mitigate potential direct and indirect Project effects on wildlife habitat availability:

- Incorporating existing legacy mining disturbances into the development and reclamation plans for the Project, and other proposed land use activities to the extent possible so that habitat loss, habitat fragmentation, linear disturbance features, and cumulative habitat loss are minimized.

- Conducting pre-disturbance surveys (wildlife sweeps) in the development area prior to any construction activities during Project development to identify the occurrence of any important wildlife habitat features such as migratory bird nests, mineral licks, active dens, bat habitat and hibernacula, active raptor nest sites, and essential raptor habitat features (*i.e.*, mature balsam poplar, platform/stick nests) that could indicate the presence of species at risk.
- Protecting all important wildlife habitat features in areas of suitable wildlife habitat (on the edge of the Project footprint boundary) with appropriate setback distances (or buffer zones) to the extent possible.
- Avoiding clearing and equipment use/storage/cleaning in undisturbed areas within and adjacent to the Project footprint.
- Retaining vegetation adjacent to high-activity linear corridors (*e.g.*, access roads, coal conveyor) to reduce noise and visual sensory disturbances to the extent possible.
- Designing the overland coal conveyor system in such a manner that will avoid or minimize the deposition of coal product along the route from the CHPP to the rail load-out area. This includes a cover for the length of the conveyor to reduce dust, and motor specifications to reduce industrial noise levels.
- Maintaining vegetated buffer zones (100 m or minimum of 30 m; depending on topographic constraints) between Project infrastructure and wetlands, creeks, and streams to the extent possible.
- Controlling all identified noxious and invasive weed species populations will be controlled prior to any site disturbance and mine operation to prevent the further spread of weeds as required by the *Weed Control Act* and Regulations. Noxious weed management will occur in compliance with R&R/03-4 *Weeds on Industrial Development Sites* (Alberta Environment, 2003b).
- As the presence of artificial lighting can potentially affect bird and bat use of nearby habitats, Benga has developed a visual impact mitigation plan that reduces stray and non-essential artificial lighting to minimize wildlife effects and that will comply with OH&S safety requirements (CR #1 – Air Quality, EIA, CEAR #42).
- To mitigate the potential effects of sensory disturbance (acoustic and visual) on effective habitat availability in the southeast portion of the Gold Creek valley, Benga will install and maintain a 15-m tall earth berm along the eastern edge of the south disposal area (CR #2 – Noise Impact Assessment, EIA, CEAR #42). The earth berm will be constructed/maintained during the day-time when required and will increase in elevation as the height of the disposal area increases.
- Mitigating sensory disturbance from the active mine site through the use of mufflers on all internal combustion engines, utilizing mine pit topography to shield noise generated from haul trucks, and conducting blasting during daylight hours (CR #2 – Noise Impact Assessment, EIA, CEAR #42).

5.1.4 Habitat Connectivity and Movement

Habitat loss and fragmentation reduces habitat connectivity and can affect daily and seasonal movements and dispersal of wildlife species. Wildlife may move into or through habitats that are physically disturbed but are unlikely to reside there, and they are also prone to sensory disturbances (acoustic or visual). The potential barriers to wildlife movement associated with the Project include:

- loss of vegetation and landscape alteration from construction of surface mine, infrastructure and roads;
- vehicular traffic activity associated with the mine access road and other mining activities;
- coal conveyor infrastructure; and
- the railway loop.

The reclamation plan outlines mitigation measures that will be implemented during progressive reclamation (*i.e.,* reclamation that will occur over the life of the mine operations and into closure) that will minimize the impact of the Project on wildlife movement.

The following general wildlife mitigation measures will be implemented to minimize potential disruption to daily and seasonal wildlife movements:

- Incorporating a minimum of six wildlife crossings (underpasses and overpasses) into the design of the 5.4 km long coal conveyor (Figure 5.1-1). To finalize wildlife crossing locations, the following will be considered:
  - Pre-disturbance surveys will be conducted to identify important wildlife habitats and trails along the access road and conveyor corridor.
  - Wildlife crossings will be strategically placed in locations to maximize wildlife use (*e.g.,* presence of well used trails, suitable habitats, and terrain features such as valleys and depressions that function as natural movement corridors).
  - Natural underpasses using topographic features are preferred.
  - Elevated wildlife crossings may be required when topographic conditions are not favourable.
- Designing surface water management ponds and ditches located in undisturbed areas of the Project footprint to allow wildlife to move around or cross safely.
- Undertaking road plowing and grading in a manner that does not restrict wildlife from crossing access roads or accessing wildlife crossings.
- Implementing measures to control dust and other air emissions (*e.g.,* watering of roads and use of dust suppressants, minimizing engine idling, *etc.*) within the Project footprint to minimize effects on adjacent wildlife habitats (CR #1 – Air Quality, EIA, CEAR #42).

Project-specific mitigations targeted to carnivore species have been incorporated into the reclamation planning. Many of these will also support habitat connectivity for migratory birds, raptors, and species at risk, and include:

- minimizing the overall disturbance footprint through the mine planning process;
- preserving remnant forest patches in the development areas to provide essential habitat features, habitat connectivity, and security cover for wildlife species;
- retaining slash and large woody debris in the reclaimed soil landscape;
- planting native shrubs early in the reclamation process to establish security cover;
- establishing mixedwood forest stands and high density coniferous tree stands;
- establishing understory diversity in the reclaimed forests by planting native shrubs such as alder and willow to provide security cover for the carnivores and their prey;
- maximizing the amount of ungulate habitat;
- disrupting linear disturbances and sight lines by mounding surface soils, piling brush prior to final reclamation; and
- limiting sight lines by maintaining mature forest stands or by planting high density coniferous stands to function as buffers between roads, Project disturbance boundaries and reclaimed mine areas.

Additional mitigations that are specifically targeted to grizzly bears and grizzly bear habitat and that will also support other carnivores and migratory birds include:

- maintaining a 100 m undisturbed forested buffer around Blairmore Creek and other riparian corridors;
- leaving patches of residual forest within and adjacent to the mine footprint; and
- initiating reclamation early on in mine operations by seeding reclaimable areas with plant species favourable to grizzly bear forage, and by planting shrub and tree species that provide suitable cover (*e.g.*, willow, alder, coniferous trees).

For migratory birds, additional relevant mitigations include:

- retaining slash and large woody debris in salvaged soil to provide microsites for native plant and security cover and perches for wildlife; and
- ensuring reclaimed areas promote the re-establishment of woody species and are on a trajectory for reforestation.

For raptors, additional relevant mitigations include:

- retaining residual patches of essential habitat and habitat features within and adjacent to the mine footprint (*i.e.,* mature poplar trees, tall conifer trees) to provide perches, nest sites, and security cover;
- minimizing loss of mature and old-growth forest habitat and complex, multi-story mixedwood forest where possible; and
- maintaining a 100 m buffer of undisturbed forest around Blairmore Creek, Gold Creek and other riparian corridors.

Targeted mitigation measures involving amphibians and amphibian habitat include:

- conducting monitoring to identify other habitable ponds and to identify habitat requirements and constraints;
- constructing trial breeding ponds;
- reclaiming upland habitat adjacent to reconstructed breeding ponds; and
- avoiding habitat destruction and alteration outside of the defined Project footprint to the extent possible.

