CANPOTEX POTASH EXPORT TERMINAL AND RIDLEY ISLAND ROAD, RAIL, AND UTILITY CORRIDOR

Air Quality Technical Data Report

FINAL REPORT

Prepared for:

Canpotex Terminals Limited
1111 – 100 Park Royal South
West Vancouver, BC V7T 1A2

and

Prince Rupert Port Authority
200 – 215 Cow Bay Road
Prince Rupert, BC V8J 1A2

Prepared by:

Stantec
4370 Dominion Street, 5th Floor
Burnaby, BC V5G 4L7

Project No.:

1231-10264

Date:

November 2011

Stantec

Stantec

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

[File Name and Path: P:_CMiC Projects\1048001_to_1049000\1048843 - EPP - Canpotex Environmental Services\01 - Ridley Island\FINAL EA\Post Client TDR\air_tdr\rpt_10264_air_q_tdr_20111125_fnl.docx]

ACRONYMS AND ABBREVIATIONS

AAQO .... Ambient Air Quality Objectives
ACE .... Air Contaminant Emissions
asl .... above sea level
ARM .... Ambient Ratio Method
BATEA .... Best Available Technology Economically Achievable
BC AAQO .... British Columbia Ambient Air Quality Objectives
BC MOE .... British Columbia Ministry of the Environment
°C .... Celsius Degrees
CACs .... Criteria Air Contaminants
CCNS .... Canadian Climate Normals Station
CDED .... Canada Canadian Digital Elevation Data
CEAA .... *Canadian Environmental Assessment Act*
CEA Agency .... Canadian Environmental Assessment Agency
CEA Case .... Cumulative Effects Assessment Case
CEMA .... Cumulative Environmental Management Association
CH_4 .... methane
cm .... centremetre
CMS .... Continuous Monitoring Station
CN .... Canadian National Railway Company
CO .... carbon monoxide
CO_2 .... carbon dioxide
CO_{2e} .... carbon dioxide equivalents
DWT .... dead weight tones
EA .... Environmental Assessment
EC .... Environment Canada
g .... grams
GCM .... General Circulation Models
GHG .... greenhouse gas
GWP .... global warming potential
h .... hour
H_2S .... hydrogen sulphide

ha .... hectares
HCFCs .... halogenated fluorocarbons
HFCs .... hydrofluorocarbons
hp .... horsepower
IPCC .... Intergovernmental Panel on Climate Change
°K .... Kelvin Degrees
K .... thousand
km .... kilometre
kW .... kilowatts
L .... litre
LAA .... local assessment area
LST .... Local Standard Time
m asl .... metres above sea level
M .... million
mm .... millimetre
MM5 .... mesoscale meteorological model (version 5)
Mt .... million tonnes
NAAQO .... National Ambient Air Quality Objectives
N_2O .... nitrous oxide
NO .... nitrogen oxide
NO_X .... oxides of nitrogen
NO_2 .... nitrogen dioxide
O_3 .... ozone
PM_{10} .... Inhalable particulate matter with diameter less than 10 µm
$PM_{2.5}$ .... Respirable particulate matter with diameter less than 10 µm
PFCs .... perfluorinated carbons
PRPA .... Prince Rupert Port Authority
RRUC .... Road, Rail, and Utility Corridor
s .... second
SO_2 .... sulphur dioxide
TDR .... Technical Data Report
tph .... tonnes per hour
TPM .... total particulate matter

ULCS...Ultra Large Container Ship
UNEP ....United Nations Environmental Program
US EPA.. United States Environmental Protection Agency
UTM ....Universal Transverse Mercator
$\mu g\ m^{-3}$.. micrograms per metre cubed
VEC.. valued environmental component
VOC ....volatile organic compounds
WBEA.. Wood Buffalo Environmental Association
WCI ....Western Climate Initiative
WMO.. Wold Meteorological Organization

THIS PAGE INTENTIONALLY LEFT BLANK.

1 INTRODUCTION

Canpotex Terminals Limited (Canpotex) and the Prince Rupert Port Authority (PRPA) are each proposing to undertake a project on Ridley Island in the Port of Prince Rupert, British Columbia. Canpotex is proposing to construct and operate a potash export terminal, the Canpotex Potash Export Terminal project (Canpotex Terminal project); PRPA is proposing to construct enabling transportation and utilities, the Ridley Island Road, Rail and Utility Corridor project (RRUC project). For the remainder of this document, “the Project” refers to the combined Canpotex Terminal and RRUC projects.

This Technical Data Report (TDR) pertains to Air Quality, and contains technical details and assumptions related to the Project air quality assessment, a component of the comprehensive environmental assessment (Stantec 2011). This TDR includes a detailed description of air quality and climatic conditions in the region surrounding the Project site. The TDR provides the technical analysis required to assess Project effects on the ambient air quality (Stantec 2011, Section 7).

1.1 Project Background

This assessment identifies potential air quality effects associated with all Project phases of the expected 50 year life cycle, including Construction, Operations and Decommissioning. The Project has both land and marine components, located on approximately 146 hectares (ha) of land and a 13.5 ha water lot. The Canpotex Terminal and RRUC projects will require approximately 21 ha and 125 ha of land, respectively.

Construction phase activities include preparation of the Project site and facilities building. Clearing, grubbing, stripping, quarrying and grading will be required for preparation of the terminal site and the road, rail loop and utility corridor. These activities require fossil-fuel powered equipment producing air emissions when in operation. Soil will be taken to the disposal areas and dumped, potentially causing dust emissions. Natural mitigation produced by the large amount of precipitation will suppress most dust emissions.

The Canpotex Terminal Operations phase has the following land-component:

- The conveyor and dust collection systems in a potash storage shed
- An automated railcar unloading and conveyor system with a dust collection system.

The marine activities include:

- An all-weather shiploading facility
- Vessels transiting, berthing, hoteling and deberthing at or near the marine wharf.

PRPA completion of the RRUC project will allow transportation services to the Canpotex Terminal and other future Ridley Island developments. PRPA RRUC Operations will produce air emissions from the following sources:

- Trains operating on the rail loop servicing the Canpotex Terminal
- Motor vehicles on an access road with a rail overpass and underpass.

Decommissioning activities are expected to be limited. The land buildings and wharf will likely remain intact after the Project is decommissioned. Only the above ground infrastructure including conveyor and shiploading equipment will likely be removed.

1.2 Objectives

The purpose of this document is to describe the methodologies and technical details related to the Project air quality assessment (Stantec 2011, Section 7). This information will be used to identify mitigation measures required to minimize or avoid effects on the receiving environment. This document will also be used as a basis against which Project effects on the Air Quality Valued Environmental Component (VEC) of the comprehensive environmental assessment will be assessed.

This TDR will present the following key information:

- Existing ambient air quality and climate baseline conditions
- Air quality emissions estimation techniques
- Assessment of the regional locomotive emissions along the Canadian National Railway Company(CN) rail line corridor between Ridley Island and Lorne Creek, BC (north of Terrace, BC)
- Air quality dispersion modelling methods and results
- Greenhouse gas (GHG) considerations.

Where necessary, mitigation measures used to minimize or avoid Construction and Operations effects on air quality will be stated.

Section 2 identifies the air quality assessment area(s). Section 3 describes the air quality and climatic baseline conditions. Section 4 details the emissions estimates followed by the dispersion modeling described in Section 5. Section 6 reports the results. The greenhouse gas considerations are described in Section 7.

2 AIR QUALITY ASSESSMENT AREA

The scope of the assessment was focused by selecting a bounded assessment area. A 30 km by 30 km area centred on the Project site was determined to be sufficient to assess the effects of the Project emissions on the ambient air quality. Figure 2.1-1 shows the geographic location of the proposed Project footprint and the selected air quality assessment area. The assessment area is equivalent to the local assessment area (LAA) used in the environmental assessment (Stantec 2011).

The increased rail traffic to Ridley Island will increase the locomotive emissions along the CN rail line. A comparative assessment from current to predicted air quality is offered for the rail line corridor starting from the Lorne Creek area north of Terrace, BC (Figure 2.1-2). The length of the rail line from Lorne Creek to Ridley Island is approximately 200 km.

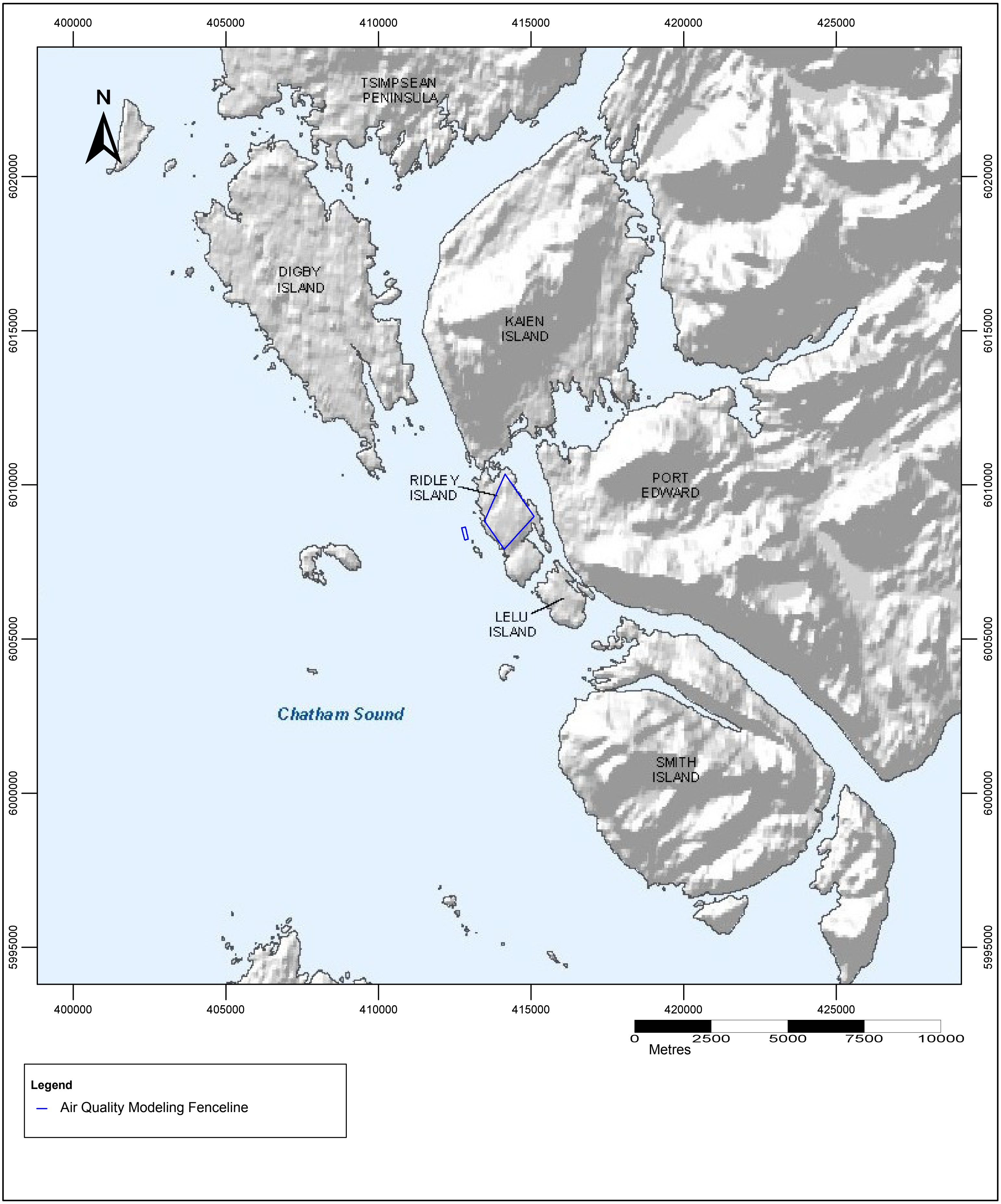
3 BASELINE CONDITIONS

An understanding of regional climate and meteorological events is required as these events can influence all Project phases. Example situations include:

- Extreme ambient air temperatures are important factors to consider for the selection of construction materials and equipment
- The safe berthing and de-berthing of the ships in the prevailing winds and subsequent waves and currents are a primary operating concern
- Most shiploading terminal operations cannot function in high wind situations at which point operations cease and equipment is secured
- Heavy rains may damage the potash product (Westmar 2007)
- Extreme precipitation rates may overwhelm the land facility drainage systems.

As well, the ambient meteorological conditions will influence the transport and dispersion of Project air emissions and must be considered as part of the Project environmental assessment. Wind speed, wind direction, and atmospheric turbulence are major meteorological elements that influence the dispersion of airborne contaminants. The climate baseline (Section 3.1) considers measurable climate parameters at the nearest regional climate stations in the assessment area.

Understanding the existing air quality helps establish the link between the air emissions (the cause) and resultant changes in ambient air quality (the effect), and allows for an assessment of potential effects of Project-related emissions. The air quality baseline (Section 3.2) considers measurable air quality parameters at the nearest most representative continuous hourly monitoring stations.



Stantec Consultants Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Stantec

Canpotex

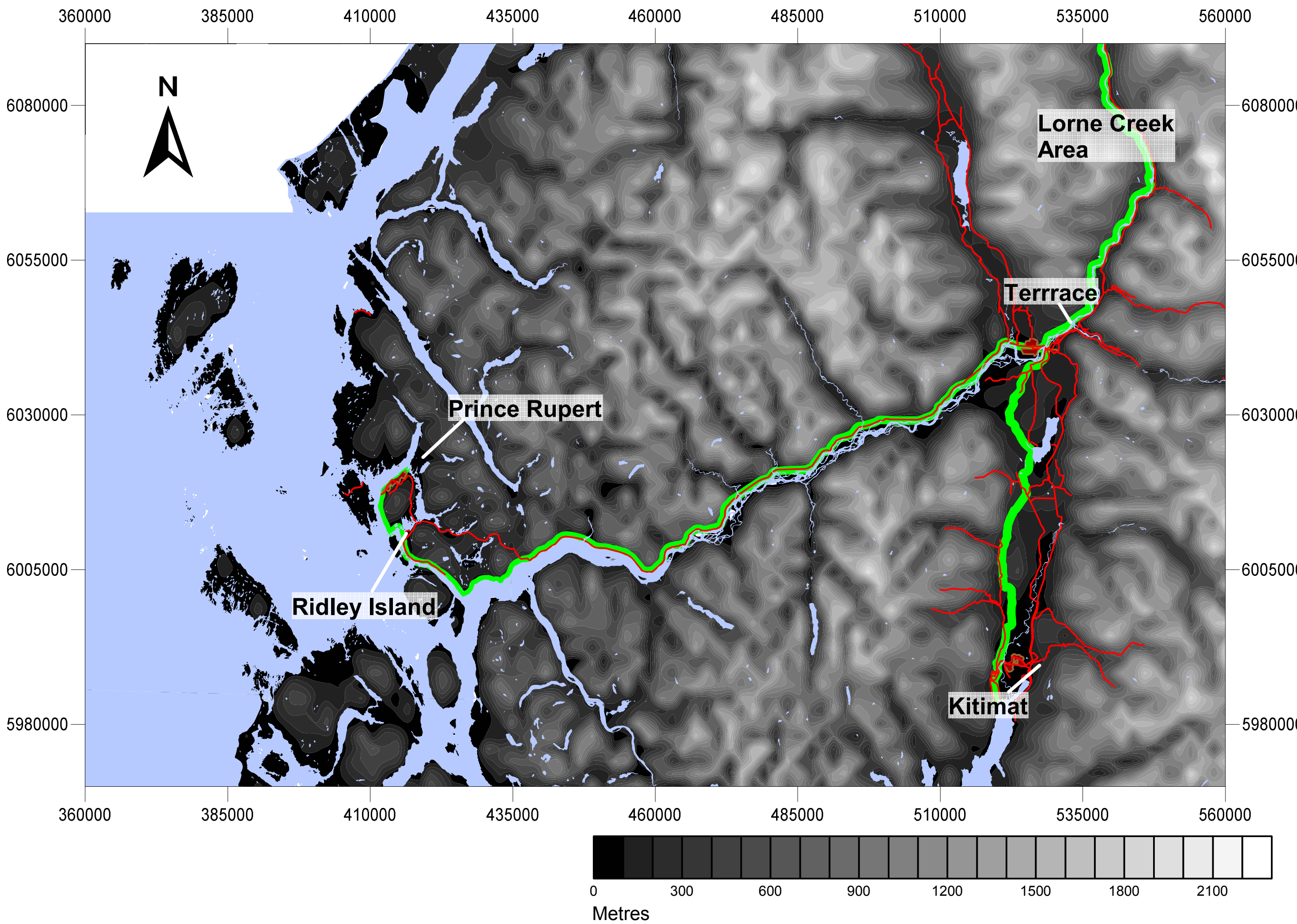
PRINCE RUPERT PORT AUTHORITY

The Air Quality Assessment Area

PROJECTION UTM	DRAWN BY JS
DATUM NAD 83	CHECKED BY MK
DATE 2010-Jul-19	FIGURE NO. 2.1-1

P:/../c4383srf/AssessmentArea.srf

Job No: 1231-10264



Legend

- CNR Railway Line
- Major Roads

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Stantec

Canpotex

PRINCE RUPERT PORT AUTHORITY

Regional Locomotive Emissions Assessment Area

PROJECTION UTM	DRAWN BY MK
DATUM NAD 83	CHECKED BY JS
DATE 2010-Jul-26	FIGURE NO. 2.1-2

3.1 Climate Baseline

To determine the possible interactions between the Project and the receiving environment, the following assessment area atmospheric parameters are characterized: air temperature, precipitation, humidity, and wind.

Meteorological data collected in the region near the Project site were analyzed to characterize the existing regional climate. Historical meteorological data are available for Canadian Climate Normal stations for the 30-year period of 1971 to 2000 (Environment Canada 2007a). The geographic coordinates and elevations of monitoring stations from which meteorological data were analyzed are provided in Table 3.1-1. The locations of these stations are shown in Figure 3.1-1.

The Prince Rupert Airport Canadian Climate Normal station collects data on air temperature, precipitation, humidity, and wind. The remaining three Prince Rupert Canadian Climate Normal stations collect data on precipitation only. Also, there is a continuous monitoring station in Prince Rupert that collects hourly observations of wind speed and direction (BC MOE 2007).

Table 3.1-1: Geographic Coordinates of Meteorological Stations in the Assessment Area

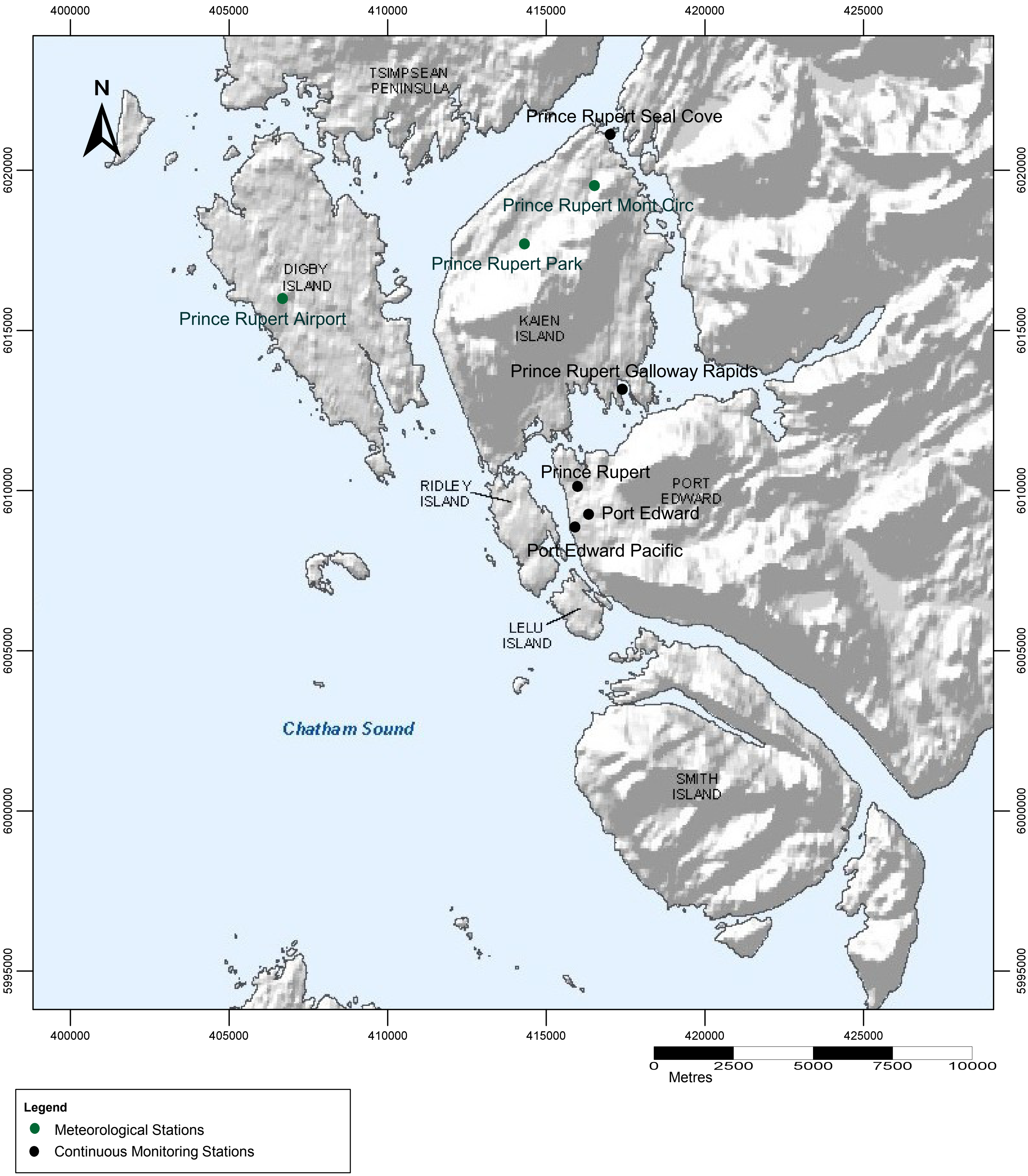
Station Type	Station Name	Latitude	Longitude	Elevation (masl)	UTM NAD83		
					Northing (m)	Easting (m)	Zone
CCNS	Prince Rupert Airport	54°17' N	130°26' W	35.4	406688	6015994	9
CCNS	Prince Rupert Mont Circ	54°19' N	130°17' W	60.0	416520	6019515	9
CCNS	Prince Rupert Park	54°18' N	130°19' W	90.8	414317	6017700	9
CCNS	Prince Rupert Shawatlans	54°19' N	130°15' W	11.0	417773	6124193	9
CMS	Prince Rupert Galloway Rapids	54°15' N	130°15' W	1.0	417400	6013161	9

NOTES:
CCNS = Canadian Climate Normals Station, Environment Canada (2007a).
CMS = Continuous Monitoring Station, British Columbia Ministry of Environment (BC MOE 2007)

3.1.1 Air Temperature

A summary of the historical seasonal and annual mean air temperatures at the Prince Rupert Airport Canadian Climate Normal station is provided in Table 3.1-2. The available data show an annual mean daily temperature range from 2.0°C in winter to 12.6°C in summer. The annual mean daily temperature is 7.1°C.

A more detailed breakdown of the monthly mean temperatures is shown in Figure 3.1-2. Extreme maximum and minimum temperatures are presented in Figure 3.1-3. The historical extreme temperatures at this location range from -24.4°C to 28.7°C.



Stantec
Stantec Consultants Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Canpotex
PRINCE RUPERT PORT AUTHORITY

Location of Meteorological and Ambient Air Quality Monitoring Stations in the Assessment Area

PROJECTION	DRAWN BY
UTM	JS
DATUM	CHECKED BY
NAD 83	MK
DATE	FIGURE NO.
2010-Jul-19	3.1-1

P:/...c4383srf/Figure3.1-1.srf

Job No: 1231-10264

Table 3.1-2: Historical Seasonal and Annual Mean Daily Temperatures in Assessment Area

Station Name	Mean Daily Temperature (°C)				
	Winter[a]	Spring[b]	Summer[c]	Autumn[d]	ANNUAL
Prince Rupert Airport	2.0	6.2	12.6	7.8	7.1

NOTES:

Data Source: Environment Canada (2007a)

[a] Winter Months: December, January, February

[b] Spring Months: March, April, May

[c] Winter Months: June, July, August

[d] Autumn Months: September, October, November

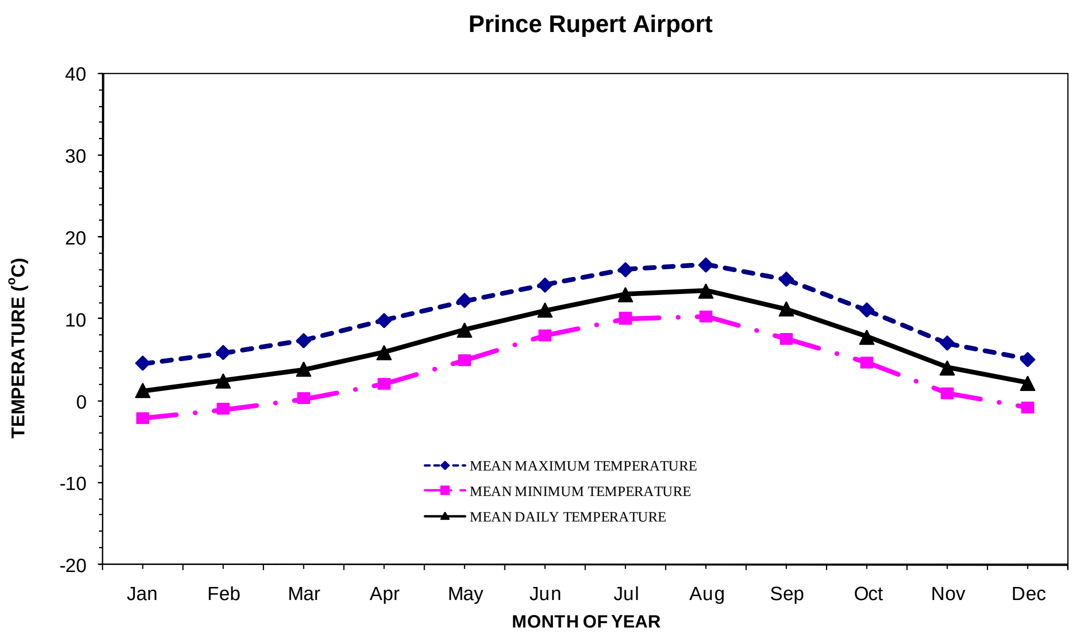


Figure 3.1-2: Historical Mean Daily Temperature in the Assessment Area

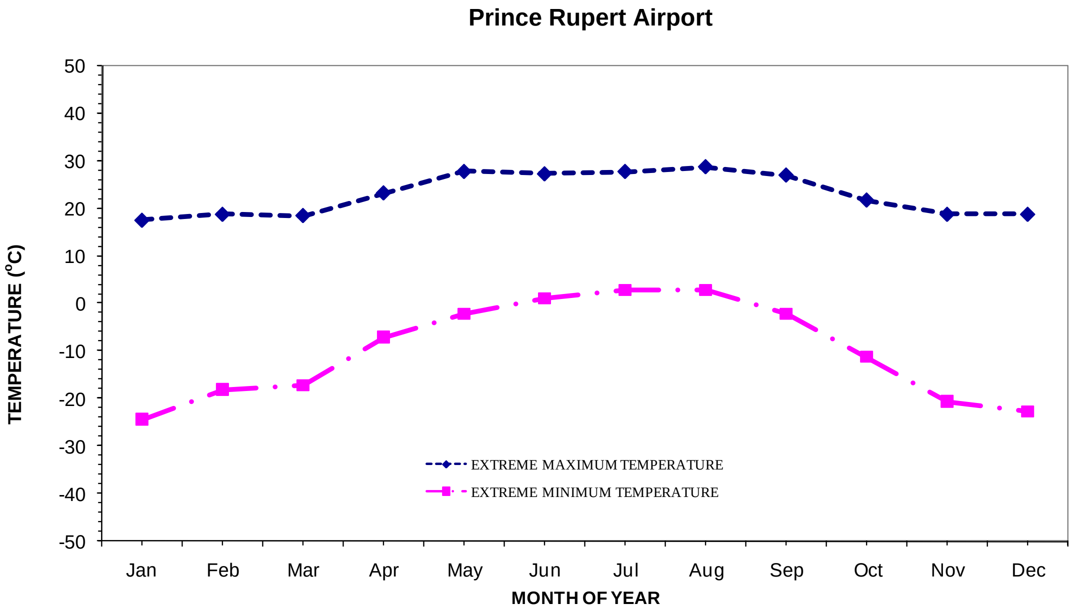


Figure 3.1-3: Historical Extreme Maximum and Minimum Temperature in Assessment Area

3.1.2 Precipitation

The monthly mean and maximum daily rainfall, snowfall, and total precipitation for the four selected Canadian Climate Normal stations in the assessment area are presented in Tables 3.1-3, 3.1-4, and 3.1-5, respectively.

As shown in Table 3.1-3, the months from October through to December are typically the wettest months of the year. The historical maximum daily rainfall at any of the sites (194.6 mm) was recorded at the Prince Rupert Shawatlans station during the month of September.

As shown in Table 3.1-4, the months with the most snowfall are typically December to February. The maximum historical daily snowfall at any of the sites (42.2 cm) was recorded at the Prince Rupert Mont Circ station during the month of December.

As shown in Table 3.1-5, annual average precipitation is high at all four sites with the Prince Rupert Mont Circ station having the highest overall annual precipitation (3,111 mm). The average annual precipitation for all four stations in the Assessment area is 2,941 mm.

The frequency of precipitation events is generally high year-round. At the Prince Rupert Airport, an average of 240 days per year, roughly two out of three days, have measureable precipitation. The driest month of the year (July) averages 17 days with rainfall, while the wettest month of the year (October) averages 24 days with measureable precipitation. These conditions tend to maintain high soil moisture content throughout the year.

Figure 3.1-4 shows the mean daily rainfall, snowfall, and precipitation by month for each of the stations.

Table 3.1-3: Historical Mean Monthly and Maximum Daily Rainfall in the Assessment Area

Station Name	Parameter	Rainfall (mm)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Prince Rupert Airport	Mean Monthly	217.7	179.0	174.4	173.3	139.5	123.7	114.3	155.4	244.0	378.9	293.7	274.7	2,469
	Max Daily	84.0	100.6	53.2	98.6	56.8	64.2	67.2	87.6	118.2	107.8	73.6	93.2	–
Prince Rupert Mont Circ	Mean Monthly	276.4	214.9	218.1	216.4	163.6	143.3	124.5	167.4	277.1	451.7	347.5	361.6	2,963
	Max Daily	117.6	106.2	98.6	102.8	58.9	66.9	77.2	98.0	162.2	150.4	140.2	175.0	–
Prince Rupert Park	Mean Monthly	272.5	222.0	239.2	225.7	167.7	144.6	116.2	153.3	252.2	427.8	354.5	335.2	2,911
	Max Daily	107.2	111.5	84.2	113.8	56.6	70.9	74.4	86.1	139.2	135.4	106.4	138.8	–
Prince Rupert Shawatlans	Mean Monthly	264.5	204.0	196.7	194.8	153.9	137.4	124.4	165.5	271.8	445.3	348.4	357.9	2,865
	Max Daily	94.2	95.2	59	99.3	55.1	51.8	74.9	86.9	194.6	140.2	150	141.3	–

NOTES: Data Source: Environment Canada (2007a)
– Not Applicable

Table 3.1-4: Historical Mean Monthly and Maximum Daily Snowfall in the Assessment Area

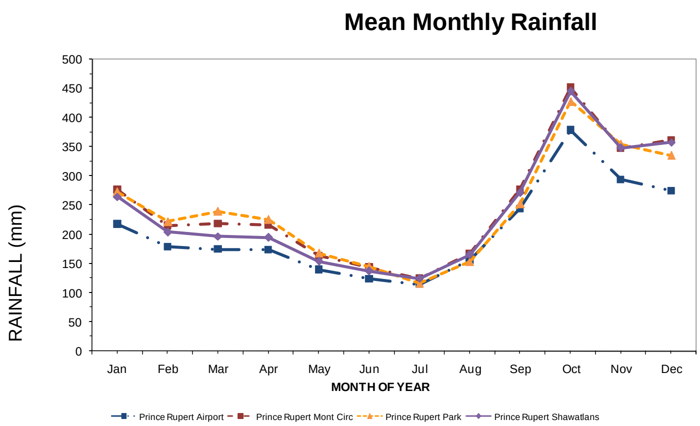
Station Name	Parameter	Snowfall (cm)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Prince Rupert Airport	Mean Monthly	40.9	26.1	17.1	5.1	0.1	0	0	0	0	0.3	9.6	27.1	126.3
	Max Daily	39.9	25.6	22.0	10.4	1.5	0	0	0	0.2	4.0	19.8	30.0	–
Prince Rupert Mont Circ	Mean Monthly	38.3	30.1	24.6	7.8	0.1	0	0	0	0	0.8	15.0	31.8	148.5
	Max Daily	32.0	38.1	34.3	18.5	3.6	0	0	0	0	9.0	27.9	42.2	–
Prince Rupert Park	Mean Monthly	35.3	30.2	24.6	8.2	0	0	0	0	0	0. 7	15.5	30.2	144.6
	Max Daily	30.5	39.4	34.3	38.6	3.8	0	0	0	0	7.6	26.7	40.6	–
Prince Rupert Shawatlans	Mean Monthly	37.4	28.9	22.5	6.9	0.1	0	0	0	0	0.7	12.8	29.4	138.6
	Max Daily	33.8	36.8	38.1	19.1	2.0	0	0	0	0	7.6	25.4	27.9	–

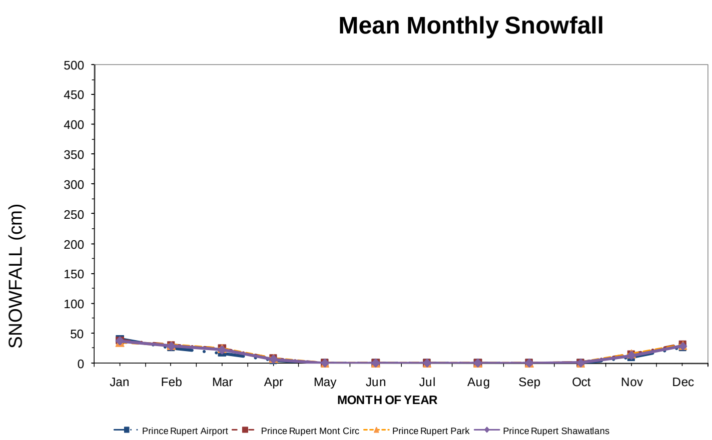
NOTES: Data Source: Environment Canada (2007a)
– Not Applicable

Table 3.1-5: Historical Mean Monthly and Maximum Daily Precipitation in the Assessment Area

Station Name	Parameter	Total Precipitation (mm)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Prince Rupert Airport	Mean Monthly	256.9	203.9	191.6	178.7	139.5	123.7	114.3	155.4	244.0	379.2	304.4	302.0	2,594
	Max Daily	84.0	100.6	53.2	98.6	56.8	64.2	67.2	87.6	118.2	107.8	73.6	93.2	–
Prince Rupert Mont Circ	Mean Monthly	314.6	245.1	242.7	224.2	163.7	143.3	124.5	167.4	277.1	452.5	362.5	393.4	3,111
	Max Daily	117.6	106.2	98.6	102.8	58.9	66.9	77.2	98.0	162.2	150.4	140.2	175.0	–
Prince Rupert Park	Mean Monthly	307.8	252.2	263.8	234.0	167.7	144.6	116.2	153.3	252.2	428.4	370.0	365.3	3,056
	Max Daily	107.2	111.5	84.2	113.8	56.6	70.9	74.4	86.1	139.2	135.4	106.4	138.8	–
Prince Rupert Shawatlans	Mean Monthly	301.8	232.8	219.2	201.7	154.0	137.4	124.4	165.5	271.8	446.1	361.2	387.3	3,003
	Max Daily	94.2	95.2	76.5	99.3	55.1	51.8	74.9	86.9	194.6	140.2	150.0	141.3	–

NOTES: Data Source: Environment Canada (2007a)
– Not Applicable





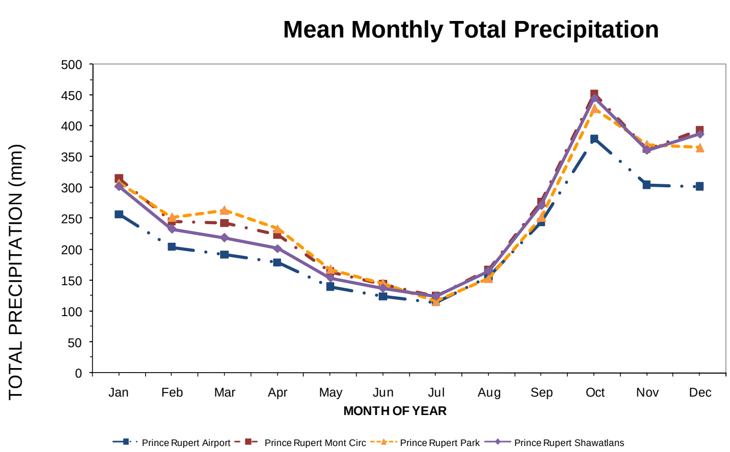


Figure 3.1-4: Mean Monthly Rainfall, Snowfall, and Total Precipitation in Assessment Area

3.1.3 Relative Humidity

Relative humidity is the ratio of the amount of water vapour actually in the air compared to the maximum amount of water vapour required for saturation at a particular temperature. It is therefore the ratio (usually expressed as percent) of the air's water vapour content to its capacity.

Relative humidity is recorded at the Prince Rupert Airport station. Table 3.1-6 shows the associated mean relative humidity for each month at 6:00 and 15:00 local standard time (LST). Consistent with the high frequency of precipitation, average relative humidity levels are high throughout the year.

Table 3.1-6: Historical Monthly Mean Relative Humidity in the Assessment Area

Month	Relative Humidity (%) Prince Rupert Airport	
	6:00 LST	15:00 LST
January	85.5	77.8
February	82.7	71.4
March	85.6	69.4
April	87.6	68.3
May	89.8	71.0
June	91.4	75.8
July	93.6	77.8
August	94.6	78.9
September	92.8	77.1
October	89.2	77.7
November	85.6	77.5
December	84.6	80.6

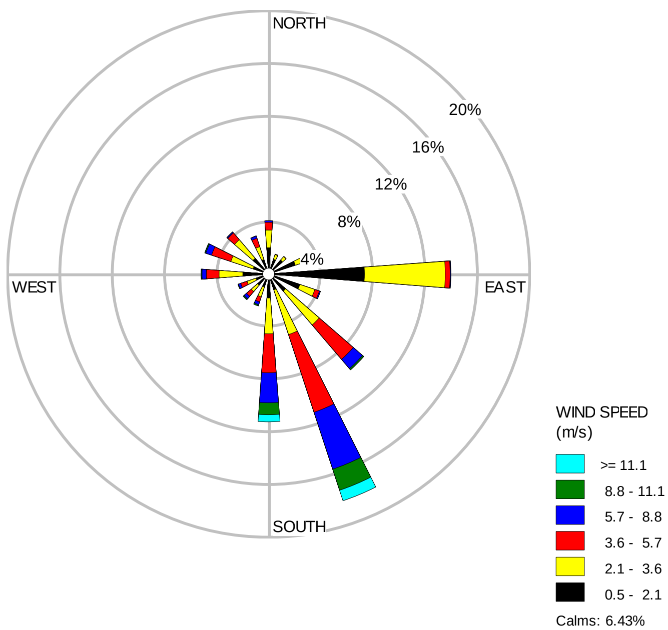
Data Source: Environment Canada (2007a)

3.1.4 Wind

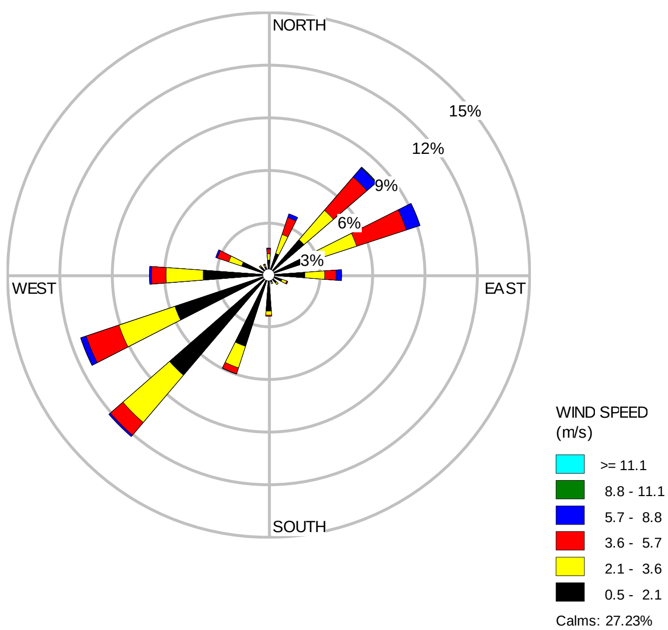
On the west coast of the North American continent, the prevailing upper level winds are westerly. However the surface level winds are strongly influenced by the topography. Valleys orientated along the axis of the prevailing wind aloft can expect to experience stronger winds, while calms are frequent when valleys are sheltered from the prevailing winds.