Mitigation measures specific to bat species include:

- avoiding direct and indirect impacts to known, primary maternity roosts should any such roosts be located/identified;
- conducting roost and hibernaculum surveys prior to removal or alteration of historic mine shafts and infrastructure, and consulting with AEP should hibernacula or roosts be located; and
- planning tree clearing to avoid the May to August bat breeding season.

5.1.5 Mortality Risk

Wildlife mortality risk may increase as a result of increased traffic, wildlife encountering equipment, or elements of the Project footprint, and wildlife being attracted to Project facilities or humans. The Grassy Mountain area currently has a considerable network of trails and roads that are heavily used. Plans are already being implemented to reduce this level of access and with the approval of this Project, the levels will be reduced further. Mitigation measures that will be implemented to reduce wildlife mortality risk include:

- Controlling all access to the Mine Permit Area; no uncontrolled access will be permitted. Common operational practices will include:
  - prohibiting use of snowmobiles and ATVs;

  - prohibiting hunting, harassment, or feeding of wildlife; and
  - implementing a strictly enforced zero tolerance policy on the use of firearms.
- Timing vegetation site clearing activities to occur outside the April 15 to August 31 restricted activity period to avoid disrupting nesting migratory and resident songbirds.
- In the event that vegetation clearing must occur within the restricted activity period, pre-disturbance nesting surveys will be conducted by experienced avian biologists according to established sensitive species inventory guidelines (GoA, 2013b). Appropriate species-specific setback distances will be established around confirmed active nest sites in consultation with Environment Canada and AEP. If the status of a nest cannot be confirmed, or if a nest is found outside of the breeding season, a setback distance will be implemented until such time as nest status is confirmed (GoA, 2013b).
- Confirming the presence/absence of bats in high quality habitats located within the Project footprint prior to initiation of any clearing activities and developing a mitigation plan if bats are found.
- Conducting pre-disturbance denning (bears, marten, *etc.*) and roosting (bats) surveys prior to vegetation clearing and other high-disturbance activities. AEP will be consulted as needed to develop appropriate mitigation and management strategies.
- Conducting pre-disturbance surveys (acoustic surveys and visual searches) to identify wetlands and watercourses used by breeding Columbia spotted frogs and western toads that feed into the protection plans.
- Benga commits to supporting active bear management plans associated with the Project. The plan is expected to be a comprehensive document that outlines operational strategies and best practices for addressing concerns related to not only bear-human conflicts but potential risks to ungulates and other wildlife resulting from attraction of bears to the area.
- Developing a Beneficial Management Plan guide to minimize potential Project-specific impacts on migratory birds and their habitat by identifying more site-specific mitigation and monitoring measures following Project approval and in consultation with federal and provincial regulators.
- Developing and implementing a detailed Waste Management Plan prior to construction and operational activities to minimize the attraction of wildlife. Benga will follow the Best Management Practices for camps, fences, and barriers as described in Bear Smart: Best Management Practices for Camps (ASRD 2011), and ensure all waste is stored in wildlife-proof containers and disposed of properly. Some of the waste management and bear awareness/Bear Smart guidelines that will be implemented include:
  - ensuring food waste, refuse, and other attractants are securely contained in enclosed and approved bear-proof containers and/or facilities (*e.g.*, hard-sided buildings, fenced

compounds, and bear-proof transfer station) prior to transportation to a disposal facility to prevent access by scavenging bears;

- providing adequate signage to inform employees of the location and proper use of bear-proof storage containers/facilities;
- ensuring waste storage containers/facilities are not filled beyond capacity;
- ensuring regular inspection and maintenance of waste storage containers/facilities is carried out;
- ensuring measures contained in the bear management plan are diligently followed by all employees and contractors;
- ensuring that all on-site staff receive Bear Awareness Training; and
- installing bear warning signs to advise staff of locations where problem bears have been reported.

- Implementing an Emergency Spill Response Plan to limit the effects of accidental spills. Spills will be minimized by restricting fuel storage and filling to designated areas that are at least 100 m from wetlands and watercourses as well as Project drainage ditches, sediment control ponds, and pit lakes.
- Storing all hazardous materials, including those used for blasting, in secure areas that are inaccessible to wildlife (*e.g.*, buildings, storage areas surrounded by wildlife-proof fencing). In addition, proper handling and storage of industrial materials and debris within the Project footprint will be maintained to minimize potential risks to wildlife.
- Developing procedures to clear blasting areas of large mammals or birds prior to blasting.
- Designing water management ponds and drainage ditches, and pit lakes to minimize potential entrapment of wildlife.
- Developing a strategy to minimize changes in water quality upstream of the mine in conjunction with a water-quality monitoring program.
- Enforcing speed limits (≤50 km/hr) along the main access road and utility corridors and placing signs at identified wildlife crossings to increase driver diligence to minimize wildlife-vehicle collisions. Vehicles will yield to all wildlife crossing the main access road.
- Mitigating bird collisions with buildings by placing visual markers on windows while collisions with the proposed power line will be mitigated by installing large 'floats' or other markers.

5.2 Hierarchy of Strategies

The mitigation measures described above adhere to the mitigation hierarchy of avoid, minimize, restore, and offset in the following manner:

- Avoid - Considerable effort in the design of the Project was completed to ensure the pit, external rock disposal areas and infrastructure did not directly impact Blairmore Creek, Gold Creek, or the Crowsnest River. No direct disturbance will occur to any of these watercourses.
- Minimize – Where impacts could not be avoided, then mitigation strategies were developed to minimize effects on wildlife. Many of the planned mitigation measures fall into this category, examples of which include:
  - Maintaining a 100 m undisturbed forested buffer around Blairmore Creek and other riparian corridors;
  - Leaving patches of residual forest within and adjacent to the mine footprint;
  - Mitigating bird collisions with buildings by placing visual markers on windows while collisions with the proposed power line will be mitigated by installing large 'floats' or other markers;
  - Enforcing speed limits (≤50 km/h) along the main access road and utility corridors, and placing signs at identified wildlife crossings;
  - Developing and implementing a detailed Waste Management Plan; and
  - Incorporating a minimum of six wildlife crossings (underpasses and overpasses) into the design of the 5.4 km long coal conveyor.
- Restore – For those Project effects that could not be avoided or minimized, a plan for restoration was developed which forms the basis of the Conservation and Reclamation Plan (Appendix 2.6-1 to JRP IR-2.6). The goal of reclamation in Alberta is to achieve a land capability that is equivalent to what existed prior to disturbance.
- Offset – No offsets for wildlife are proposed for this Project. Offsetting for westslope cutthroat trout (WSCT) habitat is a significant mitigation measure proposed for this Project and is discussed separately in Appendix B-1: Detailed Fisheries Offsetting Plan (Addendum 8, CEAR #89).

5.3 Mitigation with Positive impacts

There are several mitigation measures planned for the Project that will have positive impacts on wildlife and wildlife habitat.

Reduced Road Density

The Grassy Mountain area currently has a considerable network of trails and roads that are heavily used and have likely affected wildlife use in the area. Plans are already being implemented to reduce this level of access and with the Project approval, the access levels will be reduced even more. Over the life of the Project, road densities in the WLSA are estimated to decline from Baseline conditions (0.88 km/km^2) to 0.69 km/km^2 at Year 14 and 0.61 km/km^2 at Year 27 (CR #9, EIA, CEAR #42).