Wind roses are a graphic means for presenting wind speed and direction analyses. The length of the radial barbs gives the total percent frequency of winds from the indicated direction, while coloured portions of the barbs indicate the frequency of associated wind speed categories. Figure 3.1-5 presents wind roses depicting annual wind speed and direction frequency distributions for continuous hourly monitoring data observed at Prince Rupert Airport and Prince Rupert Galloway Rapids.

Prince Rupert Airport



Prince Rupert Galloway Rapids



Data Source: BC MOE (2007)

Figure 3.1-5: Wind Roses of Hourly Wind Speed and Direction Frequency Distributions as Observed in the Assessment Area

Table 3.1-7 provides a statistical summary of the wind data at each location. The surface winds at the Prince Rupert Airport station are predominantly from the south-southeast or easterly direction, suggesting the strong topographic influence. Winds are moderate, averaging 3.5 m s^{-1} (12.4 km h^{-1}). The maximum wind speed is 22.2 m s^{-1} (80.0 km h^{-1}). Calm winds (<0.5 m s^{-1}) occur about 6% of the time. The surface winds at the Prince Rupert Galloway Rapids station are predominantly south-westerly or north-easterly, also suggesting the strong topographic influence. Wind speeds are weaker, averaging 1.8 m s^{-1} (6.5 km h^{-1}). The maximum wind speed is 12.2 m s^{-1} (43.9 km h^{-1}). Calm winds (<0.5 m s^{-1}) occur about 27% of the time.

Table 3.1-7: Summary Statistics for Wind Data Observed in the Assessment Area

Parameter		Prince Rupert Airport	Prince Rupert Galloway Rapids
Station Location	UTM NAD83 Easting (m)	406688	417400
	UTM NAD83 Northing (m)	6015994	6013161
	Elevation (masl)	9.0	1.0
	Start Date	January 1, 2001	June 4, 2001
	End Date	December 31, 2004	February 29, 2004
Total Hours	(No.)	35,043	16,375
	(%)	99.3	68.2
Calm Hours (Wind Speeds <0. 5 m s^{-1})	(No.)	2237	4459
	(%)	6.4	27.2
Maximum Wind Speed	(m s^{-1})	22.2	12.2
	(km h^{-1})	80.0	43.9
Average Wind Speed	(m s^{-1})	3.5	1.8
	(km h^{-1})	12.4	6.5

Data Sources: Environment Canada (2007a); BC MOE (2007)

3.2 Air Quality Baseline

An analysis was completed of ambient air quality monitoring data collected at selected stations within the assessment area. Data were obtained from the BC MOE online data centre (BC MOE 2007). This assessment will focus mainly on sulphur dioxide (SO_2), and inhalable particulate matter (PM_{10}) measured (continuously) at the selected ambient air quality monitoring stations. The hydrogen sulphide (H_2S) information is the result of the analysis of local ambient monitoring data. H_2S is not related to Project emitted contaminants.

A summary of the station locations, substances monitored, and the available monitoring intervals are provided in Table 3.2-1. Available data periods for each station by contaminant are given in Table 3.2-2. The locations of these stations are shown in Figure 3.1-1.

Table 3.2-1: Continuous Ambient Air Quality Monitoring Stations in the Assessment Area

Station Name	Latitude	Longitude	Elevation (masl)	UTM NAD83 (Zone 9)		Air Species Monitored		
				Northing (m)	Easting (m)	SO_2	H_2S	PM_{10}
Prince Rupert	54°13' N	130°17' W	35.0	415987	6010126		X	
Prince Rupert Galloway Rapids	54°15' N	130°15' W	1.0	417400	6013161	X		X
Prince Rupert Seal Cove	54°19’ N	130°16’ W	2.0	417019	6021113		X	
Port Edward	54°13’ N	130°17’ W	35.0	416334	6009254		X	
Port Edward Pacific	54°13’ N	130°17’ W	10.0	415910	6008860	X	X	X

Data Source: BC MOE (2007)

Table 3.2-2: Data Periods for Continuous Ambient Air Quality Monitoring Stations in the Assessment Area

Station Name	Data Periods		
	SO_2	H_2S	PM_{10}
Prince Rupert	–	March 1, 1993 – April 1, 1998	–
Prince Rupert Galloway Rapids	April 24, 1998 – October, 2002	–	April 24, 1998 – December 31, 2002
Prince Rupert Seal Cove	–	April 17, 1998 – September 19, 2002	–
Port Edward	–	March 5, 1993 – August 23, 1996	–
Port Edward Pacific	April 12, 1998 – October 3, 2002	January 1, 1998 – October 3, 2002	April 29, 1998 – December 31, 2002

Data Source: BC MOE (2007)
– Not monitored

A summary of the statistical data analysis performed on the continuous ambient air quality monitoring data is provided in Table 3.2-3.

Table 3.2-3: Summary of Average and Maximum Hourly Concentrations at Continuous Ambient Air Quality Monitoring Stations in the Assessment Area

Substance	Parameter	Concentration ($\mu g\ m^{-3}$)				
		Prince Rupert	Prince Rupert Galloway Rapids	Prince Rupert Seal Cove	Port Edward	Port Edward Pacific
SO_2	One-hour Maximum	–	115	–	–	144
	One-hour 99th Percentile	–	13.0	–	–	8.00
	One-hour 98th Percentile	–	8.00	–	–	5.00
	One-hour 90th Percentile	–	3.00	–	–	3.00
	One-hour Average	–	0.80	–	–	0.70
	24-hour Maximum	–	26.0	–	–	17.7
	24-hour Average	–	0.80	–	–	0.70
	Annual Average	–	0.77	–	–	0.67
H_2S	One-hour Maximum	72.0	–	21.3	92.0	80.8
	One-hour 99th Percentile	3.00	–	2.80	24.0	11.3
	One-hour 98th Percentile	3.00	–	1.40	16.0	7.10
	One-hour 90th Percentile	1.00	–	0.00	3.00	1.40
	One-hour 75th Percentile	0.00	–	0.00	0.00	0.00
	One-hour Average	0.21	–	0.13	1.25	0.60
	24-hour Maximum	6.55	–	5.85	17.8	16.1
	24-hour Average	0.21	–	0.13	1.25	0.60
	Annual Average	0.21	–	0.13	1.25	0.59
PM_{10}	One-hour Maximum	–	131	–	–	168
	One-hour 99th Percentile	–	30.0	–	–	27.0
	One-hour 98th Percentile	–	24.0	–	–	22.0
	One-hour 90th Percentile	–	13.0	–	–	12.0
	One-hour Average	–	6.64	–	–	6.20
	24-hour Maximum	–	33.5	–	–	39.6
	24-hour Average	–	6.63	–	–	6.23
	Annual Average	–	6.74	–	–	6.31
	Annual Average	–	6.74	–	–	6.31

NOTES:
Data Source: BC MOE (2007)
– Not monitored

3.2.1 Sulphur Dioxide (SO_2)

Sulphur dioxide (SO_2) is monitored continuously at the Prince Rupert Galloway Rapids and Port Edward Pacific ambient air quality monitoring stations. As shown in Table 3.2-3, the average one-hour SO_2 concentrations for the Prince Rupert Galloway Rapids and Port Edward Pacific monitoring stations are 0.80 and 0.70 µg m^{-3}, respectively. The maximum one-hour concentrations were 115 and 144 µg m^{-3} at the Prince Rupert Galloway Rapids and Port Edward Pacific monitoring stations, respectively. These values are about a third of the BC Level A ambient air quality objective (BC AAQO) for one-hour average SO_2 concentrations set at 450 µg m^{-3} (BC MOE 2009).

At the Prince Rupert Galloway Rapids and Port Edward Pacific monitoring stations, the maximum 24-hour SO_2 concentrations were 26.0 and 17.7 µg m^{-3}, respectively. These values are much lower than the 160 µg m^{-3} Level A BC AAQO for 24-hour average SO_2 concentrations.

The observed SO_2 exposures at these sites indicate no adverse effects. A graphical representation of SO_2 data is provided in Figure 3.2-1.

3.2.2 Hydrogen Sulphide (H_2S)

Hydrogen sulphide (H_2S) is monitored continuously at the Prince Rupert, Prince Rupert Seal Cove, Port Edward, and Port Edward Pacific ambient air quality monitoring stations. As shown in Table 3.2-3, the region is periodically subjected to short-term odour issues. However the average of all one-hour H_2S concentrations ranging from 0.13 µg m^{-3} at the Prince Rupert Seal Cove monitoring station to 1.25 µg m^{-3} at the Port Edward monitoring station are reasonably low. At all locations, the 90th percentile one-hour H_2S concentrations are in the 1.0 to 3.0 µg m^{-3} range.

A graphical representation of H_2S data is provided in Figure 3.2-2.

3.2.3 Inhalable Particulate Matter (PM_{10})

Inhalable particulate matter (PM_{10}) is monitored continuously at the Prince Rupert Galloway Rapids and Port Edward Pacific ambient air quality monitoring stations. As shown in Table 3.2-3, the average of all one-hour PM_{10} concentrations for the Prince Rupert Galloway Rapids and Port Edward Pacific monitoring stations are 6.64 and 6.20 µg m^{-3}, respectively. The maximum one-hour PM_{10} concentrations at the Prince Rupert Galloway Rapids and Port Edward Pacific monitoring stations were 131 and 168 µg m^{-3}, respectively.

The maximum 24-hour PM_{10} concentrations at the Prince Rupert Galloway Rapids and Port Edward Pacific monitoring stations are 33.5 and 39.6 µg m^{-3}, respectively. These values are less than the applicable BC AAQO for 24-hour average PM_{10} set at 50 µg m^{-3} (BC MOE 2009).

The observed PM_{10} exposures at these sites indicate little potential for adverse effects. A graphical representation of PM_{10} data is provided in Figure 3.2-3.

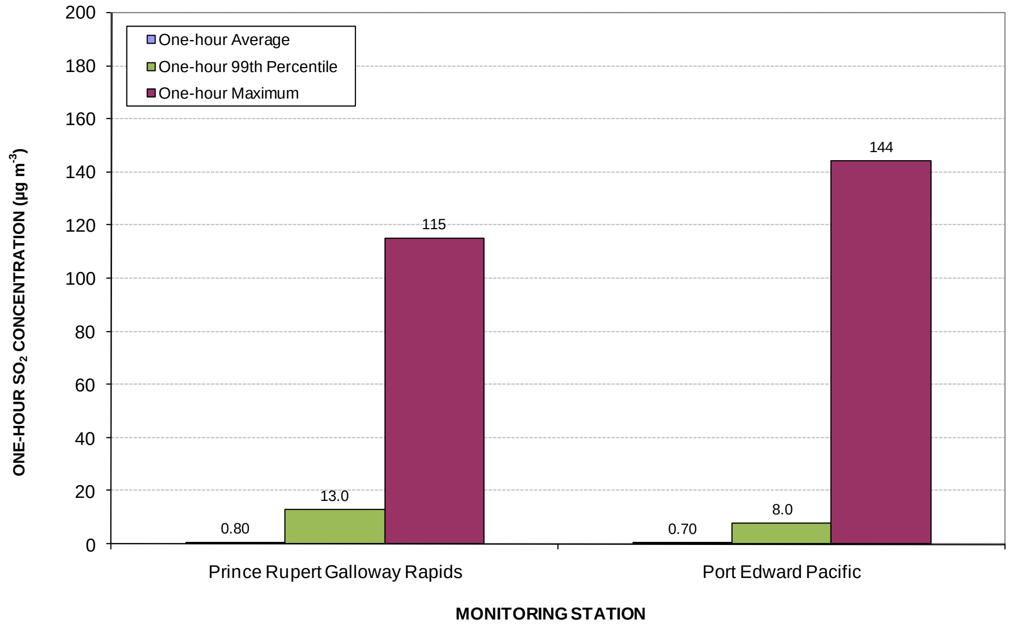


Figure 3.2-1: One-hour SO_2 Concentrations at Continuous Ambient Air Quality Monitoring Stations in the Assessment Area

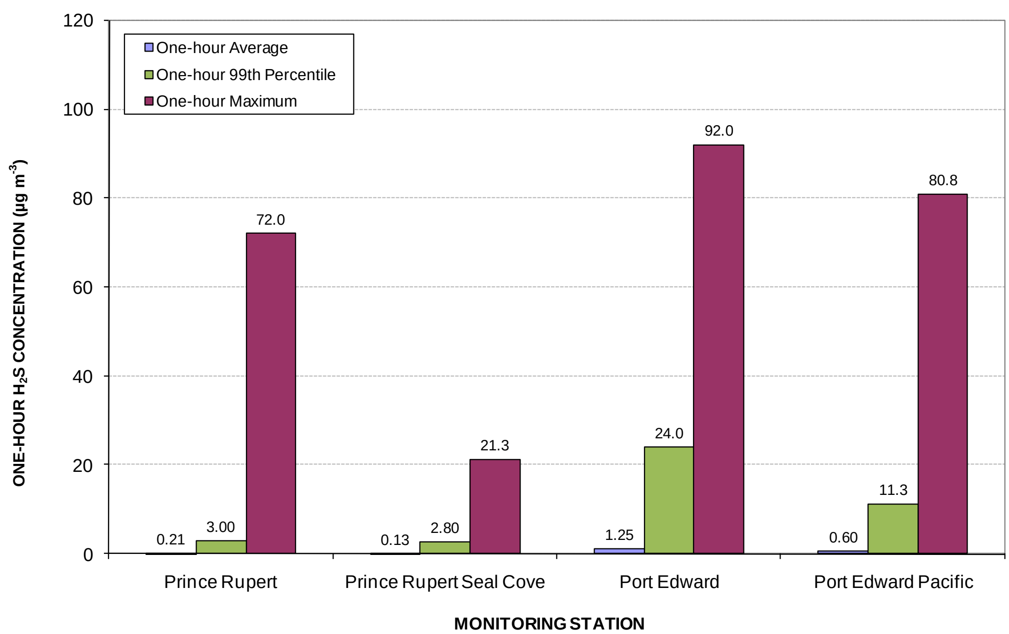


Figure 3.2-2: One-hour H_2S Concentrations at Continuous Ambient Air Quality Monitoring Stations in the Assessment Area

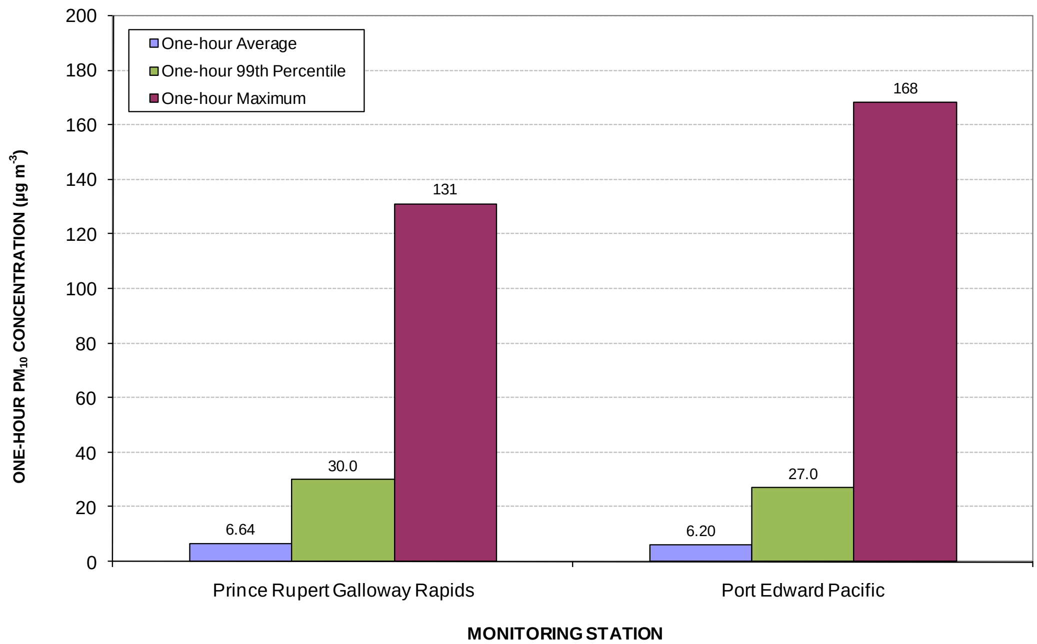


Figure 3.2-3: One-hour PM_{10} Concentrations at Continuous Ambient Air Quality Monitoring Stations in the Assessment Area

3.2.4 Summary

Assessment area baseline air quality is influenced primarily by regional industrial air emission sources. Generally, the ambient air quality in the assessment area is good.

The monitoring results show that of the substances under consideration, only H_2S concentrations have a history of exceeding the applicable regulatory objectives and standards. These exceedances were from the China Paper Group Pulp Mill that is no longer operational. All monitored concentrations of SO_2 and PM_{10} are below the applicable regulatory objectives for ambient air quality.

4 EMISSIONS ESTIMATION

Air emissions associated with Project Construction and Operations were calculated for various types of combustion sources, including heavy construction equipment and marine vessels. A separate assessment was completed to predict the increase in locomotive emissions along the CN rail line corridor from Ridley Island to Lorne Creek (Figure 2.1-2). Emissions associated with existing regional emission sources were also estimated and included in dispersion modelling as background sources.

Emission rates were calculated for several substances of interest including sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), inhalable particulate matter (PM_{10}), respirable particulate matter ($PM_{2.5}$), total volatile organic compounds (VOCs) and GHGs, where appropriate.

The methods used to calculate emissions from the various types of equipment and industrial facilities are summarized in the following sections. Estimated emission rates were input into the dispersion model to evaluate the potential effects of Project activities within the assessment area. To fulfill the dispersion modeling requirements, other source parameters such as stack heights and stack diameters (or rise areas and initial dispersions), exit temperatures and velocities must be characterized.

Activities and emission estimates for the Canpotex Terminal project were confirmed by Ausenco-Sandwell Engineering[1].

4.1 Construction Phase

For the Project Construction phase, information regarding the type and quantity of equipment was provided by Ausenco-Sandwell Engineering and PRPA. This information, in combination with the literature documenting emission rates for various types of equipment and vehicles, formed the basis of the air emissions calculations. The Project Construction phase involves both land-based and marine activities. The following onshore activities were identified as sources of air emissions:

- Site clearing, grubbing, stripping of the terminal site
- Cutting and filling of the terminal site
- Rock crushing and screening
- Construction of temporary and permanent on-site roads
- Installation of utilities
- Construction of potash storage sheds, railcar dumper buildings
- Installation of materials handling equipment including unit train indexer, railcar dumper, conveying systems and surge bins
- Construction of ancillary building (administration, operations and maintenance buildings complete with restrooms, supply and storage rooms)
- Disposal of overburden
- Delivery of materials to the site.

Similarly, a number of marine activities were identified as sources of air emissions:

- Dredging
- Installation of pilings and pile caps
- Construction of access trestle, wharf and causeway
- Installation of shiploader and conveyor system
- Installation of utilities for trestle and wharf
- Installation of the effluent disposal pipe and marine outfall.

[1] Pers. comm. with Ausenco-Sandwell Engineering, June 15, 2010

All construction material for the terminal and marine infrastructure will be delivered to the site via truck, rail, barge or ship, depending on the type of material and origin of manufacture.

The RRUC construction land-based activities will generate air emissions:

- Grubbing, stripping, blasting, cutting and filling for the road/rail loop and transmission line
- Rock crushing and screening
- Laying of three incoming tracks and two outgoing tracks that will be dedicated for use by Canpotex
- Road construction.

PRPA provided the equipment list for the RRUC construction including the bulk civil equipment for site preparation and road construction and rail specific equipment. This information and emission data extracted from the references for various types of equipment and vehicles formed the basis of the air emissions calculations. A summary of the equipment list for the Project Construction phase is presented in Table 4.1-1. For RRUC construction, machinery listed as bulk civil equipment will be used primarily for site preparation activities; rail-specific equipment will be used for the subsequent railway construction.

Emission rates for the construction equipment were calculated based on assumed construction schedules of 8 hours per day for one full year at the Canpotex Terminal and 14 hours per day for the RRUC. Emissions for heavy diesel equipment were estimated based on emission factors published by the U.S. EPA for non-road diesel equipment (U.S. EPA 2004). Tugboat and dredge emission rates were estimated based on emission and load factors obtained from *Best Practices in Preparing Port Emission Inventories* (ICF Consulting 2005). Emissions from fugitive dust sources were not included, as the high frequency of rainfall and resulting high soil moisture content will provide ample natural mitigation of dust during construction.

Table 4.1-1: Equipment Associated with Project Construction

Category	Equipment Type Used	Maximum Number of Units	Fuel Type	Engine Power (HP)	Estimated Unit Operation (Hrs/Year)
Canpotex Terminal Site Preparation Equipment Clearing and Hauling	Skidder	1	Diesel	150	560
	Dozer	1	Diesel	220	560
	Brush Cutter	1	Diesel	60	560
	Dump Truck	2	Diesel	511	560
	P/U Truck	2	Diesel	325	560
	Dozer	4	Diesel	220	1,720
	Excavator	2	Diesel	335	1,720

Category	Equipment Type Used	Maximum Number of Units	Fuel Type	Engine Power (HP)	Estimated Unit Operation (Hrs/Year)
Canpotex Terminal Site Preparation Equipment Excavating and Hauling	Loader ($6m^3$)	2	Diesel	275	1,720
	Dump Truck ($20m^3$)	16	Diesel	511	1,720
	Track Drill	2	Diesel	425	1,720
	P/U Truck	4	Diesel	225	1,720
Canpotex Terminal Site Preparation Equipment Grading	Dozer	3	Diesel	220	1,720
	Grader	2	Diesel	297	1,720
	Dump Truck ($10m^3$)	7	Diesel	325	1,720
	Dump Truck ($20m^3$)	8	Diesel	511	1,720
	Compactor	2	Diesel	100	1,720
	Water Truck	1	Diesel	240	1,720
	Loader	2	Diesel	275	1,720
	Crushing Plant (1,000tph)	1	Diesel	100	1,720
	P/U Truck	4	Diesel	225	1,720
Canpotex Terminal Construction: Land-based Equipment	Dump Truck (29 tonnes)	4	Diesel	511	2,080
	Large Crane (100 tonnes)	1	Diesel	390	2,080
	Medium Crane (22 tonnes)	2	Diesel	160	2,080
	Backhoe (8 tonnes)	2	Diesel	420	2,080
	Welding Trucks	4	Diesel	68	2,080
	Garbage Trucks	2	Diesel	100	2,080
	Hydrovac Truks	1	Diesel	435	2,080
	Drill Rig (12.5 tonnes)	1	Diesel	196	2,080
	Grader (25 tonnes)	1	Diesel	265	2,080
	Compactor (225 kg)	1	Diesel	145	2,080
	Forklift	4	Diesel	84	2,080
	Aerial work platforms	4	Diesel	84	2,080
	Boom Trucks	1	Diesel	160	2,080
Canpotex Terminal Construction: Marine-based Equipment	Large Crane (100 tonnes)	1	Diesel	390	2,080
	Medium Crane (22 tonnes)	2	Diesel	160	2,080
	Tug Boat (1000 hp)	1	Fuel oil	1000	2,080
	Drill Rig (12.5 tonnes)	1	Diesel	196	2,080
	Dredge (2,461 tonnes)	1	Diesel	370	2,080
	Vibro-hammer Excavator (17 tonne)	1	Diesel	270	2,080

Category	Equipment Type Used	Maximum Number of Units	Fuel Type	Engine Power (HP)	Estimated Unit Operation (Hrs/Year)
RRUC Bulk Civil Equipment	Excavator (small)	4	Diesel	270	2,080
	Excavator (med)	12	Diesel	360	3,380
	Excavator (large)	12	Diesel	450	2,080
	Dozer (D6)	12	Diesel	150	2,600
	Dozer (D8)	4	Diesel	305	3,380
	Haul Truck (40 tonne)	40	Diesel	320	2,080
	Drill Rig	6	Diesel	196	1,560
	Fuel Truck	1	Diesel	230	1,560
	Service Truck	1	Diesel	325	1,560
	Lube Truck	1	Diesel	325	1,300
	Bus	1	Diesel	325	1,300
	Medic Truck	1	Diesel	325	780
	P/U Truck	15	Diesel	250	1,560
RRUC Rail-Specific Equipment	Boom Truck	2	Diesel	85	3,380
	Forklift (10 tonne)	4	Diesel	100	3,380
	Front-end Loader	4	Diesel	150	3,380
	Dump Truck	2	Diesel	511	2,600
	Grader	2	Diesel	140	2,600
	Roller Compactor	2	Diesel	230	2,600
	Ballast Regulator	1	Diesel	225	3,380
	Rail Liner and Tamper	1	Diesel	175	3,380
	Tractor/Flat Deck Trailer	4	Diesel	260	2,600

Emission rates of air contaminants associated with Project Construction are summarized in Table 4.1-2. Although totals are provided, it should be noted that the various phases of construction will be staggered over a period of approximately three years. Therefore, the equipment listed in Table 4.1-1 will not all be operating simultaneously and emissions at any given time will be a fraction of the total presented.

Table 4.1-2: Emission Rates Associated with Project Construction

Equipment Type	Emission Rate (tpy)					
	SO_2	NO_x	CO	PM_{10}	$PM_{2.5}$	VOCs
Canpotex Land-based	0.14	26.6	26.6	1.5	1.5	4.1
Canpotex Marine-based	0.04	11.4	11.4	0.50	0.50	1.6
RRUC Bulk Civil	0.14	112.2	112.2	6.5	6.5	17.3
RRUC Rail-Specific	0.03	21.4	21.4	1.2	1.2	3.3
Total	**0.35**	**171.6**	**171.6**	**9.7**	**9.7**	**26.3**

4.2 Operations Phase

Emissions associated with Project operations are divided in three main categories: Marine-based, Land-based and Rail. Two emission rates were estimated. The shorter term emission rates are representative of hourly/daily rates; the longer term emission rates are representative of annual emission rates. The location of these sources is shown in Figure 4.2-1.

During the Project operations phase, key activities causing air emissions are:

- Unit trains powered by locomotives arriving/leaving the terminal
- Receiving and unloading of potash from unit trains
- Receiving ships berthing and deberthing with assistance from tugs
- Transfer of potash to vessels, from storage sheds or on a direct hit basis
- Vehicles carrying workers to and from the work areas.

4.2.1 Marine-based

Emissions associated with the operations of marine vessels during loading and off-loading activities were estimated for both short-term (hourly/daily) and long-term (annual) operating scenarios. The Marine-based emissions are from two groups of emission units. The first group consists of the water-deployed units (ships and tugboats): the second group consists of the wharf-based equipment (dust collectors).

Ships and Tugboats

It is expected that typically 130 – 150 Panamax size bulk-carrier ships per year, with an averaged capacity of approximately 68,000 dry-weight tonnes (DWT), will be required to receive the potash. Two to four tugs will be required to manoeuvre ships, both while berthing and deberthing. A summary of the relevant highlights (reviewed by PRPA) of the shipping operation is shown in Table 4.2-1. To be conservative with the emission estimate, it will be assumed that 150 bulk carriers will be required per year, requiring four support tugs for each berthing and deberthing.

Table 4.2-1: Marine-based Vessel Characteristics and Wharf-based

Features	Vessel Type	
	Bulk Carrier	Tugboat
Maximum Vessel Size (DWT)	68,000	–
Main Engine Power Rating (kW)	16,400	3,700 each
Auxiliary Engine Power Rating (kW)	2,400	
Number of Vessels per Year	130-150 (assume 150)	400
Number of Vessels in Port at One Time	1	2-4 (assume 4)
Total Time Manoeuvring (hrs/yr)	750	3,000
Total Time Hoteling (hrs/yr)	4,500	–
Fuel Type	Residual oil	Marine diesel oil

R:\2010Stantec\123110264_Canpotex_Ridley_Island\gis\Figures\TDR\AirQuality\123110264 Fig 4.2-1_RidleyIslandPotashTerminalSiteMap.dwg PRINTED: Nov 24, 2011

Client: Canpotex / PRINCE RUPERT PORT AUTHORITY	Job No.: 123110264	Fig. No.:	
	Scale: 1:20,000	4.2-1	Stantec
	Date: 24-Nov-11		
CANPOTEX POTASH EXPORT TERMINAL AND ROAD, RAIL AND UTILITY CORRIDOR AIR QUALITY RIDLEY ISLAND, BRITISH COLUMBIA	Dwn. By: NP		
	App'd By: SW		

The phases of the ship visit cycles include berth manoeuvring, hoteling, loading, and deberthing. For modelling of short-term predicted maximum concentrations (24 hrs and less), it was conservatively assumed that the marine vessels will be present at the berth and emitting at their nominal rates continuously. This approach will result in an over-estimate of the potential effect of emissions at the berth. To estimate short-term marine emissions, the following assumptions were made:

- 100% of the bulk-carrier ship idling occurs at the berth
- 25% of bulk-carrier vessel manoeuvring occurs at or near the berth
- 100% of tugboat traffic will occur at or near the berth
- Berthing takes 2.5 hours and deberthing takes the same amount of time.

Ship berthing/deberthing time duration is estimated to be five hours total. Preparation time for loading and ship departure is estimated to be six hours each. Loading durations at a rate of near 6,000 tph will be about 11 – 12 hours per bulk-carrier ship. The total time requirement suggests 35 hours of ship emissions per visit. The daily emission rates should approximate the hourly emission rates. 150 ship visits per year suggest 4,500 hours of emissions. The long-term emissions amount to approximately 52% of the short-term emissions.

Emissions from the tugboats used to assist these bulk-carrier ships in and out from the berths are also included. Four tugboats are assumed to assist near the wharf for five hours each during the trip cycle, 2.5 hours during berthing and 2.5 hours during deberthing. However, berthing and deberthing do not occur on the same day. Therefore the shorter-term emission rates should be the 2.5 hour work period emissions averaged over a 24 hour period. The 150 bulk-carrier ship visits require a total of 3,000 tugboat support hours. These estimates suggest that the longer-term emission rate should approximate 35% of the shorter-term rate.

A summary of the stack emission rates and emission parameters associated with marine vessel traffic during the Project Operations phase is presented in Table 4.2-2 and Table 4.2-3. Emissions of CACs and VOCs were calculated using the engine power ratings along with load and emissions factors obtained from *Best Practices in Preparing Port Emission Inventories* (ICF Consulting, 2005). Ship SO_2 emissions are based on 2.7% sulphur content in the residual oil fuel. Under the International Maritime Organization North American Emission Control Area (ECA) implementation plan (Environment Canada 2011), from August 1, 2012 until 2015 vessels operating in the ECA must use fuel with a maximum sulphur level of 10,000 mg/kg (1.0% by weight). Beginning January 1, 2015, that limit drops by 90% to 1,000 mg/kg (0.10% by weight). As the Project is scheduled to begin operations in 2013, ship SO_2 emissions were assumed to be from residual oil containing 1.0% sulphur.

Table 4.2-2: Marine Vessel Fuel Consumption Rates

Fuel Consumption	Vessel Type	
	Cape Ships	Tug boat
Main Engines Manoeuvring (t/hr)	0.359	0.247
Main Engines Hoteling (t/hr)	–	–
Auxiliary Engines Manoeuvring (t/hr)	0.282	
Auxiliary Engines Hoteling (t/hr)	0.157	–
Auxiliary Boiler Manoeuvring and Hoteling (t/hr)	0.0125	–
Total in Port Fuel Consumption (tpy)	**884**	**89**

The sulphur limit for production and importation of locomotive and non-category three marine diesel fuels will be 15 mg/kg as of June 1, 2012 (Environment Canada 2011). Tug boat SO_2 emission rates were adjusted accordingly. GHG emissions were calculated using fuel consumption rates, as shown in Table 4.2-3, along with US EPA emissions factors for fuel oil combustion (US EPA 1998). GHG emissions are presented in Section 7.4.3. Fuel consumption rates were obtained from Analysis of Commercial Marine Vessel Emissions and Fuel Consumption Data (US EPA 2000).

Table 4.2-3: Summary of Stack and Emission Parameters Associated with Marine Vessel Sources at the Terminal Berth

Parameter		Cape Size Bulk Carriers	Assist Tugboats			
Source Modelling ID		BULKC1	TUG1	TUG2	TUG3	TUG4
Source Type		Point	Point	Point	Point	Point
UTM Coordinates (NAD83)	mE	412824	412885	412913	412784	412828
	mN	6008465	6008248	6008260	6008539	6008549
Base Elevation (m)		0.0	0.0	0.0	0.0	0.0
Stack/Release Height (m)		41.0	11.0	11.0	11.0	11.0
Stack/Source Diameter (m)		1.00	0.50	0.50	0.50	0.50
Exit Temperature	°C	400	400	400	400	400
	K	673	673	673	673	673
Exit Velocity (m/s)		9.0	5.5	5.5	5.5	5.5
Maximum Emission Rate (g/s) (for Short-Term Effects Modelling)	SO_2	2.657	0.201	0.201	0.201	0.201
	NO_x [a]	3.313	4.206	4.206	4.206	4.206
	CO	0.261	0.350	0.350	0.350	0.350
	PM_{10}	0.258	0.918	0.918	0.918	0.918
	$PM_{2.5}$	0.207	0.184	0.184	0.184	0.184
	VOC	0.090	0.159	0.159	0.159	0.159

Parameter		Cape Size Bulk Carriers	Assist Tugboats			
Average Emission Rate (g/s) (for Long-Term Effects Modelling)	SO_2	1.155	0.034	0.034	0.034	0.034
	NO_x [a]	1.479	0.720	0.720	0.720	0.720
	CO	0.127	0.060	0.060	0.060	0.060
	PM_{10}	0.115	0.039	0.039	0.039	0.039
	$PM_{2.5}$	0.110	0.031	0.031	0.031	0.031
	VOC	0.050	0.027	0.027	0.027	0.027

NOTES:
[a] NO_x expressed as NO_2 equivalent
– Not available

Wharf-based Equipment

Dust collectors will operate during shiploading operations. A summary of the relevant features of these emission units is shown in Table 4.2-4.

Table 4.2-4: Marine-Based (Wharf) Dust Collector Characteristics

Features	Dust Collector Deployment
	Shiploader Transfer
Number	5
Flow rate (m^3/h)	8.495
PM max concentrations (mg/m^3)	50
Average run time	25%

At 6,000 tph rate, the shiploaders will be operating about 2,160 hours or 25% of the year. As a long-term average, the annual emission rate will be assumed 25% of the short-term emission rate.

A summary of the stack and emission parameters associated with the wharf-based shiploaders is presented in Table 4.2-5. Baghouse specifications for discharge concentrations and flow rate are available for Total Particulate Matter (TPM), also referred to as Total Suspended Particles (TSP), from which an emissions rate can be calculated. Clearly, only a portion is sized less than PM_{10} with a smaller portion sized less than $PM_{2.5}$. Size apportionment information for potash dust was not available, so it was assumed that the size distributions were equivalent to baghouse emissions found in plywood mill sander/sawdust baghouse operations. These size apportionments are 0.465 and 0.234 for PM_{10} and $PM_{2.5}$, respectively (FPAC 2007).

Dispersion simulations for these types of units require specification of stack diameter and exit velocity. The actual values are applicable only to vertical oriented stacks. Since the baghouses are vented horizontally, stack diameter and rise-velocity pseudo-parameters must be assumed. It is assumed that a 2 m diameter rise area occurs immediately after venting. As well, the rise area upward velocity starts at approximately 0.1 m/s (BC MOE 2008).

For the shorter-term estimates, it is assumed that all the emissions described above are occurring at the same time, a conservative operating and thus emissions scenario. In reality, the shiploader will not be operating while the vessels are manoeuvring, only while hotelling; the assist tugboats likely will have departed the wharf area to provide port services elsewhere. The modeled operating scenario for the long-term emissions is more realistic.

Table 4.2-5: Summary of Stack and Emission Parameters Associated with the Wharf-based Shiploader Dust Collectors

Modelling ID		DC-03	DC-04	DC-05	DC-08	DC-09
Dust Collector TPM Concentration density (mg/m^3)		50	50	50	50	50
Description		Bin Vent, BC611 head	Bin Vent, BC612 skirting	Bin Vent, BC612 tripper head	Bin Vent, Boom conveyor skirting	Bin Vent, Boom Conveyor head
TPM Flow rate (m^3/h)		8,495	8,495	8,495	8,495	8,495
Duration (hours/day)		24	24	24	24	24
Frequency (days/week)		7	7	7	7	7
Approximate UTM locations (Zone 9)	mE	412863	412865	412855	412822	412810
	mN	6008300	6008350	6008400	6008474	6008511
Base Elevation (m)	m	0	0	0	0	0
Stack Outlet Elevation (m)	m	20	9.5	31	26.5	32
Exit Temperature	^oC	20	20	20	20	20
	^oK	293	293	293	293	293
Maximum Emission Rate (g/s) for Short-Term Impact Modelling	PM_{10}	0.055	0.055	0.055	0.055	0.055
	$PM_{2.5}$	0.028	0.028	0.028	0.028	0.028
Average Emission Rate (g/s) for Long-term Impact Modelling	PM_{10}	0.014	0.014	0.014	0.014	0.014
	$PM_{2.5}$	0.007	0.007	0.007	0.007	0.007

For the shorter-term estimates, it is assumed that all the emissions described above are occurring at the same time, a conservative operating and thus emissions scenario. In reality, the shiploader will not be operating while the vessels are manoeuvring, only while hotelling. The assist tugboats likely will have departed the wharf area to provide port services elsewhere. The modeled operating scenario for the long-term emissions is more realistic.

4.2.2 Land-based Equipment

To estimate air emissions from Project Operations land-based equipment, information regarding the type and quantity of equipment was provided by the project design team. Aside from the rail operations, the land-based emission units consists of two dust collectors (Table 4.2-6), one for the dumper equipment and one for the transfer towers. As explained above, the horizontal vents require the estimate of pseudo-parameters for the dispersion modeling simulation. The plume rise area and rise velocity for PM emissions are set to 2.0 m and 0.1 m/s, respectively.

Table 4.2-6: Summary of Land-based Equipment Associated with Project Operations

Modelling ID		DC-01,	DC-02,
Dust Collector TPM Concentration rate (mg/m^3)		50	50
Description		Rail Car Dumper and Transfer point TT-03	Transfer Towers TT-01 and TT-02
TPM Flow rate (m^3/h)		54,368	45,873
Duration (hours/day)		24	24
Frequency (days/week)		7	7
Approximate UTM locations (Zone 9)	mE	413762	413800
	mN	6008514	6008460
Base Stack Elevation (m)	m	25	25
Stack Outlet Elevation above base stack elevation (m)	m	22	42
Exit Temperature	^{o}C	20	20
	^{o}K	293	293
Maximum Emission Rate (g/s) for Short-term Impact Modelling	PM_{10}	0.346	0.269
	$PM_{2.5}$	0.174	0.135
Average Emission Rate (g/s) for Long-term Impact Modelling	PM_{10}	0.085	0.066
	$PM_{2.5}$	0.043	0.033

4.2.3 Rail

Onsite Project rail emissions were developed using information provided by Ausenco-Sandwell Engineering, supplemented and confirmed by CN. This information included the number of trains per year, operating hours and modes, as well as the locomotive engine horsepower. This information, along with emission factors published by US EPA (US EPA 1997) is the foundation of the air emissions calculations.