Reclaiming Legacy Mining Footprint

Throughout the proposed Mine Permit Area and surrounding region, there is evidence of disturbance from historical underground and surface mining activities. These legacy mine disturbances were created in the early 1900's to the mid-1960's with little to no implementation of environmental mitigation or reclamation. The potential effects of these legacy activities have been substantial in the form of erosion and sedimentation and continue to this day. Recent short-term mitigation measures have been implemented by Benga that include surface water management and erosion and sediment control. Based on this historical disturbance, it is Benga's intention during mining operations and at closure, to include all legacy Grassy Mountain mining areas as part of the mitigation measures planned for the entire Project. The legacy mines occupy an area of 185 ha (12%) of the total Project disturbed footprint (1,520 ha). This will result in an overall net positive improvement in the current environmental conditions on Grassy Mountain and its associated watersheds.

Gold Creek Stewardship Program

Considerable degradation has occurred within and along Gold Creek because of legacy mining activities and other historical land uses that include ATV and four-wheel drive use in the creek and along riparian areas. In the absence of any substantive long-term remediation plan to address historical mining activities, which largely ended in the early 1960s, Benga plans to establish and be a catalyst for a Gold Creek Stewardship Program. The program will address some of the current issues that relate to the water quality and fisheries in Gold Creek. While the aquatic environment is the first priority of this program, the terrestrial components may also be captured. Benga will spearhead this program and foresees involvement from a wide range of stakeholders, environmental groups, Indigenous communities, academia, researchers and regulators.

WSCT Habitat Offsetting Program

Although the habitat offsets in the Detailed Fisheries Offsetting Plan (Appendix B-1, Addendum 8, CEAR #89) are directed at WSCT, the restoration of riparian habitat will have benefits for terrestrial components as well, such as amphibians, shorebirds, waterfowl, and other wetland-dependent wildlife.

6.0 MONITORING PROGRAM

A monitoring program was developed to monitor the effectiveness of mitigation designed to minimize changes in wildlife habitat availability, habitat connectivity and movement and mortality risk (Goal #2 from Table 3.0-1).

Monitoring will be conducted throughout the life of the Project to document wildlife responses to the Project and to Benga's mitigation program. Monitoring is required to assess and verify environmental performance (*i.e.*, that the mitigation program is being completed as planned and is achieving its objectives) and to ensure continual improvement in environmental performance. The focus of the monitoring program will be on obtaining key information that can inform and guide the mitigation process.

Benga will focus mitigation monitoring efforts on parameters that are directly related to mitigation effects that provide opportunities to improve mitigation performance over time. This wildlife monitoring approach will enable Benga to evaluate the effectiveness of their wildlife protection, mitigation, and reclamation procedures and to ensure that the Project does not adversely affect wildlife in the region. The wildlife mitigation monitoring program for the Project is summarized in Table 6.0-1. As with the mitigation program, the mitigation monitoring program is viewed as adaptive and is expected to change as understanding of the responses of wildlife to Project development increases.

A summary of the monitoring program is provided in Table 6.0-1 and is discussed in detail in Section 6.1.

Table 6.0-1 Wildlife Monitoring Program

Potential Project Effects	Mitigation Objectives	Mitigation Monitoring	Indicator	Metric and Target
Change in habitat availability	Reduce direct habitat loss	• Track reclaimed ecosite availability throughout mine life.	• All ecosites included for reclamation as outlined in the C&R Plan.	• Area cleared for the Project footprint (C&R Plan). • Area and ecosites reclaimed each year (C&R Plan). • Targets to be developed using baseline data on undisturbed sites, years since reclamation, in coordination with regulators, and consistent with regional plans and recovery strategies. • Increasing trajectory of key grizzly bear forage index at vegetation monitoring sites. • Wildlife habitat that has qualities and wildlife densities/capabilities similar to adjacent undisturbed areas of similar seral stage.
		• Monitor wildlife use: Continuing with and expanding the use of wildlife camera monitoring as a low-disturbance, passive monitoring approach to quantitatively measure changes in use of preferred habitat types in the vicinity of the Project footprint. • Monitoring breeding birds, raptors, waterbirds, bats, and amphibians using Alberta's sensitive species inventory guidelines (GoA 2013b) and recommendations from federal recovery strategies as reclamation progresses over the landscape. • Post -reclamation and post-closure wildlife monitoring linked with the reclamation monitoring program and any other related environmental monitoring programs.	Indicator species will include, but not be limited to: • olive-sided flycatcher • common nighthawk • short-eared owl • little brown myotis • western toad, • barn swallow; • grizzly bear, • moose • elk • marten, • lynx, and • wolverine	• Habitat occupancy and abundance of wildlife indicators. • Wildlife use of reclaimed areas. • Targets to be finalized using baseline data on undisturbed sites, years since reclamation, in coordination with regulators and consistent with regional plans and recovery strategies.

Table 6.0-1 Wildlife Monitoring Program

Potential Project Effects	Mitigation Objectives	Mitigation Monitoring	Indicator	Metric and Target
Change in habitat availability	Reduce indirect habitat loss (*i.e.,* sensory disturbance)	• Monitor wildlife use in habitat adjacent to the Project and in undisturbed vegetated buffers prior to and during construction and operations.	Indicator species will include, but not be limited to: • olive-sided flycatcher • common nighthawk • short-eared owl • little brown myotis • western toad, • barn swallow; • grizzly bear, • moose • elk • marten, • lynx, and • wolverine	• Wildlife species and relative abundance in monitoring plots • Targets to be developed using baseline data on undisturbed sites, years since reclamation, in coordination with regulators, and consistent with regional plans and recovery strategies.
Change in movement	Reduce changes in movement	• Implement a wildlife sighting program for Project personnel and contractors to document wildlife occurrences within the Project footprint during the construction and operations to document wildlife presence and movements within and adjacent to the Project footprint. • Monitoring wildlife use of Project-related linear features (*e.g.,* railway loop, transmission line, drainage ditches, and ponds) during the operations phase. • Monitoring wildlife crossings to determine the effectiveness to allow wildlife passage through the area. • Monitoring movement of wildlife across the reclaimed landscape	Indicator species will include, but not limited to: • Carnivores (*e.g.,* grizzly bears, black bears, cougar, lynx, wolverine, *etc.*) • Ungulates (*e.g.,* moose, elk, white-tailed deer, *etc.*) • Other mammals (*e.g.,* coyote, marten, *etc.*)	• Wildlife species composition and relative abundance at monitoring sites. • Wildlife crossing success each crossing structure. • Number of potential barriers • Species composition and crossing success rate targets to be developed using baseline data from undisturbed sites, years since reclamation, in coordination with regulators, and consistent with regional plans and recovery strategies. • Change in wildlife habitat use patterns.

Table 6.0-1 Wildlife Monitoring Program

Potential Project Effects	Mitigation Objectives	Mitigation Monitoring	Indicator	Metric and Target

Change in mortality risk	Reduce changes in mortality risk (*i.e.,* clearing/removal of natural habitat, vehicle-wildlife collisions, increased access to the area, contamination of water)	• Monitoring and documenting all human-wildlife interactions that occur within the Project footprint
		  • wildlife sighting program
		  • vehicle-animal collisions
		  • off-site human activity
		  • mortality of wildlife during clearing
		  • accidental spills of contaminants
		  • human-bear interactions
		• Compliance audits, including inspections of waste storage facilities and records, spills, training records.
			Indicator species will include, but not be limited to:
			• olive-sided flycatcher
			• common nighthawk
			• short-eared owl
			• little brown myotis
			• western toad,
			• barn swallow;
			• grizzly bear,
			• moose
			• elk
			• marten,
			• lynx, and
			• wolverine
				• Number of vehicle-wildlife collisions/year (target= 0)
				• Number of wildlife observed along roads
				• Number of traffic speed violations (target = 0)
				• Number of equipment-wildlife interactions (target = 0)
				• Number of bird mortalities from collisions (buildings or transmission lines) (target = 0)
				• Number of nuisance animals removed from site (target =0)
				• Number of human/wildlife interactions (target = 0)
				• Number of dens, nests or other sensitive habitat features affected (target = 0)
				• Percentage of site personnel given wildlife awareness training (target = 100%)

6.1 Discussion of Monitoring Program

The following subsections discuss the mitigation objectives and the proposed monitoring that will be used to document mitigation effectiveness.

6.1.1 Species and Habitats to be Monitored

Wildlife surveys were conducted in 16 habitat types comprised of 17 ecosite phases in the Montane Natural Subregion (2,716.1 ha or 48.1%), 10 ecosite phases in the Subalpine Natural Subregion (1,790.5 ha or 31.7%), and 17 anthropogenic disturbances and non-vegetated lands (1,027.3 ha or 18.2%) that characterized the WLSA at baseline (CR#9, EIA, CEAR #42). These baseline surveys, which were conducted between 2013 and 2016, included acoustic and visual amphibian surveys, breeding songbird surveys, nocturnal owl surveys, aerial raptor nest and essential raptor habitat surveys, short-eared owl surveys, bat surveys, wildlife camera trapping, a winter mammal tracking survey, and a pellet count survey. Incidental observations of wildlife were also recorded during the baseline wildlife surveys (CR#9, EIA, CEAR #42).

Based on the baseline wildlife surveys and a review of existing wildlife information, the WLSA provides suitable habitats for a diversity of wildlife species was recorded including six amphibians, 87 birds, and 28 mammals (CR#9, EIA, CEAR #42). Of the 121 wildlife species recorded in the WLSA, 29 were provincially and/or federally designated at risk wildlife species. In addition, many of the wildlife species that occur in the WLSA are important for traditional and cultural uses as well as for consumptive and non-consumptive uses. Key Project-related development issues that can directly and indirectly affect wildlife in the WLSA includes habitat loss, decreased habitat quality, habitat fragmentation and effects on wildlife movements, increased mortality risk.

Benga is committed to responsible resource development. The primary goals of the wildlife monitoring program are to assess and verify environmental performance (*i.e.,* that the mitigation program is being completed as planned and is achieving its objectives) and to ensure continual improvement in environmental performance. The focus of the monitoring program will be on obtaining key information that can inform and guide the mitigation process. This will include parameters that are directly related to mitigation effects that provide opportunities to improve mitigation performance over time. This wildlife monitoring approach will enable Benga to evaluate the effectiveness of their wildlife protection, mitigation, and reclamation procedures and to ensure that the Project does not adversely affect wildlife in the region. As with the mitigation program, the mitigation monitoring program is viewed as adaptive and is expected to change as understanding of the responses of wildlife to Project development increases over time based on EPEA approvals, regulatory feedback, Indigenous community concerns, and changing Recovery Strategies and *SARA*

listings. Wildlife species that will be included as part of the monitoring program will include (but will not be limited to):

- Schedule 1 species under the *SARA*: olive-sided flycatcher, common nighthawk, short-eared owl, and little brown myotis;
- COSEWIC-listed species known to occur in the WLSA: western toad, barn swallow;
- provincially listed or protected species;
- species of traditional use or value; and
- larger species such as grizzly bear, moose, and elk and elusive species of concern such as marten, lynx, and wolverine.

The wildlife monitoring program, which is described below, will be focused on the key wildlife issues that were associated with Project development in the WLSA.

6.1.2 Direct Habitat Loss

Since Project development will result in the direct loss of habitats for wildlife, various mitigation measures will be implemented to minimize these losses (Table 5.0-1). The primary method for mitigating direct Project effects on wildlife habitat availability is based on progressive reclamation of the Project footprint. In this regard, monitoring the effectiveness of various reclamation measures will be implemented (Table 6.0-1) which is discussed below.

6.1.2.1 Track Reclamation and Ecosite Development

The area (ha) cleared for construction of Project facilities/infrastructure will be estimated annually from surveyor data collected during new clearing of vegetation and soils. Project infrastructure undergoing active reclamation is intended to provide effective habitat for wildlife species over the long-term. The area (ha) reclaimed each year will also be estimated from surveyor data. Benga will initiate progressive reclamation on reclamation-ready sites in the Project area to minimize delays in reclaiming disturbed sites to effective habitat. An additional monitoring program will be established to monitor occurrence and use of target species throughout the Project area. For ecosite and vegetation reclamation monitoring, refer to Table F.3.9-1 in the updated C&R plan (Appendix 2.6-1 to JRP IR-2.6).

6.1.2.2 Track Wildlife Use of Reclaimed Areas

The objectives are to measure wildlife habitat use patterns, relative abundance, and movement in relation to the Project. The metrics that will be used to measure wildlife habitat use, relative abundance, and movement include the rate of habitat use (count/unit time/habitat type or distance category), detection frequency (count per unit time), and wildlife movement (count/unit time, success rate for wildlife using crossing structures) for indicator wildlife species/monitoring year at various

distances from the Project components. The targets for these wildlife responses will be to monitor annual changes in habitat use patterns, relative abundance and movements in relation to the Project area from baseline.

An important consideration in selecting monitoring procedures is the need to minimize observer influence and ensure that monitoring activities do not create added disturbance to sensitive wildlife species. Therefore, effective monitoring programs should involve the use of low-disturbance methods such as wildlife camera trapping to quantitatively measure changes in use of preferred habitats by wildlife species of management concern. These methods are favoured for monitoring moose and other medium to large mammals because they involve very low levels of human disturbance and do not facilitate predator access (*e.g.*, by wolves along packed snowshoe or snowmobile trails). Wildlife cameras are also an effective way of monitoring wildlife use of designed crossing structures along the conveyor.

To assess wildlife responses to Project effects, Benga proposes the use of a monitoring approach that involves deployment of remotely-operated wildlife cameras to quantitatively measure changes in use of available habitat types by wildlife as well as relative wildlife abundance throughout the Project area at various distances from the Project infrastructure. Remote wildlife cameras are an effective tool for monitoring large mammals, such as moose, elk, and bears, as well as furbearers, such as wolverine and Canada lynx. Wildlife cameras can also provide important information on off-site human activity. Benga will also implement incident reporting and wildlife sighting programs for staff and contractors as part of the mitigation monitoring data collection protocol.

Sampling will be conducted in the various habitat types that occur within the Project area, but will be primarily focused on riparian zones, mature/old-growth forest, subalpine habitats, shrubby habitats, and linear corridors at various distances from the Project footprint. Remote cameras will also be deployed at the conveyor crossings to assess wildlife use of crossing structures and underpasses. Wildlife sighting cards will also be utilized to provide additional data on spatial distribution of wildlife in the Project area, and the movement of wildlife across Project infrastructure, such as roads. The Project effects monitoring program will be based on establishing relevant monitoring intervals that will result in the collection of sufficient data to determine trends in wildlife habitat use and movements.