To achieve the export rate, an estimated number of 400-600 trains carrying approximately 18,000 tonnes of potash will visit the Canpotex Terminal every year. Each train will be typically powered by three or four locomotives. It expected that the maximum emissions will occur when the train is approaching the terminal and destined for the unloading equipment as this is when the exposure duration to the locomotive emissions is longer. The same emissions mode is expected after the unloading finishes and the train is leaving the terminal. The maximum approach/departure duration is assumed to be one hour. After reaching the unloading equipment, the train will enter the pacesetter mode with two locomotives operating. At a 6,000 tph unloading rate, the unloading period will take approximately three hours.

Fuel rate estimates received from CN suggest that the fuel burn rates applicable to the above scenarios are:

- 180 L/hr per locomotive during the regular duty cycle mode
- 40 L/hr per locomotive during the pacesetter mode.

During the approach/departure, the trains powered by four locomotives are assumed to be burning fuel at a regular duty cycle rate representing the short-term emissions scenario (a conservative assumption[2]). For the long term emissions scenario it is assumed that while unloading, the trains with two locomotives are burning fuel at the pacesetter rate for three hours. Three to four locomotives powered for 600 hours at regular duty cycle rate and two locomotives powered at 1,800 hours for pacesetter mode, suggest that the long-term emissions are about 6 – 7% of the short-term emissions.

Locomotive emissions are included in dispersion simulations as an area source. Source and emissions parameters for the locomotives are summarized in Table 4.2.7.

Table 4.2-7: Summary of Source and Emission Parameters Associated with Locomotives during Project Operations

Modelling ID		**RAIL**			
Source Type		**Area**			
UTM Coordinates of area breakpoints	mE	413475	414151	415103	414122
	mN	6008823	6010345	6008970	6007909
Base Elevation (m)		30.0			
Release Height (m)		4.0			
Initial sigma z (m)		10.0			
Area (km^2)		1.79			
Maximum Emission Rate (g/s) for Short-term Effects Modelling	SO_2	0.17			
	NO_x	8.98			
	CO	1.08			
	PM_{10}	0.32			
	$PM_{2.5}$	0.32			
	VOC	0.34			

[2] Pers. comm. 2010. email from Lonny Kubas, CN to Canpotex.

Modelling ID		**RAIL**
Source Type		**Area**
Average Emission Rate (g/s) for Long-term Effects Modelling	SO_2	0.011
	NO_x	0.61
	CO	0.73
	PM_{10}	0.022
	$PM_{2.5}$	0.022
	VOC	0.023

4.3 Decommissioning Phase

The Project facilities lifetime is expected to be 50 years or more. At the end of the Project, the wharf will probably be reused for another industrial purpose suitable for the times. The rail lines will probably be maintained to service the new facility. Only the potash handling infrastructure is likely to be removed. If this scenario is correct, the amount of air emissions will be very low during this phase.

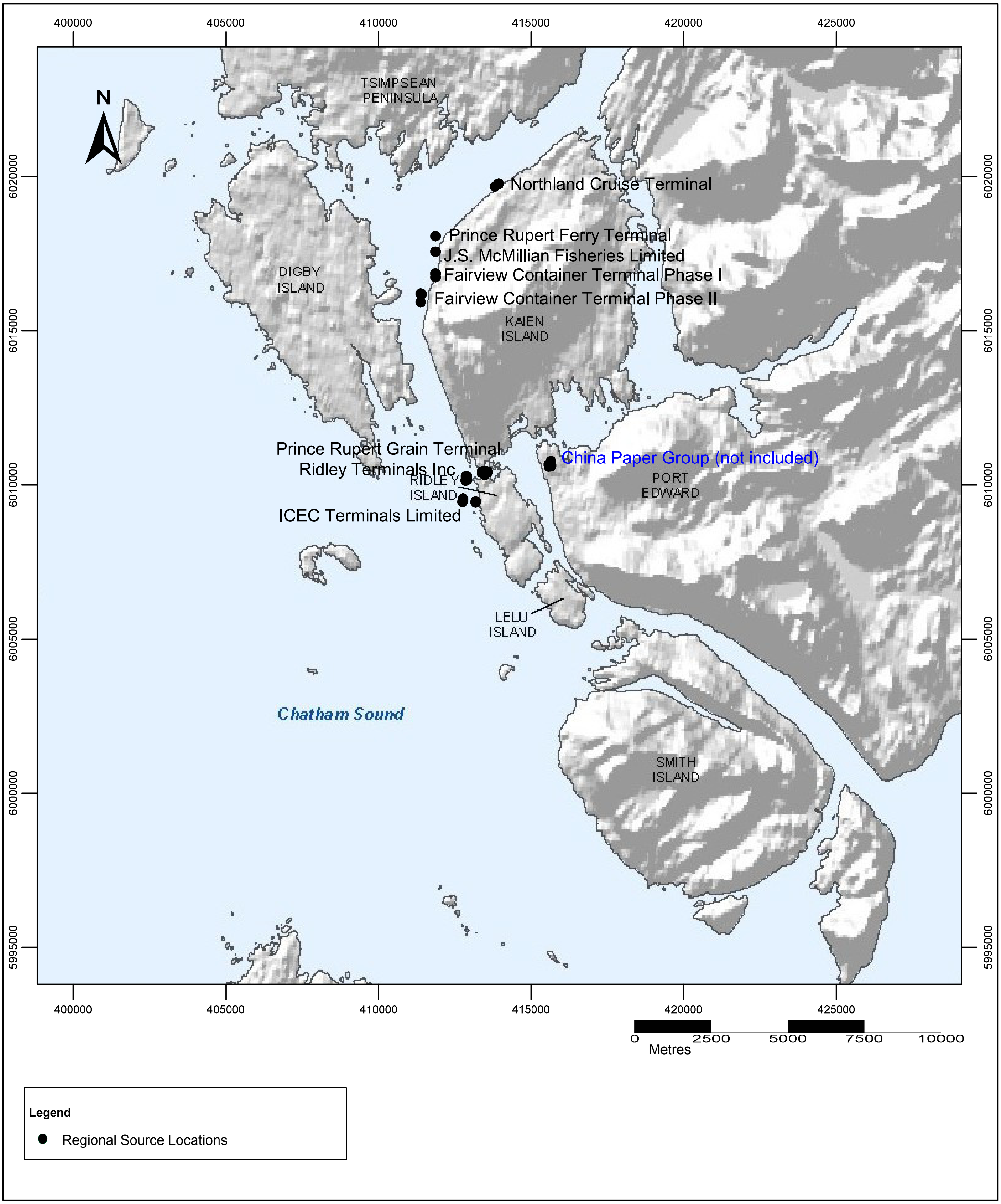
4.4 Regional Emission Sources

The effects of air emission sources associated with existing, approved or planned operations in the assessment area are evaluated. Background emission sources applied in the dispersion modelling are summarized in Table 4.4-1 and shown in Figure 4.4-1.

Table 4.4-1: Summary of Regional Emission Sources Included in Dispersion Modeling

Operation/Facility	Status
Northland Terminal	Operational
Ridley Island Coal Terminal	Operational
Prince Rupert Grain Ltd.	Operational
BC and Alaska Ferries	Operational
J S McMillan Fish Reduction Plant	Operational
Fairview Terminal (Phase I)	Operational
ICEC Terminal Company Ltd. Sulphur Forming, Handling and Storage Facility	Approved
Fairview Terminal (Phase II)	Planned
China Paper Group Pulp Mill	Not expect to restart operations

Emissions for most of the permitted sources within the assessment area were estimated using the approved emissions limits. Emissions information for the Fairview Terminal II facility was taken from the Fairview Terminal Phase II environmental assessment (Stantec 2009).



Stantec Consultants Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Canpotex

PRINCE RUPERT PORT AUTHORITY

Background Facilities within the Air Quality Assessment Area

PROJECTION	UTM	DRAWN BY	JS
DATUM	NAD 83	CHECKED BY	BK
DATE	2010-Jul-19	FIGURE NO.	4.4-1

P:/...c4383srf/Figure4.4-1.srf

Job No: 1231-10264

Table 4.4-2: Summary of Annual Emission Rates Associated with Existing, Approved, and Planned Background Facilities included in Dispersion Modelling

Parameter	Emission Rate (tpy)					
	Fairview Terminal Phase I	Fairview Terminal Phase II	J.S. McMillan Fisheries Limited	Ridley Island Coal Terminal	Prince Rupert Grain Limited	ICEC Terminal Company Ltd. Sulphur Terminal
SO_2	16.1	538.6	0.039	–	–	0.137
NO_X	223	687.2	5.74	–	–	8.28
CO	168	58.3	4.82	–	–	8.31
PM_{10}	10.7	22.4	0.327	47.6	166	1.62
$PM_{2.5}$	10.7	17.9	0.109	29.8	84.8	1.62
VOCs	28.0	27.4*	0.315	–	–	0.997*

*these are estimates as the facilities are not yet operational

Table 4.4-3: Summary of Maximum Emission Rates (Short-term) Associated with Existing and Approved Marine Vessel Sources included in Dispersion Modelling

Parameter	Emission Rate (g/s)									
	Fairview Terminal Phase I		Ridley Island Coal Terminal		Prince Rupert Grain Limited		Northland Cruise Terminal		BC Ferries Terminal	Alaska Ferries Terminal
	ULCS[1]	Tugs	Bulk Carriers	Tugs	Bulk Carriers	Tugs	Cruise Ships	Tugs	Ferries	Ferries
SO_2	4.011	–	3.015	–	2.141	–	24.241	–	1.352	1.318
NO_X	4.612	–	2.755	–	1.917	–	28.789	–	1.160	1.127
CO	0.358	–	0.223	–	0.159	–	2.167	–	0.101	0.099
PM_{10}	0.098	–	0.073	–	0.052	–	0.591	–	0.033	0.032
$PM_{2.5}$	0.078	–	0.059	–	0.042	–	0.473	–	0.026	0.026
VOCs	0.126	–	0.093	–	0.065	–	0.784	–	0.039	0.038

NOTES:
[1] ULCS – Ultra Large Container Ship

Table 4.4-4: Summary of Average Emission Rates (Long-term) Associated with Existing and Approved Marine Vessel Sources Included in Dispersion Modelling

Parameter	Emission Rate (g/s)									
	Fairview Terminal Phase I		Ridley Island Coal Terminal		Prince Rupert Grain Limited		Northland Cruise Terminal		BC Ferries Terminal	Alaska Ferries Terminal
	ULCS[1]	Tugs	Bulk Carriers	Tugs	Bulk Carriers	Tugs	Cruise Ships	Tugs	Ferries	Ferries
SO_2	2.318	0.006	1.247	0.003	0.890	0.003	2.487	0.003	0.251	0.252
NO_X	2.850	0.131	1.214	0.073	0.849	0.073	3.003	0.073	0.217	0.062
CO	0.246	0.011	0.107	0.006	0.076	0.006	0.233	0.006	0.019	0.021
PM_{10}	0.093	0.007	0.044	0.004	0.031	0.004	0.072	0.004	0.006	0.006
$PM_{2.5}$	0.074	0.006	0.035	0.003	0.025	0.003	0.057	0.003	0.005	0.005
VOCs	0.113	0.005	0.054	0.003	0.038	0.003	0.090	0.003	0.007	0.002

NOTES:
[1] ULCS – Ultra Large Container Ship

In addition to the above point sources of emissions, area and mobile sources from the surrounding community (home heating, vehicles, etc.) contribute significantly to the assessment area's total annual emissions. Information about these additional sources of CACs is available from periodic emission inventories compiled by the BC MOE. Emission totals from the year 2000 inventory were obtained from the Ministry's Air Contaminant Emissions (ACE) inventory system for the relevant assessment area and are listed in Table 4.4-5.

Table 4.4-5: Total Existing CAC Emissions from the BC MOE year 2000 Emission Inventory

Source	CAC Emissions (tpy)					
	SO_2	NO_X	CO	PM_{10}	$PM_{2.5}$	VOCs
Total emissions in the assessment area	1,946	3,893	6,886	2,910	1,793	1,012

Background marine traffic emissions were calculated based on known operating parameters and published emission factors. The operational status of the regional background sources are summarized in Table 4.4-1 and the emissions are shown in Table 4.4-2. Permitted emissions from the China Paper facility were not considered since it is not expected that the facility will not be reactivated in the foreseeable future. Maximum and average emissions associated with background marine vessel sources are summarized in Table 4.4-3 and Table 4.4-4, respectively.

4.5 Locomotive Emissions along the CN line, Ridley Island to Lorne Creek

Although the assessment is focussed on the Project area, locomotive emissions will also affect the environment further to the west. The eastern boundary for the locomotive emissions assessment has been set at Lorne Creek, situated along the west bound rail line north of Terrace. The length of the rail line from Lorne Creek to Ridley Island is approximately 200 km. At an average speed of 20 km per hour, trains will take approximately 10 hours to make the journey. Conservative estimates assume that the locomotives are operating and emitting at full duty cycle mode. Full throttle is a likely situation when the locomotives are powering the trains up a hill, but not when a descent is being made.

Table 4.5-1 provides the estimates of the annual emissions for the increased regional train activity and assuming full throttle operations. A comparison is made with the emission estimates within 10 km of Terrace BC (Stantec 2009). The largest increase is for the nitrogen oxides at approximately 5%. Since the locomotive emission estimates assume full throttle while travelling through the area, these estimates are very conservative.

Table 4.5-1: Regional Locomotive Emissions Compared to Terrace Area Emissions

	Maximum Emission Rates (tpy)					
	SO_2	NO_x	CO	PM_{10}	$PM_{2.5}$	VOC
Regional Locomotive Emissions	0.52	27.8	3.34	1.00	1.00	1.06
Emissions at Terrace Area, B.C.	44.0	536.6	6,768.1	1,231.5	726.8	1,266.8
Incremental Increase (%)	**1.2**	**5.2**	**0.05**	**0.08**	**0.13**	**0.07**

4.6 Emissions Summary Discussion

Table 4.6-1 has a comparison of the emission estimates for Construction versus Operations. Although some Construction emissions are comparable to Operations emissions, the construction activities will be staggered and temporary while the operations activities are continuous. Also, the Construction phase is short lived compared to the Operations phase. CAC emissions from construction vehicles are expected to be small in comparison to the total emissions of the assessment area. Consequently, air dispersion modeling (presented in Section 5) is completed only for Operations, as this is represents the longer-term continuous emissions from the Project.

Table 4.6-1: Project Phases Emissions Comparison

Project Phase	Emission Rate (tpy)					
	SO_2	NO_X	CO	PM_{10}	$PM_{2.5}$	VOCs
Construction	0.34	171.6	171.6	9.8	9.78	26.2
Operations	40.8	156.6	13.9	16.2	11.6	5.7

5 DISPERSION MODELLING

Project effects on ambient air quality were assessed using the results obtained from dispersion simulations. All modelling was conducted in accordance with applicable regulatory guidance given by the BC MOE in their current *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MOE 2008), henceforth referred to as the BC Guidelines.

5.1 Dispersion Model Selection

Dispersion modelling predictions provide a link between air emissions and ambient air quality changes as a result of these emissions. Dispersion modelling was conducted using the United States Environmental Protection Agency (US EPA) CALPUFF dispersion modelling system. The CALPUFF model is a non-steady-state Gaussian puff dispersion model which incorporates simple chemical transformation mechanisms, wet and dry deposition, complex terrain algorithms, and building downwash. The CALPUFF model is suitable for estimating air contaminant ground-level concentrations on both local and regional scales, from tens of meters to hundreds of kilometres.

The CALPUFF model is described in detail in Appendix A.

5.2 Meteorological Data

Meteorology plays a major role in determining air contaminant concentration levels downwind of industrial and non-industrial emission sources. CALMET provides the meteorological environment as input to the CALPUFF model. The CALMET model requires the input of surface and upper air meteorological fields. For this application, CALMET was initialized with surface station information from three surface weather stations in the domain, as summarized in Table 5.2-1.

Upper-level meteorological data were obtained from the MM5 meso-scale model covering the year 2002. Hourly output from the MM5 model at 12 km resolution was provided by Environment Canada. The MM5 model was initialized with gridded binary data obtained from the National Center for Atmospheric Research.

Table 5.2-1: Input Surface Meteorological Stations

Station Name	Type	Easting (km)	Northing (km)	Elevation (m asl)	Surface Input Data Used
Port Edward Mill	MOE	415.773	6010.285	30	Temperature, Wind Speed (January – September)
Galloway Rapids	MOE	417.491	6013.160	1	Temperature, Wind Speed and Direction (January – September)
Prince Rupert Airport	EC	406.688	6015.994	35	Temperature, Wind Speed and Direction, Cloud Cover and Ceiling Height, Station Pressure, Relative Humidity

Further details regarding the application of the CALMET model are provided in Appendix A. This meteorological model produced three-dimensional meteorological fields (e.g., winds, temperatures and turbulence) for the CALPUFF dispersion model.

5.3 Topography and Receptors

The proposed Project is located on Ridley Island off the northern mainland coast of British Columbia. Terrain in the region is complex with elevations ranging from sea level to heights greater than 950 m above sea level (asl). The base elevation at the land portion of the proposed Project site is approximately 40 m asl or lower.

Terrain elevations in the model were initialized with data from the Natural Resources Canada Canadian Digital Elevation Data (CDED). The Canadian Digital Elevation Data (CDED) consists of an ordered array of ground level elevations at regularly spaced intervals. Depending on the latitude of the CDED section, the grid spacing varies in resolution from a minimum of 0.75 arc seconds to a maximum 3.0 arc seconds (about 90 m). Since topographic relief within the study area is substantial, the CALPUFF must be capable of handling all potential receptors on nearby terrain. All receptors are located in UTM Zone 9.

Multiple receptor networks centred on the Project site were established for the purposes of extracting predictions from the dispersion simulations. The grids and their corresponding receptor spacing are:

- 30 km by 30 km, with 1,000 m spacing
- 13 km by 13 km, with 500 m spacing
- 7 km by 7 km, with 250 m spacing
- 4 km by 4 km, with 50 m spacing
- 20 m spacing along the Project boundary and in areas of maximum predicted effect.

5.4 Sensitive Receptors

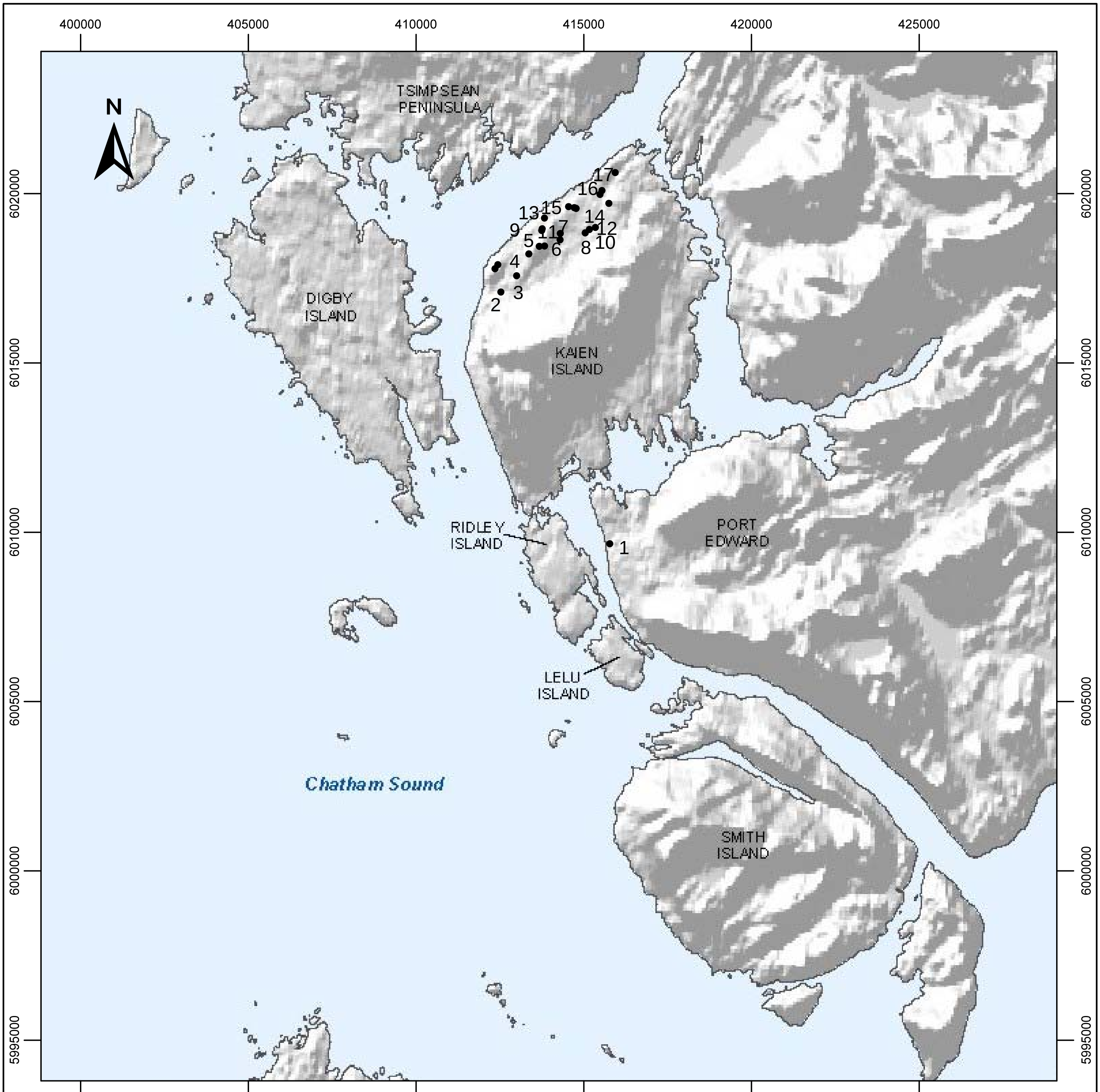
A number of schools, hospitals and residences were selected as sensitive receptors within the assessment area such that maximum predicted ground-level concentrations of air contaminants of interest could be determined for these locations. Table 5.4-1 and Figure 5.4-1 show the location of sensitive receptors included in dispersion modelling.

Table 5.4-1: Sensitive Receptors Included in Dispersion Modelling

Receptor	UTM NAD83		Elevation (m asl)
	Easting (m)	Northing (m)	
Port Edward Elementary	415775	6009659	24.6
Prince Rupert Closest Residence	412529	6017092	34.0
Pineridge Elementary	412998	6017575	58.3
Prince Rupert Regional Hospital	413363	6018220	68.6
Roosevelt Park Elementary	413672	6018444	74.4
Prince Rupert Middle School	414296	6018637	20.0
First Nations Education	414300	6018822	21.3
Discovery Child Care	415045	6018841	37.8
Seniors Centre	413748	6018909	39.1
Charles Hays Secondary School	415169	6018939	39.0
Northwest Community College	413763	6018959	41.7
Cedar Road Aboriginal Headstart Program	415347	6019000	45.2
Berry Patch Child Care	413828	6019277	32.9
Fellowship Baptist Nursery School	414774	6019563	32.3
Kaien Senior Citizens Housing	414548	6019614	38.1
Conrad Street Elementary	415484	6019977	35.8
KIDS Daycare	415543	6020091	34.7

5.5 Building Downwash Effects

Buildings or other solid structures may affect the flow of air near a source and cause building downwash (e.g., eddies on the downwind side) which have potential to reduce plume rise and enhance air contaminant concentrations. Only the Canpotex Terminal potash storage building is planned. Unfortunately, the building plans were not advanced enough to model these structures and predict the effects. Overall, building downwash effects are second order and will be assumed small compared to the primary dispersion effects. As well, any downwash effects will likely be on the on ocean side of the facility and isolated from any human or biota receptors.



0 2500 5000 7500 10000
Metres

1 Port Edward Elemenentary
2 Prince Rupert Closest Residence
3 Pineridge Elementary
4 Prince Rupert Regional Hospital
5 Roosevelt Park Elementary
6 Prince Rupert Middle School
7 First Nations Education
8 Discovery Child Care
9 Seniors Centre
10 Charles Hays Secondary School
11 Northwest Community College
12 Cedar Road Aboriginal Headstart Program
13 Berry Paatch Child Care
14 Fellowship Baptist Nursery School
15 Kaien Senoir Citizens Housing
16 Conrad Street Elementary
17 KIDS Daycare

Stantec Consultants Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Stantec

Canpotex

PRINCE RUPERT PORT AUTHORITY

Location of Sensitive Receptors in the Air Quality Assessment Area

PROJECTION	UTM	DRAWN BY	JS
DATUM	NAD 83	CHECKED BY	MK
DATE	2010-Jul-19	FIGURE NO.	5.4-1

P:../c4383srf/Figure5.4-1.srf

Job No: 1231-10264

5.6 NO_X to NO_2 Conversion

Oxides of nitrogen (NO_x) are comprised of nitric oxide (NO) and nitrogen dioxide (NO_2). Ambient air quality guidelines exist for NO_2 rather than total NO_x. Therefore, it is important to be able to estimate the NO_2 portion of predicted ground-level NO_x. One method is the Ambient Ratio Method (ARM), recommended by BC MOE (2008).

ARM provides a realistic prediction of NO_2 concentrations based on actual monitored concentrations of NO_2 and NO_x preferably near the assessment area. Two separate non-linear regressions were developed based on NO_X and NO_2 measurements from the Smithers, St. Josephs, and Kitimat Rail continuous ambient monitoring stations from 2001 to 2005. However, it was determined that due to the low observed values at both sites, an accurate relationship that holds for all concentrations could not be developed. Therefore, to ensure a conservative approach, observed data from Wood Buffalo Environmental Association (WBEA) monitoring stations at several oil sands mines (CEMA 2005) were investigated. The data from the Albian Mine site were used to develop the ARM equation relating NO_x and NO_2 predictions for all averaging periods. These data were selected as being representative of average conditions in the oil sands area.

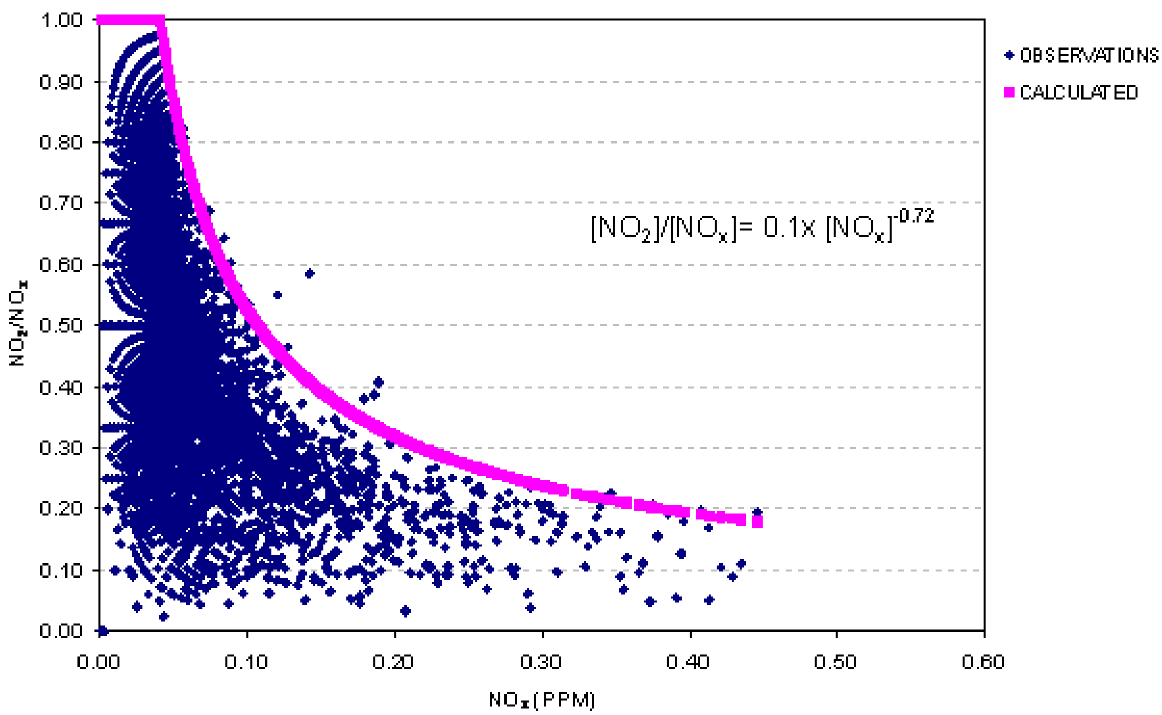


Figure 5.6-1: Hourly NO_X and NO_2 Concentrations Applied in ARM Conversion

The equation is as follows:

$$[NO_2]/[NO_x] = 0.100*[NO_x]^{-0.72}$$

where:

$[NO_2]$ = Concentration of nitrogen dioxide (ppm)
$[NO_x]$ = Concentration of oxides of nitrogen (ppm)

A graphical representation is shown in Figure 5.6-1.

The above relationship was used to calculate NO_2 levels from the NO_x concentrations obtained through dispersion modelling.

5.7 Ambient Air Quality Criteria

The Canada (or National) Ambient Air Quality Objectives (NAAQO) and British Columbia Ambient Air Quality Objectives (BC AAQO) are shown in Table 5.7-1. Historically, the NAAQO are denoted as Desirable, Acceptable and Tolerable. The BC AAQO are denoted as Levels A, B and C. The NAAQO are defined as follows:

Maximum Desirable Level—is the long-term goal for Air Quality and provides a basis for anti-degradation policy for unpolluted parts of the country, and for the continuing development of control technology.

Maximum Acceptable Level—provides adequate protection against effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being.

Maximum Tolerable Level—denotes time-based concentrations of air contaminants beyond which, due to a diminishing margin of safety, appropriate action is required to protect the health of the general population.

The BC AAQO are defined as follows:

Level A—is set as the objective for new and proposed discharges and, within the limits of best practicable technology, to existing discharges by planned staged improvements for these operations.

Level B—is set as the intermediate objective for all existing discharges to meet within a period of time specified by BC MOE, and as an immediate objective for existing discharges which may be increasing in quantity or altered in quality as a result of process expansion or modification.

Level C—is set as the immediate objective for all existing chemical and petroleum industries to reach within a minimum technically feasible period of time.

In 2009, the BC Ministry of Healthy Living and Sport, adopted new objectives for $PM_{2.5}$ concentrations. The 24-hour objective is now 25 µg m^{-3} bracketed by the 98 percentile over one year duration. The annual objective is now 8 µg m^{-3} with a recommendation to reduce to 6 µg m^{-3}. Currently there are no ambient air quality objectives for total VOCs.

Table 5.7-1: National and Provincial Ambient Air Quality Objectives

Substance (units)	Averaging Time Period	British Columbia[a]			Canada[b]			
		Level A	Level B	Level C	Canada Wide Standards (pending)	Maximum Desirable	Maximum Acceptable	Maximum Tolerable
Sulphur Dioxide ($\mu g\ m^{-3}$)	One-hour	450	900	900–1,300	–	450	900	–
	3-hour	375	665	–	–	–	–	–
	24-hour	160	260	360	–	150	300	800
	Annual	25	50	80	–	30	60	–
Nitrogen Dioxide ($\mu g\ m^{-3}$)	One-hour	–	–	–	–	–	400	1000
	24-hour	–	–	–	–	–	200	300
	Annual	–	–	–	–	60	100	–
Carbon Monoxide ($\mu g\ m^{-3}$)	One-hour	14,300	28,000	35,000	–	15,000	35,000	–
	Eight-hour	5,500	11,000	14,300	–	6,000	15,000	20,000
PM_{10} ($\mu g\ m^{-3}$)	24-hour	50			–	–	–	–
$PM_{2.5}$ ($\mu g\ m^{-3}$)	24-hour	25[c]			30[d]	–	–	–
	Annual	8[c]			–	–	–	–

SOURCES:

[a] BC Ministry of Environment. Air Quality Objectives and Standards. 2009. Available at: http://www.bcairquality.ca/reports/pdfs/aqotable.pdf.

[b] Health Canada. National Ambient Air Quality Objectives. Available at: http://www.hc-sc.gc.ca/ewh-semt/pubs/air/naaqo-onqaa/index-eng.php and http://www.hc-sc.gc.ca/ewh-semt/air/out-ext/reg-eng.php#a3.

[c] British Columbia Ministry of Healthy Living and Sport, Air Quality Objectives and Standards.2009. Available at: http://www.bcairquality.ca/reports/pdfs/aqotable.pdf. The $PM_{2.5}$ 24-hour average is based on 98th percentile value for one year.

[d] CCME (2000), Canada-Wide Standards for Respirable Particulate Matter ($PM_{2.5}$), effective 2010. The $PM_{2.5}$ Standard is based on the based on annual 98th percentile value, averaged over 3 consecutive years.

5.8 Dispersion Modelling Scenarios

Four dispersion modelling scenarios were considered:

- **Baseline Case**—including emissions from existing and approved industrial sources within the study area
- **Project Case**—including emissions solely from the proposed Project (marine, land and rail emissions)
- **Application Case**—the Baseline Case plus Project Case emissions
- **Cumulative Case**—Application Case plus future planned developments within the study area.

6 DISPERSION MODELLING RESULTS

The following sections present the results of the dispersion modelling completed as part of the Project air quality assessment. An interpretation of the dispersion modelling results is included in Section 7 (Air Quality) of the Project environmental assessment (Stantec 2011).

6.1 Baseline Case

The Baseline Case modelling scenario includes emissions from existing and operational industrial sources in the air quality assessment area (Table 4.4-1). Isopleths of maximum predicted ground-level concentrations for the Baseline Case are shown in Figures B-1 to B-9 in Appendix B of this TDR. A summary of the maximum predicted ground-level concentrations associated with the Baseline Case emissions are presented in Table 6.1-1. Modelling results show all maximum predicted ground-level concentrations of SO_2, NO_2, CO, PM_{10}, and $PM_{2.5}$ were below the corresponding BC AAQO and NAAQO.

Table 6.1-1: Maximum Predicted Ground-level Concentrations Associated with Baseline Case

Substance	Averaging Period	Maximum Predicted Ground-level Concentration ($\mu g\ m^{-3}$)	BC AAQO ($\mu g\ m^{-3}$)			NAAQO ($\mu g\ m^{-3}$)		
			Level A	Level B	Level C	Maximum Desirable	Maximum Acceptable	Maximum Tolerable
SO_2	One-hour	442	450	900	900 – 1,300	450	900	–
	3-hour	259	375	665	–	–	–	–
	24-hour	80.7	160	260	360	150	300	800
	Annual	4.07	25	50	80	30	60	–
NO_2	One-hour	174	–	–	–	–	400	1,000
	24-hour	110	–	–	–	–	200	300
	Annual	46.8	–	–	–	60	100	–
CO	One-hour	963	14,300	28,000	35,000	15,000	35,000	–
	Eight-hour	430	5,500	11,000	14,300	6,000	15,000	20,000
PM_{10}	24-hour	9.75	50			–	–	–
$PM_{2.5}$ [a]	24-hour	9.74	25			30 (CWS)		
	Annual	2.44	8			–		
VOCs	One-hour	163	–	–	–	–	–	–
	24-hour	35.2	–	–	–	–	–	–
	Annual	6.23	–	–	–	–	–	–

NOTE:
[a] 98th percentile value of 24-hour ground-level concentration.

The maximum predicted one-hour, 3-hour, 24-hour and annual average ground-level SO_2 concentrations predicted from the Baseline Case are equal to 442, 259, 80.7 and 4.07 µg m^{-3}, respectively. The one-hour predicted concentration is less than the most stringent ambient air quality objective of 450 µg m^{-3} (Level A). The 3-hour predicted concentration is about 30% less than the Level-A BC AAQO of 375 µg m^{-3}. The maximum predicted 24-hour and annual average SO_2 concentrations are about half and one-sixth, respectively, of the most stringent ambient air quality objectives.

Maximum predicted one-hour and 24-hour ground-level NO_2 concentrations, of 174 and 110 µg m^{-3}, respectively are approximately half of the maximum acceptable NAAQO. The maximum predicted annual average ground-level NO_2 concentrations of 46.8 µg m^{-3} is less than the national maximum desirable objective of 60 µg m^{-3} by about 22%.

Maximum predicted one-hour and eight-hour ground-level CO concentrations for the Baseline Case are 963 and 430 µg m^{-3}, respectively. Both predictions are far less than the most stringent one-hour (14,300 µg m^{-3}) and eight-hour (5,500 µg m^{-3}) ambient air quality objectives.

24-hour PM_{10} and $PM_{2.5}$ maximum values are the 98th percentile of the year's daily values. The maximum predicted 24-hour PM_{10} concentration of 9.75 µg m^{-3} is about 20% of the BC AAQO. Similarly, the maximum predicted 98th percentile 24-hour $PM_{2.5}$ concentration of 9.74 µg m^{-3} is much less than the CWS of 30 µg $m^{-3,}$ and the BC AAQO of 25 µg m^{-3}. The maximum annual $PM_{2.5}$ concentration is 2.44 µg m^{-3}, much less than the current BC AAQO of 8 µg m^{-3}.

Maximum predicted one-hour, 24-hour and annual average ground-level VOC concentrations are 163, 35.2, and 6.23 µg m^{-3}, respectively. Currently, there are no provincial or national ambient air quality objectives for total VOCs.

6.2 Project Case

The Project Case scenario includes emissions solely from the Canpotex Terminal component and the CN service. Isopleths of maximum predicted ground-level concentrations for the Project Case are shown in Figures B-10 to B-18, Appendix B, of this TDR. A summary of the maximum predicted ground-level concentrations associated with emissions from the Project Case are presented in Table 6.2-1. For the Project Case, all maximum predicted ground-level concentrations of SO_2, NO_2, CO, PM_{10}, and $PM_{2.5}$ were below the corresponding BC AAQO and NAAQO.

The maximum predicted one-hour, 3-hour, 24-hour and annual average ground-level SO_2 concentrations associated with the Project Case are 48.9, 37.4, 22.2 and 0.05 µg m^{-3}, respectively, well below the most stringent objectives.

Maximum predicted one-hour, 24-hour and annual average ground-level NO_2 concentrations are 157, 128 and 6.94 µg m^{-3}, respectively. The one-hour and 24-hour maxima are 39% and 64%, respectively, of the most stringent NAAQO; the annual average is much less.

Maximum predicted one-hour and eight-hour ground-level CO concentrations associated with the Project Case are 87.8 and 57.8 µg m^{-3}, respectively. Both concentrations are much less than the most stringent one-hour (14,300 µg m^{-3}) and eight-hour (5,500 µg m^{-3}) ambient air quality objectives.

24-hour PM_{10} and $PM_{2.5}$ maximum values are the 98th percentile of the year's daily values. The maximum predicted 24-hour averaged PM_{10} concentration of 74.7 µg m^{-3} exceeds the BC AAQO of 50 µg m^{-3}. However there is no NAAQO for 24-hour averaged PM_{10}. The maximum predicted 24-hour $PM_{2.5}$ concentration of 21.8 µg m^{-3} is 73% of the CWS of 30 µg m^{-3} and 87% of the BC AAQO, which is 25 µg m^{-3}. These predictions are very conservative, as it is assuming that emissions from the ship berthing/deberthing and shiploading are occurring at the same time, an unlikely event. As well the predicted maxima are found to the northwest of the wharf area over the ocean (See Figure B-16 for 24-hour averaged PM_{10}. The predicted annual $PM_{2.5}$ concentration of 0.87 µg m^{-3} is much lower than the current BC objective of 8 µg m^{-3}.