6.1.3 Indirect Habitat Loss

The Project will result in increased sensory disturbances which will lead to reduced habitat effectiveness for some wildlife species. Various mitigation measures to minimize sensory disturbances associated with Project development will be implemented (Table 5.0-1). Sensory disturbances associated with Project development can alter wildlife habitat use through increased off-site human presence, vegetation clearing, increased noise levels, and the presence of artificial lighting.

Benga's mitigation monitoring objectives are designed to provide quantifiable and meaningful data-oriented solutions to adaptive mitigation approaches to minimize sensory disturbance to wildlife in the Project area. These objectives are guided by the mitigation program directives to minimize disturbance, and which also aims to minimize off-site human activity. In this regard, monitoring the effectiveness of minimizing indirect habitat losses in the WLSA will be implemented (Table 6.0-1).

Wildlife use of undisturbed habitats and habitats adjacent to and within the Project footprint will be compared to determine the effects of sensory disturbance on the distribution and relative abundance of wildlife in the WLSA. Benga will record dates when vegetation clearing and site preparation were undertaken, areas of all clearing conducted, and when pre-disturbance surveys were completed to determine the presence of nesting migratory birds, species at risk, and other wildlife. These data will be summarized annually to determine any conflicts with Environment Canada and Government of Alberta restricted activity periods. Benga will investigate noise complaints in the Project footprint to ensure compliance with AER *Directive 38* (AER 2007). Benga will audit existing artificial lighting and develop a target, if appropriate, to reduce the number of uncontrolled artificial lights for inclusion in annual wildlife reporting. Benga will also monitor off-site human activity by collecting data from remote wildlife cameras distributed in the Project area. This information will include the date, time, location, and type of activity to identify the frequency and spatial distribution of human use in the Project area and will be used to determine success and/or need for any additional mitigation measures.

6.1.4 Wildlife Movement

Since the Project will result in reduced habitat permeability for some wildlife species, various mitigation measures will be implemented to facilitate wildlife movement around and through the Project footprint to the extent possible (Table 5.0-1). Changes in wildlife movement resulting from Project construction and operations will result in increased anthropogenic activities and linear feature creation. The primary mitigation measures to reduce the size of the Project footprint for wildlife are related to progressive reclamation (discussed above) and provision of crossing opportunities along the coal conveyor and access road. Benga's mitigation monitoring objectives are designed to provide quantifiable and meaningful data-oriented solutions to adaptive mitigation approaches to facilitate wildlife movement within the Project area (Table 6.0-1).

6.1.4.1 Implement a Wildlife Sighting Program

Implement a wildlife sighting program for Project personnel and contractors to document wildlife occurrences within the Project footprint during the construction and operations phased. This information can be used for monitoring wildlife use and locations of access road crossings to assist in placement of wildlife crossing signage, improve employee/contractor wildlife awareness, and to assist with monitoring the effectiveness of mitigation measures (*i.e.,* avoiding wildlife-vehicle collisions).

6.1.4.2 Monitoring Wildlife Use of Project-related Linear Features

Wildlife occurrences within the Project footprint related to linear features, such as roads, rail and transmission lines will be monitored. Methods for this may include wildlife camera trapping, winter tracking programs, and results of the wildlife sighting program.

6.1.4.3 Monitoring Wildlife Crossings

Use of wildlife crossing structures will be monitored to determine the effectiveness of allowing wildlife to cross over or under the coal conveyor. Benga will document the specifications of the coal conveyor and all wildlife underpasses and overpasses following installation. Wildlife cameras will be installed at each of the wildlife crossing structures to monitor wildlife crossing success or deflections. Benga will document the number, extent, location, and effects of potential barriers to wildlife movement within identified movement corridors, particularly those associated with riparian areas.

6.1.4.4 Monitoring Wildlife Movements Across the Reclaimed Landscape

Monitoring movements of wildlife in the reclaimed landscape will be conducted with the use of wildlife camera trapping and winter tracking programs (see Subsection 6.1.2.2).

6.1.5 Mortality Risk

Since the Project may result in increased mortality risk for some wildlife species, various mitigation measures will be implemented to minimize mortality risk associated with Project development (Table 5.0-1). Changes in wildlife mortality risk can result from increased human access, direct loss of habitat (*i.e.,* vegetation clearing), attraction of predators, and changes in environmental quality resulting from Project construction and operation. Benga's mitigation monitoring objectives are designed to provide quantifiable and meaningful data-oriented solutions to adaptive mitigation within the Project area in order to minimize wildlife mortality. These objectives are guided by the mitigation program, which strives to minimize collisions, minimize exposure of wildlife to predators and poachers, minimize mortality of wildlife during clearing operations, minimize contaminant spills, and minimize human-bear interactions. The monitoring planned to evaluated mitigation effectiveness for changes in wildlife mortality is summarized in Table 6.0-1 and discussed below.

6.1.5.1 Monitoring/Documenting Human-wildlife Interactions

6.1.5.1.1 Wildlife Sighting Program

A wildlife sighting program for Project personnel and contractors to document wildlife occurrences within the Project footprint during the construction and operations phases will be implemented. This information can be used for monitoring wildlife use and crossings of access roads, and to identify major wildlife crossing areas, which can assist in placement of wildlife crossing signage, improving employee/contractor wildlife awareness, and avoiding wildlife-vehicle collisions.

6.1.5.1.2 Monitoring Vehicle-animal Collisions

Benga will record all wildlife collision incidents involving employees and contractors on site continuously. In the event that a collision occurs, the date, time, circumstances, location, and vehicle speed will be recorded and used to identify factors that may have contributed to the collision.

6.1.5.1.3 Monitoring Exposure of Wildlife to Predators and Poachers

Using wildlife cameras, Benga will monitor off-site human activity in the Project area, including such parameters as the date, time, location, and type of human activity, so that the frequency and spatial distribution of human use in the Project area can be determined and potential mitigation measures are identified

6.1.5.1.4 Monitoring Wildlife During Vegetation Clearing

Benga will record all nests/dens known to be directly affected by clearing and construction activities. Should such an incident occur, Benga will record the incident using such factors as the date, time, location, and circumstances to identify contributing factors. In consultation with AEP, Benga will address any additional mitigation measures that may be required.

6.1.5.1.5 Monitoring Potential Contaminant Spills

Benga will record any wildlife interactions with contaminant spills. Benga will record the date, time, location, circumstances of the spill, and wildlife-contaminant interactions to identify potential contributing factors and, in consultation with AEP, improve mitigations as required.

6.1.5.1.6 Minimize Human-Bear Interactions

Benga will record all human-bear interactions reported by employees and contractors in the Project area. Benga will record the date, time, location, and circumstances of the interaction to identify potential contributing factors and improve mitigations as required.

6.1.5.2 Compliance Audits

Internal compliance audits will be conducted, including inspections of waste storage facilities and records, spills, training records. Effectiveness of waste management programs, bear awareness training program and delivery of such programs, materials storage and handling procedures and facilities will also be assessed.

7.0 ADAPTIVE MANAGEMENT PROGRAM

Adaptive management is a planned and systematic process for continuously improving environmental management practices by learning about their outcomes. Adaptive management provides flexibility to identify and implement new mitigation measures or to modify existing ones during the life of a project. As with the mitigation program, the mitigation monitoring program is

viewed as adaptive and is expected to change as understanding of wildlife responses to Project development and operations increases. Benga's adaptive management program is organized into four main components, which are reevaluated and reassessed in a feedback loop (Figure 7.0-1).