Maximum predicted one-hour; 24-hour and annual average ground-level VOC concentrations associated with the Project Case are 35.4, 17.2 and 0.26 µg m^{-3}, respectively. Currently, there are no AAQOs for total VOCs.

Table 6.2-1: Maximum Predicted Ground-level Concentrations Associated with Project Case

Substance	Averaging Period	Maximum Predicted Ground-level Concentration (µg m^{-3})	BC AAQO (µg m^{-3})			NAAQO (µg m^{-3})		
			Level A	Level B	Level C	Maximum Desirable	Maximum Acceptable	Maximum Tolerable
SO_2	One-hour	48.9	450	900	900 – 1,300	450	900	–
	3-hour	37.4	375	665	–	–	–	–
	24-hour	22.2	160	260	360	150	300	800
	Annual	0.05	25	50	80	30	60	–
NO_2	One-hour	157	–	–	–	–	400	1,000
	24-hour	128	–	–	–	–	200	300
	Annual	6.94	–	–	–	60	100	–
CO	One-hour	87.8	14,300	28,000	35,000	15,000	35,000	–
	Eight-hour	57.8	5,500	11,000	14,300	6,000	15,000	20,000
PM_{10}	24-hour	74.7	50			–	–	–
$PM_{2.5}$ [a]	24-hour	21.8	25			30 (CWS)		
	Annual	0.87	8			–		
VOCs	One-hour	35.4	–	–	–	–	–	–
	24-hour	17.2	–	–	–	–	–	–
	Annual	0.26	–	–	–	–	–	–

NOTE:
[a] 98th percentile value of 24-hour ground-level concentration.

6.3 Application Case

The Application Case modelling scenario includes emissions from the Project combined with emissions from existing assessment area industrial sources. Isopleths of maximum predicted Application Case ground-level concentrations are shown in Appendix B, Figures B-19 to B-27. A summary of the maximum predicted Application Case ground-level concentrations are presented in Table 6.3-1. All maximum predicted ground-level concentrations, with the exception of 24-hour PM_{10} are below the BC AAQO. All maximum predicted concentrations are below the NAAQO.

Table 6.3-1: Maximum Predicted Ground-level Concentrations Associated with the Application Case

Substance	Averaging Period	Maximum Predicted Ground-level Concentration ($\mu g\ m^{-3}$)	BC AAQO ($\mu g\ m^{-3}$)			NAAQO ($\mu g\ m^{-3}$)		
			Level A	Level B	Level C	Maximum Desirable	Maximum Acceptable	Maximum Tolerable
SO_2	One-hour	442	450	900	900 – 1,300	450	900	–
	3-hour	259	375	665	–	–	–	–
	24-hour	80.7	160	260	360	150	300	800
	Annual	4.08	25	50	80	30	60	–
NO_2	One-hour	174	–	–	–	–	400	1,000
	24-hour	128	–	–	–	–	200	300
	Annual	47.2	–	–	–	60	100	–
CO	One-hour	964	14,300	28,000	35,000	15,000	35,000	–
	Eight-hour	430	5,500	11,000	14,300	6,000	15,000	20,000
PM_{10}	24-hour	74.7	50			–	–	–
$PM_{2.5}$ [a]	24-hour	21.8	25			30 (CWS)		
	Annual	2.47	8			–		
VOCs	One-hour	164	–	–	–	–	–	–
	24-hour	35.2	–	–	–	–	–	–
	Annual	6.25	–	–	–	–	–	–

NOTE:
[a] 98^{th} percentile value of 24-hour ground-level concentration

Except for the PM_{10} and $PM_{2.5}$ maxima, the Project emissions added only incremental amounts to the Baseline Case maximum values, so the Application Case maxima for the other CACs are similar to the Baseline Case maxima. Since most of the Project emissions are particulate matter, these results should be expected. As well, most of the increased PM_{10} and $PM_{2.5}$ levels are over the ocean to the northwest of the wharf and far away from the other Baseline Case sources.

6.4 Cumulative Effects Assessment Case

The cumulative effects assessment case (CEA Case) modelling scenario includes emissions from the Application Case as well as emissions from planned sources within the assessment area. Planned sources include the ICEC Terminal at the Fairview II complex (Table 4.4-3).

Isopleths of maximum predicted ground-level concentrations for the CEA Case are shown in Figures B-25 to B-32 in Appendix B. A summary of the maximum predicted ground-level concentrations associated with emissions from the CEA Case are presented in Table 6.4-1. For the CEA Case, nearly all of the maximum predicted ground-level concentrations of SO_2, NO_2, CO, PM_{10}, and $PM_{2.5}$ were below the corresponding BC AAQO and NAAQO.

Table 6.4-1: Maximum Predicted Ground-level Concentrations Associated with CEA Case

Substance	Averaging Period	Maximum Predicted Ground-level Concentration (µg m^{-3})	BC AAQO (µg m^{-3})			NAAQO (µg m^{-3})		
			Level A	Level B	Level C	Maximum Desirable	Maximum Acceptable	Maximum Tolerable
SO_2	One-hour	449	450	900	900 – 1,300	450	900	–
	3-hour	259	375	665	–	–	–	–
	24-hour	80.7	160	260	360	150	300	800
	Annual	8.48	25	50	80	30	60	–
NO_2	One-hour	175	–	–	–	–	400	1,000
	24-hour	128	–	–	–	–	200	300
	Annual	50.3	–	–	–	60	100	–
CO	One-hour	985	14,300	28,000	35,000	15,000	35,000	–
	Eight-hour	436	5,500	11,000	14,300	6,000	15,000	20,000
PM_{10}	24-hour	74.7	50			–	–	–
$PM_{2.5}$ [a]	24-hour	21.8	25			30 (CWS)		
	Annual	2.63	8			–		
VOCs	One-hour	168	–	–	–	–	–	–
	24-hour	35.7	–	–	–	–	–	–
	Annual	6.63	–	–	–	–	–	–

NOTE:
[a] 98th percentile value of 24-hour ground-level concentration.

The maximum predicted one-hour, 3-hour, and 24-hour average ground-level SO_2 concentrations associated with the CEA Case are 449, 259, and 80.7 µg m^{-3} respectively, little changed from the Application Case predictions and still within the most stringent objectives. The annual concentration prediction of 8.48 µg m^{-3} is slightly higher than the Application Case, but well below the most stringent BC AAQO objective.

Maximum predicted one-hour and 24-hour ground-level NO_2 concentrations, of 175 and 128 µg m^{-3}, respectively, are little changed from the Application Case. The maximum predicted annual average ground-level NO_2 concentration of 50.3 µg m^{-3} is incrementally changed from the Application Case average of 47.2 µg m^{-3}.

Maximum predicted one and eight-hour ground-level CO concentrations are 985 and 436 µg m^{-3}, respectively. Both concentrations are much less than the most stringent one-hour (14,300 µg m^{-3}) and eight-hour (5,500 µg m^{-3}) ambient air quality objectives.

24-hour PM_{10} and $PM_{2.5}$ maximum values are the 98th percentile of the year's daily values. The maximum predicted 24-hour PM_{10} and $PM_{2.5}$ concentrations of 74.7 µg m^{-3} and 21.8 µg m-3, respectively, are unchanged from the Application Case.

As with the Project Case, the maximum PM_{10} prediction of 74.7 µg m^{-3} is above the BC AAQO, however there is no NAAQO. Also the areas for maximum predictions of found to the northeast of the wharf. The national standard for $PM_{2.5}$ is the Canada Wide Standard of 30 µg m^{-3} for a 24-hour average; this standard is not exceeded by the CEA Case.

Maximum predicted one-hour, 24-hour and annual average VOC concentrations are 168, 35.7, and 6.63 µg m^{-3}, respectively, and are little changed from the Application Case results. Currently, there are no AAQOs for total VOCs.

6.5 Sensitive Receptors

The maximum predicted CAC ground-level concentrations were determined for the sensitive receptor locations identified in Table 5.4-1.

The results for the Baseline, Project, Application and CEA Emissions scenarios are presented in Tables 6.5-1, 6.5-2, 6.5-3 and 6.5-4, respectively. All predicted ground-level concentrations at the sensitive receptors are below the relevant regulatory objectives. All concentration predictions are purposely conservative, so the predicted effects support an acceptable air quality assessment when considering all current and planned emission sources.

Table 6.5-1: Summary of Maximum Predicted Ground-level Concentrations at Sensitive Receptors Associated with Baseline Case

Receptor	Maximum Predicted Ground-level Concentration (µg m^{-3})													
	SO_2				NO_2			CO		PM_{10}	$PM_{2.5}$ [a]	VOCs		
	1-hour	3-hour	24-hour	Annual	1-hour	24-hour	Annual	1-hour	8-hour	24-hour	24-hour	1-hour	24-hour	Annual
Port Edward Elementary	19.5	15.0	5.5	0.22	27.4	6.8	0.52	15.0	7.5	1.56	0.84	2.5	0.61	0.05
Prince Rupert Closest Residence	92.2	82.9	12.6	0.74	119	73.2	4.22	261	131	1.78	1.74	43.6	9.18	0.49
Pineridge Elementary	61.0	43.1	10.0	0.55	104	38.9	2.29	161.5	71.4	1.00	0.93	27.1	4.74	0.25
Prince Rupert Regional Hospital	74.5	46.0	11.5	0.41	92.1	22.0	1.48	91.3	46.8	0.78	0.61	15.6	2.39	0.16
Roosevelt Park Elementary	85.2	51.5	11.0	0.35	87.0	18.7	1.23	68.6	38.6	0.71	0.54	11.9	1.95	0.13
Prince Rupert Middle School	69.3	51.8	11.2	0.25	84.0	13.9	0.93	49.7	28.7	0.54	0.40	8.3	1.60	0.10
First Nations Education	76.9	58.2	14.5	0.27	93.1	17.2	0.93	44.6	27.7	0.51	0.41	7.4	1.49	0.09
Discovery Child Care	84.6	46.5	21.3	0.31	83.8	25.4	0.86	37.1	23.1	0.55	0.42	6.2	1.30	0.08
Seniors Centre	84.2	53.5	14.1	0.27	84.7	17.6	1.06	52.2	35.2	0.55	0.44	9.2	1.81	0.11
Charles Hays Secondary School	83.7	57.1	27.4	0.32	83.6	32.5	0.84	34.4	22.0	0.55	0.42	5.9	1.25	0.08
Northwest Community College	84.9	50.6	14.2	0.27	84.9	17.9	1.05	51.3	34.9	0.55	0.45	9.1	1.81	0.11
Cedar Road Aboriginal Headstart Program	106	63.3	29.4	0.32	89.4	37.8	0.81	31.9	20.6	0.52	0.42	5.5	1.32	0.07
Berry Patch Child Care	185	69.9	14.0	0.22	105	19.3	0.95	43.9	31.6	0.51	0.39	7.9	1.62	0.10
Fellowship Baptist Nursery School	155	97.5	39.1	0.48	99.4	48.0	1.08	33.9	21.9	0.74	0.57	6.0	1.53	0.08
Kaien Senior Citizens Housing	159	99.7	46.0	0.57	100	56.2	1.25	36.3	23.4	0.84	0.69	6.5	1.76	0.09
Conrad Street Elementary	81.9	48.1	20.9	0.28	84.8	28.4	0.72	23.3	18.1	0.49	0.37	4.2	1.37	0.06
KIDS Daycare	74.1	47.1	17.7	0.26	83.5	26.2	0.68	26.0	17.9	0.48	0.34	4.9	1.39	0.06

NOTE:
[a] 98^{th} percentile value of 24-hour ground-level concentration.

Table 6.5-2: Summary of Maximum Predicted Ground-level Concentrations at Sensitive Receptors Associated with Project Case

Receptor	Maximum Predicted Ground-level Concentration (µg m^{-3})													
	SO_2				NO_2			CO		PM_{10}	$PM_{2.5}$ [a]	VOCs		
	1-hour	3-hour	24-hour	Annual	1-hour	24-hour	Annual	1-hour	8-hour	24-hour	24-hour	One-hour	24-hour	Annual
Port Edward Elementary	9.01	5.22	1.94	0.011	112	54.63	0.422	30.29	18.78	4.06	1.41	11.00	2.06	0.016
Prince Rupert Closest Residence	3.58	3.11	0.97	0.007	21.6	8.24	0.125	5.09	1.86	1.31	0.37	2.29	0.31	0.005
Pineridge Elementary	4.24	2.73	0.82	0.006	21.0	8.04	0.105	4.71	1.68	1.00	0.31	2.10	0.30	0.004
Prince Rupert Regional Hospital	4.25	4.04	0.84	0.006	20.8	6.87	0.090	4.27	1.40	0.85	0.26	1.86	0.26	0.003
Roosevelt Park Elementary	5.80	4.30	0.97	0.006	21.7	6.42	0.085	4.47	1.34	0.78	0.25	1.95	0.24	0.003
Prince Rupert Middle School	3.57	3.46	0.66	0.004	17.5	5.76	0.071	3.35	1.31	0.71	0.21	1.43	0.21	0.003
First Nations Education	3.56	3.45	0.65	0.004	17.3	5.52	0.069	3.35	1.24	0.69	0.21	1.44	0.20	0.003
Discovery Child Care	4.02	3.26	0.60	0.004	18.6	5.50	0.074	3.54	1.28	0.75	0.22	1.55	0.20	0.003
Seniors Centre	3.88	3.07	0.72	0.005	19.7	5.68	0.075	4.06	1.21	0.71	0.21	1.77	0.21	0.003
Charles Hays Secondary School	3.57	2.80	0.51	0.004	18.6	5.18	0.073	3.50	1.26	0.75	0.21	1.53	0.19	0.003
Northwest Community College	3.96	3.09	0.73	0.005	19.8	5.65	0.075	4.11	1.23	0.71	0.21	1.80	0.21	0.003
Cedar Road Aboriginal Headstart Program	4.06	3.38	0.43	0.004	18.6	4.78	0.072	3.49	1.32	0.76	0.21	1.52	0.18	0.003
Berry Patch Child Care	3.49	2.70	0.66	0.004	17.7	5.01	0.069	3.63	1.09	0.67	0.19	1.58	0.19	0.003
Fellowship Baptist Nursery School	3.82	3.48	0.67	0.004	16.3	4.60	0.064	3.22	1.11	0.56	0.19	1.39	0.17	0.002
Kaien Senior Citizens Housing	3.56	3.25	0.69	0.004	17.2	4.62	0.065	3.50	1.16	0.58	0.20	1.52	0.17	0.002
Conrad Street Elementary	2.71	2.22	0.36	0.003	15.5	3.87	0.060	2.79	1.03	0.54	0.17	1.18	0.15	0.002
KIDS Daycare	2.73	2.20	0.36	0.003	15.1	3.76	0.058	2.73	1.00	0.53	0.16	1.15	0.14	0.002

NOTE:
[a] 98^{th} percentile value of 24-hour ground-level concentration.

Table 6.5-3: Summary of Maximum Predicted Ground-level Concentrations at Sensitive Receptors Associated with Application Case

Receptor	Maximum Predicted Ground-level Concentration (µg m^{-3})													
	SO_2				NO_2			CO		PM_{10}	$PM_{2.5}$ [a]	VOCs		
	1-hour	3-hour	24-hour	Annual	1-hour	24-hour	Annual	1-hour	8-hour	24-hour	24-hour	1-hour	24-hour	Annual
Port Edward Elementary	20.4	15.9	6.4	0.23	113	55.6	0.94	32.0	19.3	5.07	2.01	11.1	2.1	0.06
Prince Rupert Closest Residence	92.2	82.9	12.6	0.74	119	74.9	4.35	260.7	131.0	2.31	1.74	43.6	9.2	0.50
Pineridge Elementary	61.0	43.1	10.0	0.55	105	40.2	2.40	161.6	71.5	1.76	0.97	27.1	4.8	0.26
Prince Rupert Regional Hospital	74.5	46.0	11.5	0.41	92.5	23.6	1.57	91.5	47.0	1.41	0.77	15.7	2.4	0.16
Roosevelt Park Elementary	85.2	51.5	11.0	0.35	87.7	20.3	1.32	68.9	38.8	1.36	0.74	12.1	2.0	0.13
Prince Rupert Middle School	69.4	51.8	11.2	0.25	85.9	15.0	1.00	50.2	28.8	0.99	0.57	8.5	1.6	0.10
First Nations Education	77.0	58.2	14.5	0.27	95.0	17.2	1.00	45.1	27.9	0.98	0.53	7.6	1.5	0.10
Discovery Child Care	84.6	46.5	21.3	0.32	83.9	25.4	0.93	37.7	23.3	1.08	0.52	6.4	1.4	0.08
Seniors Centre	84.2	53.5	14.1	0.27	85.1	19.1	1.13	52.2	35.4	1.17	0.58	9.2	1.9	0.11
Charles Hays Secondary School	83.8	57.1	27.4	0.32	83.7	32.5	0.91	35.0	22.2	1.08	0.57	6.1	1.3	0.08
Northwest Community College	85.0	50.7	14.2	0.27	85.3	19.3	1.12	51.3	35.1	1.19	0.56	9.1	1.9	0.11
Cedar Road Aboriginal Headstart Program	106	63.3	29.4	0.32	89.4	37.8	0.89	32.6	20.8	1.11	0.55	5.8	1.3	0.07
Berry Patch Child Care	185	69.9	14.1	0.22	105	20.7	1.02	43.9	31.7	1.11	0.58	7.9	1.7	0.10
Fellowship Baptist Nursery School	155	97.5	39.1	0.48	99.4	48.0	1.14	33.9	22.2	1.17	0.64	6.0	1.5	0.09
Kaien Senior Citizens Housing	159	99.7	46.0	0.58	100	56.2	1.31	36.3	23.7	1.24	0.72	6.5	1.8	0.09
Conrad Street Elementary	81.9	48.1	20.9	0.28	85.0	28.5	0.78	23.4	18.4	1.02	0.44	4.3	1.4	0.06
KIDS Daycare	74.2	47.1	17.7	0.27	83.8	27.5	0.74	26.1	18.3	1.00	0.44	4.9	1.5	0.06

NOTE:
[a] 98th percentile value of 24-hour ground-level concentration.

Table 6.5-4: Summary of Maximum Predicted Ground-level Concentrations at Sensitive Receptors Associated with CEA Case

Receptor	Maximum Predicted Ground-level Concentration (µg m^{-3})													
	SO_2				NO_2			CO		PM_{10}	$PM_{2.5}$ [a]	VOCs		
	1-hour	3-hour	24-hour	Annual	1-hour	24-hour	Annual	1-hour	8-hour	24-hour	24-hour	1-hour	24-hour	Annual
Port Edward Elementary	46.1	25.8	7.9	0.51	114	52.1	1.44	47.7	34.2	3.03	2.14	12.6	2.64	0.09
Prince Rupert Closest Residence	92.2	82.9	17.6	1.54	141	83.4	5.60	410.5	209.6	2.28	2.22	72.9	10.89	0.57
Pineridge Elementary	74.3	45.4	17.1	1.17	123	65.3	3.33	248.4	131.1	1.47	1.28	43.5	6.93	0.31
Prince Rupert Regional Hospital	93.7	62.1	15.1	0.89	111	49.1	2.28	154.1	92.3	1.14	0.93	28.1	5.03	0.20
Roosevelt Park Elementary	94.7	63.3	13.2	0.79	104	43.0	1.97	121.3	78.4	1.19	0.79	22.2	4.33	0.17
Prince Rupert Middle School	69.6	51.8	11.2	0.56	93.0	32.9	1.47	91.2	60.0	0.92	0.67	16.2	3.35	0.13
First Nations Education	77.2	58.2	14.5	0.57	91.3	32.2	1.45	84.4	58.5	0.89	0.64	15.1	3.28	0.12
Discovery Child Care	85.1	46.5	21.3	0.58	89.9	28.2	1.34	71.0	47.1	0.78	0.67	12.91	2.72	0.10
Seniors Centre	86.3	54.8	14.1	0.60	99.5	39.5	1.63	103.3	71.2	0.98	0.66	18.9	3.97	0.14
Charles Hays Secondary School	84.3	57.1	27.4	0.58	88.9	32.5	1.30	67.0	45.3	0.84	0.66	12.2	2.63	0.10
Northwest Community College	91.9	52.0	14.2	0.60	99.3	39.5	1.62	101.4	70.4	0.99	0.65	18.6	3.94	0.14
Cedar Road Aboriginal Headstart Program	106	63.3	29.6	0.58	89.4	41.3	1.26	63.0	43.2	0.92	0.65	11.6	2.53	0.09
Berry Patch Child Care	197	80.1	15.2	0.51	108	34.9	1.46	89.5	63.3	0.90	0.67	16.3	3.54	0.13
Fellowship Baptist Nursery School	155	97.5	39.3	0.74	99.4	49.1	1.53	60.1	46.6	0.90	0.76	11.0	2.72	0.11
Kaien Senior Citizens Housing	159	99.7	46.2	0.84	100	57.2	1.71	62.6	48.8	1.07	0.88	11.7	2.87	0.11
Conrad Street Elementary	84.7	49.6	23.0	0.52	94.9	37.4	1.12	55.7	39.3	0.70	0.55	11.1	2.68	0.08
KIDS Daycare	77.0	47.1	19.6	0.49	92.9	40.4	1.08	59.3	38.8	0.70	0.54	11.2	2.74	0.08

NOTE:
[a] 98th percentile value of 24-hour ground-level concentration.