Figure 7.0-1 Benga's Adaptive Management Process

Benga's adaptive management approach will involve establishing end land use objectives according to pre-development land use capability, site-specific conditions, improved practices based on research and monitoring results, and input from the public engagement and Indigenous consultation programs. As reclamation proceeds, monitoring of reclamation and revegetation performance in conjunction with the wildlife mitigation and monitoring programs will allow land use objectives to be reviewed and, if necessary, modifications can be made to site expectations according to natural revegetation processes and wildlife and wildlife habitat goals.

Adaptive management is intended to respond to changes and advances in technology to meet specific objectives. Benga will incorporate adaptive management techniques as routine components in all of its environmental management activities. These techniques provide the opportunity to develop and fine-tune the monitoring program using data collected on-site and from other regional operators.

Benga will use the experience gained during the development of the Project, and other successes by the regional coal operators over the next 24 years, to manage and implement an effective monitoring

program. Benga will work with other operators of coalmines, AEP, AER and local stakeholders, to further develop criteria and monitoring programs that clearly demonstrate progress toward reclaiming environmentally sound sustainable ecosystems that can support native wildlife populations occur in the region.

With respect to Adaptive Management, Benga is committed to achieving continual improvement in environmental performance. The development and implementation of all monitoring and mitigation identified for the Project and housed in the monitoring and follow-up programs will be tracked in relevant management plans. As site conditions and monitoring dictate, or as new technology emerges, Benga will adaptively manage site practices and monitoring programs to meet the defined objectives. For some programs this would involve regular evaluation of predictive models; which would be clearly defined in each applicable management plan.

If a monitoring and follow-up program identifies that adverse environmental effects are greater than predicted, then Benga will evaluate whether they result in changes to the conclusions presented in the effects assessment. If changes are confirmed, then Benga will evaluate the need for revised mitigation actions and management practices to manage effects. Where the need for revised mitigations is identified, they will be developed and implemented.

7.1 Assess the Problem

Benga recognizes that there is a large degree of natural variation and complexity inherent within ecosystems and that predicting the effects of Project development (construction and operations) on wildlife and wildlife habitat use can result in uncertainties regarding the effectiveness of proposed mitigation measures. An important first step in Benga's Adaptive Management Process is assessing the problem. From a wildlife perspective, this step reflects the uncertainty that may be associated with the effectiveness of specific mitigation measures, the likelihood that the uncertainty associated with specific mitigation measures can be reduced, and/or the potential to adjust or modify best practices.

As identified in the wildlife assessment, the Project may affect wildlife populations (relative abundance) by altering wildlife habitat availability (direct habitat loss) and use (indirect habitat loss), habitat fragmentation and connectivity (movements), and abundance (CR #9, EIA, CEAR #42). The wildlife mitigation and monitoring program for the Project, which is structured around these key issues, will serve to improve Benga's understanding of the effects of Project construction and operations on wildlife within the Project footprint and surrounding area and to verify impact predictions.

Many of the mitigation measures identified to address Project-related direct habitat losses are related to progressive reclamation and reclamation following mine closure. Uncertainty associated with reclamation success is discussed in the updated C&R Plan Section F.5.3 (Appendix 2.6-1 in response to JRP IR-2.6), where it outlines strategies that will be used to manage this risk. Benga believes that

reclamation success can be monitored effectively and if required, adjusted to meet wildlife habitat objectives so that the likelihood of reducing uncertainty is high.

In the case of indirect habitat loss associated with sensory disturbances (*e.g.*, noise, light), mitigation measures are generally limited to Project design features, and to available technologies and current best practices for reducing noise on operating equipment and limiting stray light within the Project footprint and in adjacent habitats. However, ongoing wildlife monitoring should reduce uncertainty as more information regarding wildlife responses to the Project is collected and any future mitigation measures or best practices are implemented to address potential limitations associated with indirect habitat losses.

Development of the Project footprint will affect wildlife movements in the area during construction and operations and therefore, mitigation to reduce the effects of changes in wildlife connectivity are generally limited. However, progressive reclamation and incorporating wildlife crossing structures along the coal conveyor should address some of the uncertainty regarding potential effects on wildlife movements through the area. For example, wildlife cameras can be used to determine crossing success rates at each crossing structure which can be used to identify the need for and type of any other mitigation measures that may be required.

Many of the mitigation measures proposed for the Project, particularly those related to reducing mortality risk to wildlife, can be effectively implemented with little uncertainty since most are accepted industry best practices. Benga is confident that such best practices will minimize collisions, minimize poaching, minimize mortality of wildlife during clearing operations, minimize contaminant spills, and minimize human-bear interactions. These mitigation measures can be easily modified as required.

7.2 Adaptive Management Process Design

Once the problem has been identified and assessed, the design of the adaptive management program can commence, beginning with determining the best approach to adaptive management. The following are design considerations for the adaptive management program:

- data analysis methods and frequency;
- predicted trajectories for indicators; and
- triggers for action and potential adaptations.

Benga is confident in the mitigation measures selected but acknowledges that a formal process is warranted to optimize the measures, as opportunities to refine aspects of the management strategies become available. This formal process includes the following points:

- Indicators of mitigation effectiveness.
- Predicted trajectories through time for the indicators of mitigation effectiveness.

- A monitoring program designed to allow observed trends to be compared to predicted trajectories.
- Triggers for action, should predicted trajectories and observed trends not align, and a plan of action if and when triggers are pulled.

To design the adaptive management process, Benga will develop a desired trajectory or performance objectives through time for each wildlife metric (*e.g.*, species composition and abundance), so that trends observed through monitoring can be evaluated against desired objectives. The desired performance objectives can be used to define a trigger to indicate when observed wildlife metrics vary substantially from the objectives. These triggers and thresholds will be developed in conjunction with regulators, Indigenous community consultation, and EPEA approval conditions. They may change over time, as they are also informed by documents that continue to evolve, such as species recovery strategies, or regional frameworks and targets. They are also informed by the monitoring data collected on reference sites, and species general presence in the region. As such, triggers will be determined with stakeholders and regulators upon receipt of regulatory approvals when the final wildlife monitoring plan is required under the EPEA approval.

Some triggers and thresholds are appropriate to set at this time. These include triggers associated mainly with Project infrastructure-human interactions, such as vehicle collisions or bird collisions with buildings. As indicated in Table 6.0-1, targets for these interactions are zero. Anything above zero will trigger an evaluation of the incident and mitigation to determine if modifications are required under the adaptive management process.

To evaluate wildlife use of reclaimed habitats, wildlife use trajectories and associated management triggers would be developed from baseline reference data collected and from control sites established in undisturbed habitats outside of the Project footprint. If the composition or relative abundance of indicator species in reclaimed areas are not approaching the values in natural habitats with similar site type conditions and structural stages, then adaptive management can be implemented.

To evaluate wildlife use of underpasses or overpasses at the conveyor, crossing structures performance would be based on observed wildlife responses to the crossings. Responses could be categorized as described below. Management triggers would subsequently be developed based on an acceptable level of crossing success by selected wildlife species.

- direct crossing of conveyor using crossing structure
- direct crossing conveyor not using crossing structure
- deflected movement along the conveyor before using crossing structure
- deflected movement along and then across the conveyor, without using crossing structure
- failed crossing of conveyor

A summary of the adaptive management program for the Project is provided in Table 7.2-1.

7.3 Implement, Monitor and Evaluate

Once Project development begins and the mitigation has been implemented, effectiveness monitoring will commence and observed trends will be compared to predicted trajectories. An evaluation of the monitoring results will determine if adaptations to mitigation need to be implemented. A sequence of actions is triggered if monitoring data indicate that environmental performance does not meet targets.

The mitigation described throughout the EIA (and as updated) will be incorporated into monitoring plans for the Project. Monitoring protocols will be established soon after Project development begins so that trends and progress can be evaluated. Should indicators meet targets or align with desired trends, business will be conducted as usual. Should indicators not meet targets or trends diverge from the desired trajectory, a sequence of Project-specific actions will be triggered. Prior to adjusting any mitigation, steps will be taken to investigate the observations, as necessary. If required, the following sequence will be followed:

1. Monitoring results will be verified and investigated.
2. Adaptations to mitigation will be identified and evaluated based on monitoring results.
3. Develop a work plan to adapt mitigation or monitoring, if required.

7.4 Adjust the Mitigation as Required

If mitigation adjustments are determined to be required, then they will be implemented with careful consideration to proper planning, approvals, notifications and/or consultation. In this step of the adaptive management process, a work plan may be developed and implemented. Any required notifications and/or approvals will be obtained before acting to confirm that all interested/affected parties are properly informed. If adjustments to mitigation measures are required, the Wildlife Mitigation and Monitoring Plan will be updated as appropriate to reflect the adapted mitigation for the Project.

Table 7.2-1 outlines some adaptive management adjustments that could be implemented if monitoring indicates that wildlife use of the Project area is not meeting targets. Since the monitoring plan has not been implemented, nor monitoring conducted, these are options for consideration.

Table 7.2-1 Wildlife Adaptive Management Program

Potential Project Effects	Mitigation Objectives	Mitigation Summary	Options for Adaptations
Change in habitat availability	Reduce direct habitat loss	• A C&R Plan that aims to establish suitable wildlife habitat. • Pre-disturbance surveys will be conducted along the edges of all areas to be cleared during Project development to determine the occurrence of any important wildlife habitat features. • Where appropriate, vegetated buffer zones (100 m or minimum of 30 m; pending topography constraints) will be maintained between Project infrastructure and wetlands, creeks, and streams to the best extent possible. • Retain slash and large woody debris in the salvaged soil to provide microsites for perches for migratory birds. • Ensuring reclaimed areas promote the re-establishment of woody species and are on a trajectory for reforestation. • Conducting monitoring to identify other habitable ponds and to identify habitat requirements and constraints. • Retain residual patches of essential habitat and habitat features within and adjacent to the mine footprint (*i.e.*, mature poplar trees, tall conifer trees) to provide perches, nest sites, and hide cover	• See C&R plan for soil and vegetation related reclamation adaptive management strategies. • Development or implement appropriate setback or timing procedures for sensitive wildlife habitat features. • Consulting with ECCC and AEP should hibernacula, fall swarming sites, or maternity roosts be observed during operations.

Table 7.2-1 Wildlife Adaptive Management Program

Potential Project Effects	Mitigation Objectives	Mitigation Summary	Options for Adaptations
	Reduce indirect habitat loss (*i.e.*, sensory disturbance)	• Vegetation adjacent to high-activity linear corridors (*e.g.*, access roads, coal conveyor) will be retained to reduce the extent of noise and visual sensory disturbances to the extent possible. • Benga has developed a visual impact mitigation plan that reduces stray and non-essential artificial lighting to minimize wildlife effects and that will comply with OH&S safety requirements. • To mitigate the potential effects of sensory disturbance (acoustic and visual) on effective habitat availability in the southeast portion of the Gold Creek valley, Benga will install and maintain a 15 m tall earth berm along the eastern edge of the south disposal area. • Noise mitigation (see Noise CR #2a).	• Lighting: Change the positioning and timing of use of mobile lighting set ups or alter the directional shades (CR#1, EIA, CEAR #42) • Noise: consider replacing noise alarms with lights during night-time activities; use of directional back-up alarms, varying the tones on the back-up alarms (CR#2a, EIA, CEAR #42)
Change in movement	Reduce changes in movement	• A minimum of six wildlife crossings will be incorporated into the design of the coal conveyor • Where appropriate, vegetated buffer zones will be maintained between Project infrastructure and wetlands, creeks, and streams to the best extent possible. • Surface water management ponds and ditches located in undisturbed areas of the Project footprint will be designed to allow wildlife to move around or cross safely. • Road plowing and grading will be conducted in a manner that does not restrict wildlife from crossing access roads or accessing wildlife crossings.	Crossing modifications: • Evaluate wing fencing at entrances to crossing passages. • Alter walking substrate in underpasses • Create vegetated buffers adjacent to crossing structures Modify road plowing and grading Modifications to vegetated buffers (frequency, width, composition) See C&R plan adaptive management for changes that could be made to reclamation plans

Table 7.2-1 Wildlife Adaptive Management Program

Potential Project Effects	Mitigation Objectives	Mitigation Summary	Options for Adaptations

		• A C&R Plan that aims to establish suitable wildlife habitat, including:
		  • Minimize the overall disturbance footprint through the mine planning process.
		  • Preserve remnant forest patches in the development areas to provide essential habitat, habitat connectivity, and hide cover for wildlife species.
		  • Retain slash and large woody debris in the replaced soil landscape.
		  • Plant native shrubs early in the reclamation process to initiate hiding cover.
		  • Establish mixed wood forest stands and high density coniferous tree stands.
		  • Provide understory complexity in the reclaimed forests by planting native shrubs such as alder and willow to provide security cover for the carnivores and their prey.
		  • Maximize the amount of ungulate habitat.
		  • Prior to final reclamation, disrupt linear disturbances and sight lines by mounding surface soils, piling brush.
		  • Limit sight lines by maintaining mature forest stands or by planting high density coniferous stands to act as buffers between roads, project disturbance boundaries and the reclaimed mine areas	

Change in mortality risk	Reduce changes in mortality risk (*i.e.*, clearing/removal of natural habitat, vehicle-wildlife collisions, increased access to the area, contamination of water)	Mitigations for effects on wildlife mortality risk include: • Timing vegetation site clearing activities are to occur outside the April 15 to August 31 period to avoid disrupting nesting migratory and resident songbirds • In the event that vegetation clearing must occur within the restricted activity period, pre-disturbance nesting surveys will be conducted by experienced avian biologists according to established sensitive species inventory guidelines (Government of Alberta 2013b). • Surface water management ponds and ditches located in undisturbed areas of the Project footprint will be designed to allow wildlife to move around or cross safely. • Retaining slash and large woody debris in the salvaged soil to provide hide cover. • All access to the Mine Permit will be controlled; no uncontrolled access will be permitted. • Design water management ponds and drainage ditches, and pit lakes to minimize potential entrapment of wildlife. • Bird collisions with buildings will be mitigated by placing visual markers on windows, and collisions with the proposed power line will be mitigated by installing large 'floats' or other markers. • Enforce speed limits (≤50 km/h) along the main access road and utility corridors, and place signs at identified wildlife crossings. • A detailed Waste Management Plan will be developed and implemented prior to construction and operational activities to minimize the attraction of wildlife.	• Establish appropriate buffers around discovered nests • C&R plan adaptive management • Modify onsite access and control activities, or employee training around operations practices regarding ATVs or hunting. • Alter speed limits, road signage, or employee training • Modify waste storage and management (*I.e.* different type of trash containers, or height/type of fencing of waste areas) • Modify spill response or materials storage • Modify the timing or structure of the procedures to clear areas prior to blasting.

Table 7.2-1 Wildlife Adaptive Management Program

Potential Project Effects	Mitigation Objectives	Mitigation Summary	Options for Adaptations
		• Implementing an Emergency Spill Response Plan to limit the effect of accidental spills. • Storing all hazardous materials, including those used for blasting, in secure areas that are inaccessible to wildlife. In addition, proper handling and storage of industrial materials and debris within the Project footprint will be maintained to minimize potential risks to wildlife. • Developing procedures to clear blasting areas of large mammals or birds prior to blasting. • Developing a strategy to minimize changes in water quality upstream of the mine in conjunction with a water-quality monitoring program. Effects on mortality for little brown myotis will be additionally be mitigated by: • Timing clearing outside of the summer breeding/rearing window (falls into the breeding bird window). • Avoiding direct and indirect impacts to known, primary maternity roosts should any such roosts be located/identified. To mitigate effects on grizzly bear mortality (in addition to mitigations for wildlife in general): • Benga commits to supporting active bear management plans associated with the Project. If a site specific plan is required, it will be developed in consultation with AEP personnel as part of the Wildlife Mitigation and Monitoring Plan.	

8.0 IMPLEMENTATION

8.1 Roles and Responsibilities

This section will be included in the final version of the Plan and will outline specific roles and responsibilities for employees and contractors related to the implementation of the Plan.

8.2 Information Management and Reporting

This section will outline how the monitoring results and adaptive management actions will be recorded, stored, tracked and made available to interested stakeholders. Accurate record keeping will be necessary to assess the implementation of the Plan, to measure the effectiveness of management and to develop and implement any necessary improvements.

8.3 Change Management

This section will outline the process for altering any part of this Plan, which may be required due to changes resulting from ongoing adaptive management.

8.4 Communication Management

This section will outline the process that will be used for communicating the results of the program to interested stakeholders.

9.0 REFERENCES

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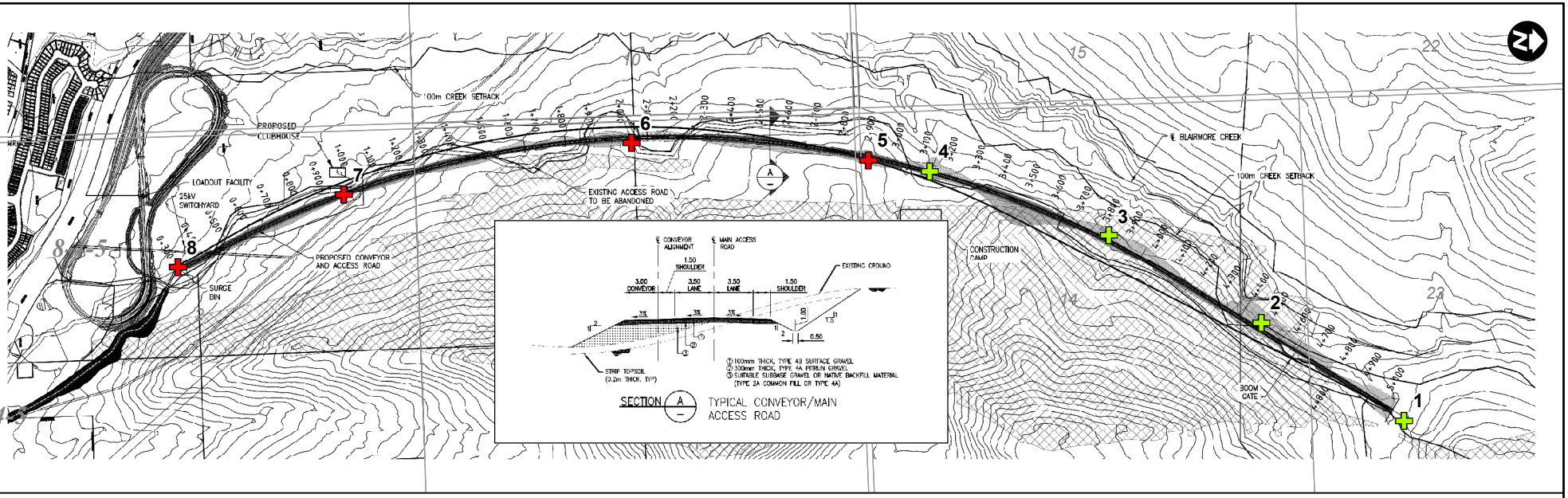
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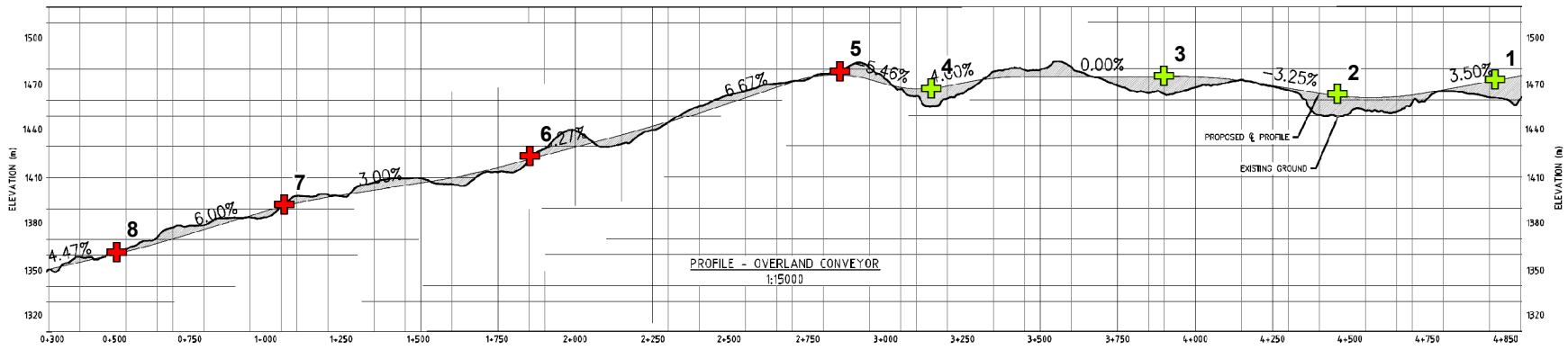
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APPENDIX A: FIGURE





LEGEND

Location of Proposed Wildlife Crossing

- Natural Due to Topography
- Man-Made Crossing Required

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

POTENTIAL WILDLIFE CROSSING LOCATIONS FOR THE PROPOSED COAL CONVEYOR ROUTE

AltaLIS, 2019; MEMS, 2019

Coordinate System: NAD 1983 UTM Zone 11N

0 500 1,000
Metres

MILLENNIUM EMS Solutions Ltd.

PROJECT: 14-00201
DRAWN BY: JLAMBERTS
CHECKED BY: TB
DATE: JUNE 14, 2019

FIGURE
5.1-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Landuse\Resubmission\Information Request 3\Fig 5-1-1 Potential Wildlife Crossings 14-00201.mxd

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