6.6 Background Ambient Air Quality

Background concentrations are the concentration of substances in ambient air due to emissions from both natural and human-caused sources.

For air-quality effects assessments, it is important to consider background concentrations to understand the full cumulative effect of the Project and any future facility developments. This can be done by two means:

- Adding adequately representative concentrations measured locally or at a different location to the Project case predictions
- By modelling background sources alone (Baseline Case), modelling the new source (Project case), then including both in a cumulative modelling exercise (Application case).

The latter has been completed as part of the current dispersion modelling exercise.

Measured CAC background concentrations for the region were developed consistent with BC MOE (2008) guidance. The results are shown in Table 6.6-1. Ambient monitoring data (1998 to 2002) from two local monitoring stations (Prince Rupert Galloway Rapids, Port Edward Pacific) and one distant site (Victoria Topaz) are the source information. The Prince Rupert Galloway Rapids and Port Edward Pacific monitoring stations were selected due to their proximity to the Project site. For air substances for which monitoring data are unavailable for these two sites (CO, NO_2, PM_{10}), data from the Victoria Topaz monitoring station was selected due its coastal location.

Table 6.6-1: Background Values or Reference Levels for CACs

Species	Averaging Period	Concentration ($\mu g\ m^{-3}$)
SO_2[a]	One-hour	13.0
	24-hour	26.0
	Annual	0.77
NO_2[c]	One-hour	90.0
	24-hour	82.4
	Annual	24.2
CO[c]	One-hour	3,300
	8-hour	4,125
PM_{10}[b]	24-hour	39.6
$PM_{2.5}$[c]	24-hour	33.0

NOTES:
[a] Prince Rupert Galloway Rapids (1998 – 2002)
[b] Port Edward Pacific (1998 – 2002)
[c] Victoria Topaz (1998 – 2002)
One-hour values are the 99thPercentile of monitored concentrations
8-hour, 24-hour and annual values are the maximum observed concentrations

These background concentrations compare favorably with the Baseline Case predicted maximum values. The requirement of the BC MOE Guidelines (BC MOE 2008) regarding the inclusion of background concentrations in the CEA Case scenario is fulfilled.

7 GREENHOUSE GAS CONSIDERATIONS

7.1 Introduction

A GHG is defined as any gas in the atmosphere that absorbs infrared radiation. GHGs include water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halogenated fluorocarbons (HCFCs), ozone (O_3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs). GHGs are transparent to incoming solar radiation, but absorb outgoing terrestrial (infrared) radiation, and in turn re-emit the radiation into the atmosphere. The net effect is a trapping of energy and a tendency to warm the earth's atmosphere, land, and water surfaces.

The prevailing scientific theory links increases in atmospheric concentrations of GHGs (mainly CO_2, CH_4, and N_2O) to alterations in the earth's climate. Climate scientists have connected GHG increases to increases in temperature, moisture, and the occurrence of severe weather events such as drought, floods, and storms. Long-term changes such as melting glaciers and polar ice, desertification, sea-level rise, and ecosystem-level alterations are the consequences of the general temperature rise. Climate change-related health effects include an expansion of the range of tropical diseases to areas previously unaffected and deaths related to extreme heat and other severe weather. Warmer temperatures have supported massive infestations, such as the mountain pine beetle now devastating BC's forests. GHGs are considered in this section of the assessment because of the importance of climate change as a national and international issue.

The Project construction and operations activity will result in the emissions of GHGs, thereby contributing incrementally to national and provincial GHG emission totals.

This section of the assessment discusses:

- The analytical techniques and relevant policies considered in this assessment
- The emissions of GHGs predicted for all relevant project sources
- The potential changes in the climate of British Columbia
- Mitigation measures available to control Project GHG emissions
- The sensitivity of the Project to climate change.

In the Construction and Operations phases, Project activities that can emit GHGs include:

- Operation of construction equipment and support traffic to prepare the site and construct facility
- Operation of marine vessels to support the wharf construction
- Maintenance of equipment

- Operation of the locomotives
- Operations of the carrier ships and assist tugboats at the wharf.

7.2 Analytical Techniques for Consideration of Climate Change

The Canadian Environmental Assessment Agency (CEA Agency) document "Incorporating Climate Change Considerations in Environmental Assessments: General Guidance for Practitioners" is the primary source of guidance for the incorporation of Climate Change considerations into an environmental assessment in Canada (CEA Agency 2003). Also helpful in understanding the general magnitude of climatic changes is climatological modelling presented in the *Third Assessment Report of the Intergovernmental Panel on Climate Change* (IPCC 2001). The IPCC was established by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP). Of direct interest are the regional interpretations of this and later works as published from time to time by Canada and British Columbia, including *Climate Change Impacts and Adaptation: A Canadian Perspective* (Government of Canada 2004).

To assess the potential Projects effects on climate or the potential effects of climate on the project, guidance provided by the CEA Agency (2003) suggests an examination of the following aspects in a stepwise fashion:

- Establish the quantities of GHG emissions for each phase of the Project
- Estimate the marginal contribution of the Project emissions to the provincial and national emissions
- Establish relevant jurisdictional policies
- Establish the industry profile for GHG emissions and best practices for projects that are similar in nature to the Project
- Identify whether the Project is a low, medium, or high intensity emitter of GHGs.

Once these steps are completed, it is suggested that the following questions be answered:

- Will the Project be a medium or high emitter?
- Will the Project exceed relevant jurisdictional policies?
- Will the Project exceed the industry profile?
- Will best practices be used in all phases of the Project?

The net quantities of Project GHG emissions were estimated and considered in the provincial and federal context. The Project was examined for all related GHG emissions and for all possible opportunities to reduce emissions using the criteria of current availability, proven technology, and economic feasibility. The effects of the Project on climate considered mitigation and adaptive management of GHG emissions, and the application of "Best Available Technology Economically Achievable" (BATEA).

7.3 Relevant Policies for Climate Change

A number of policy initiatives have been implemented in recent years to address GHG emissions. In 2001, the Kyoto Protocol established aggressive targets for reducing GHG emissions and consequently reducing the potential for adverse environmental effects that may be caused by climate change. The Government of Canada ratified the Kyoto Protocol in December 2002, and has since been active in the development and implementation of initiatives relating to Climate Change. An example is the *Regulatory Framework for Air Emissions* (Environment Canada 2007b). In this document a regulatory framework for existing facility industrial GHG emissions is presented.

The Canadian federal government released its *Turning the Corner Plan* in April 2007 (Environment Canada, 2007c, modified in March 2008) outlining an action plan for the regulation of GHGs and other air pollutants from industry[3]. The plan includes Canada-wide, as well as sector-specific, targets for reduced GHG emissions. The regulatory framework is expected to achieve approximately 165 Mt and 25 Mt in directed and indirect emission reductions from the industrial and electricity sectors, respectively, by 2020.

The BC government has made climate change a top priority through measures such as the BC Energy Plan, the Climate Action Plan, and new legislation to address provincial GHG emissions. The Government of BC is a founding member of the new Climate Registry. This Western Climate Initiative (WCI) has established a regional goal to reduce GHG emissions to 15% below 2005 levels by 2020, a target that will lay the foundation for a common cap and trade system. It has also signed memorandums of understanding with California and Washington State on climate change and Pacific Ocean conservation.

The BC Energy Plan includes aggressive targets for the provincial energy sector, including a commitment to both zero net GHG emissions from generation facilities and electrical self-sufficiency by 2016.

New legislation includes Bill 44 (the *Greenhouse Gas Reduction Targets Act*) and Bill 18 (the *Greenhouse Gas Reduction (Cap and Trade) Act*). Bill 44 requires the province to reduce its emissions by 33% by 2020 and 80% by 2050 (from 2007 levels). Bill 18 is enabling legislation intended to begin the development of a cap-and-trade system in compliance with the Western Climate Initiative. Under the WCI, facilities emitting more than 10,000 tonnes of carbon dioxide (CO_2) will be required to report their emissions annually. Facilities emitting more than 25,000 tonnes of CO_2 will require third party verification. In addition, effective July 1, 2008, BC has a carbon tax[4] applicable to all combusted fossil fuels in the province.

7.4 Project GHG Emissions

In this section the emissions of GHGs predicted for all relevant Project sources are presented. A comparison with The BC and Canada GHG emission totals suggest marginal Project contributions.

[3] Environment Canada, 2007. http://www.ecoaction.gc.ca/turning-virage/index-eng.cfm
[4] http://www.ec.gc.ca/pdb/ghg/inventory_report/2007/som-sum_eng.cfm

Total GHG emissions are normally reported as carbon dioxide equivalents (CO_{2e}). This is accomplished by multiplying the emission rate of each substance by its global warming potential (GWP) relative to CO_2. The GWP of the three main greenhouse gases: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are as follows: CO_2 = 1.0, CH_4 = 21, and N_2O = 310. Therefore, CO_{2e} is equal to [(CO_2 mass x 1.0) + (CH_4 mass x 21) + (N_2O mass x 310)].

The Canada and British Columbia GHG emissions for year 2007 and the projection for year 2020 are presented in Table 7.4-1.

Table 7.4-1: Greenhouse Gas Emissions, Canada and British Columbia

Year	GHG (CO_{2e}) Emissions (tpy)	
	Canada	British Columbia
2007	747,000,000[1]	67,300,000[2]
2020 (projected)	557,000,000	45,091,000

NOTES:
[1] http://www.ec.gc.ca/pdb/ghg/inventory_report/2007/som-sum_eng.cfm
[2] http://www.livesmartbc.ca/learn/emissions.html

7.4.1 Construction Phase GHG Emissions

During the site preparation and Construction phases, heavy and light duty equipment activities in and around the Project were identified as sources of GHG emissions. The amount and type of equipment used will vary depending on the construction contractor, so the inventory of construction equipment to be used is speculative. These estimates do not include emissions associated with offsite energy use (indirect emissions).

The estimated total annual GHG emissions for key species of interest and CO_2 equivalent (CO_{2e}) associated with Project construction activities are provided in Table 7.4-2.

Table 7.4-2: Summary of GHG Air Emissions from the Project during the Construction Phase

Equipment Type[a]	GHG Emissions (tpy)			
	CO_2	CH_4	N_2O	CO_{2e}
Canpotex Land-based[b]	2984	0.149	0.823	3243
Canpotex Marine-based[c]	380	0.020	0.153	428
RRUC Bulk Civil[b]	9224	0.447	2.115	9889
RRUC Rail-Specific[b]	1967	0.075	0.402	2094
Total	**14,555**	**0.691**	**3.493**	**15,654**

NOTES:
[a] A detailed equipment list is provided in Section 4.1.
[b] Based on emission factors and methodologies developed by Environment Canada (EC, 2006).
[c] Based on emission factors and methodologies developed by the US EPA for fuel oil combustion (US EPA, 1998).

The direct GHG emissions from construction (15,654 tonnes CO_{2e}) are minute compared to the Canada and British Columbia GHG emission totals (Table 7.4-1).

As with the CAC emissions, the GHG emissions for decommissioning this type of facility are typically much less than construction emissions.

7.4.2 Operations Phase GHG Emissions

During the Operations phase, GHG emissions will occur mostly from marine vessel and locomotive operations. It is quite likely that Canpotex Terminals Ltd. will not report marine GHG emissions as part of their corporate GHG inventory as these emissions are most appropriately attributed to the vessel ownership. They are included here to remain consistent with the assessment methodology where all marine vessels emissions are considered within the assessment area.

The estimated total annual GHG emissions for key species of interest and CO_2 equivalent (CO_{2e}) associated with Project operations activities are provided in Table 7.4-3. These estimates do not include emissions associated with offsite energy use (indirect emissions).

Table 7.4-3: Summary of GHG Air Emissions from the Project during the Operations Phase

Equipment Type[a]	GHG Emissions (tpy)			
	CO_2	CH_4	N_2O	CO_{2e}
Bulk Carrier Ships[b]	1086	0.04	0.005	1,088
Assist Tugboats[b]	666	0.03	0.003	667
Locomotives[c]	17,219	0.9	6.9	19,389
Total	**18,971**	**0.97**	**6.91**	**21,144**

NOTES:
[a] A detailed equipment list is provided in the Section 4.2.
[b] Based on emission factors and methodologies developed by Environment Canada (EC, 2006).
[c] Based on emission factors and methodologies developed by the US EPA for fuel oil combustion (US EPA 1998).

Direct GHG emissions from Operations (21,144 tonnes CO_{2e}) are very small in comparison with the year 2020 projected Canada (about 0.004%) and British Columbia (about 0.05%) GHG emission totals.

7.5 Annual Project GHG Intensity and Comparison to Similar Facilities

Currently there is no specific guidance respecting the designation of low, medium and high intensity emitters of GHGs. The Project itself is a very low emitter of GHGs. Shipping terminal facilities are in general low intensity emitters, and as such do not report GHG emission.

Given the high profile of climate change issues and the importance of maintaining an energy efficient facility, the Project will continue to apply sustainable development principles to all business activities. This ensures that GHG emissions will remain low throughout the Project life cycle.

7.6 Effect of Climate Change on the Project

Climate change issues for the Project are assessed with reference to the Canadian Environmental Assessment Agency (CEA Agency) Guidelines and other sources. Considerations included:

- Project contributions to GHG emissions, primarily through the combustion of fossil fuels
- Climate parameters that could change over project life influencing project operating conditions and magnifying or Project related environmental effects
- Mitigation and adaptive management measures.

The Project will, where economically appropriate, be designed to account for potential direct and indirect climate changes. Direct effects relate to the influence of climate parameters such as temperature, precipitation, and wind extremes. Indirect effects relate to other influences that could be affected by climate change, including changes in sea level and severe storms, especially severe winter storms.

General Circulation Models (GCMs) are considered to be the most comprehensive models for predicting the effects of GHG emissions on the global climate. However, these models become less accurate when attempting to predict regional changes in climate. Historical data must be used together with GCMs to provide more precise predictions of climate change.

Stantec conducted a parallel environment assessment for the Fairview Terminal Phase II Expansion Project (Stantec 2009) located 8.5 km further north of the Project. The climate change predictions made for the Fairview II assessment are applicable to the Project area and are described here.

GCM models and historical data were used to predict changes in regional climate based on a range of scenarios suggested by IPCC. The IPCC plan starts from a low-emission scenario where it is assumed that there will be a local and worldwide shift towards cleaner and more efficient technologies resulting in decreased GHG emissions, going towards a business-as-usual scenario with current trends continuing into the future, and ending with a high-emission scenario which predicts rapid economic growth and continued dependence on fossil fuels (IPCC 2000).

7.6.1 Climate Change on the North Coast of British Columbia

The following section summarizes climate change predictions for the North Coast of British Columbia (Stantec 2009), focusing on the two most important factors:

- Changes in sea level and frequency
- Harshness of severe weather events.

Climate can be described in terms of average temperature and precipitation, as well as day-to-day and year-to-year variations and extremes that define weather. The baseline climate for this region is described in Section 3.1. A review of the available regional analyses regarding temperature and precipitation trends and expected effects on the North Coast were examined. Climate models and scenarios suggest that the climate in BC will continue to change during the remainder of the 21st century. This will have ongoing effects on ecosystems and in communities. For example:

- Average annual temperature in BC may increase by 1ºC to 4ºC per century; however changes on the North Coast will be moderated to a large extent by the Pacific Ocean.
- Average annual precipitation may increase by 10 to 20 percent in the next century. Coupled with the increase in temperature, the North Coast may see more precipitation, and less precipitation as snow, in the coming century.
- Wind speed and direction are expected to change, however global circulation models have not yet been able to accurately predict the changes in regional wind speed and direction.

A change in sea level is the combined result of three distinct forces: two associated with the land surface, and one with the sea surface. On BC's West Coast the land is still rebounding from the glacial loading during the last ice age (isostatic forces) plus it is down-warping owing to tectonic plate movements (tectonic forces). The oceans themselves are expanding owing to the warming, plus increasing in volume owing to glacial melt (uestatic forces). The net result is that the next-century sea level may rise by up to 88 cm along parts of the BC coast. In the vicinity of Prince Rupert the increase is projected to be 30 cm.

The frequency of extreme weather events such as heavy downpours, floods, heat waves, droughts, tornadoes, and snowstorms is predicted to increase. The intensity of these events is also expected to increase. An increase in the frequency and intensity of storms on the west coast may lead to larger wind-generated waves off of Ridley Island. This may exacerbate the effect of the projected sea level increase on local infrastructure. Increases in wind speeds accompanying these storms have the potential to affect Project infrastructure.

7.6.2 Project Sensitivity to Climate Change

The effect of potential climate change on the project was assessed qualitatively following the CEA Agency Guidelines (CEA Agency 2003). This assessment was based on the analysis of predicted changes to present climate, which were deemed sufficient to conclude whether or not there is a risk to the public or the environment.

The sensitivity of various phases of the project to these predicted changes was ranked (see Table 7.6-1). These rankings reflect the effect of climate change on the Project in terms of productivity or additional environmental management required.

Project sensitivity for the Construction phase is ranked as nil to low because weather conditions are likely to affect transportation of materials and construction activities only modestly in the period between approval and completion of construction.

Project sensitivity for operations is low overall. An increase in sea level and winds may affect both the wharf and the land-based infrastructure. Heavy rain may result in product moisture absorption. An increase in storms may introduce weather delays in ship berthing and unloading. This is a medium risk, but one the Project chooses to absorb. Project sensitivity to increases in temperature is ranked as nil. Project sensitivity to heavy precipitation is ranked as low and can be mitigated by a proper design.

Project sensitivity for decommissioning is ranked as low overall based on the assumption of converting the site to another industrial land use.

Table 7.6-1: Project Sensitivities to Direct and Indirect Climate Influences

Climate Parameter	Project Phase		
	Construction	Operations	Decommissioning
Direct			
Mean temperature	Nil	Nil	Nil
Extreme temperature	Nil	Nil	Nil
Mean rainfall	Nil	Nil	Nil
Mean snowfall	Nil	Nil	Nil
Extreme precipitation	Low	Low	Low
Extreme winds	Low	Low	Low
Indirect			
Sea level increases	Nil	Low	Low
Extreme weather events	Low	Low	Low

8 REFERENCES

Ausenco-Sandwell Engineering. Pers comm, June 15, 2010. Project activities and emission estimates were confirmed with the engineering firm

BC Ministry of Environment. 2007. British Columbia Air Data Acquisition and Management System (ADAMS). Available at: http://www.elp.gov.bc.ca:8000/pls/aqiis/aqi.bulletin

BC Ministry of Environment. 2008. British Columbia Ministry of Environment. Guidelines for Air Quality Dispersion Modelling in British Columbia. March 2008. Available at http://www.env.gov.bc.ca/epd/bcairquality/reports/pdfs/aqotable.pdf

BC Ministry of Environment. 2009. Air Quality Objectives and Standards. Available at: http://www.bcairquality.ca/reports/pdfs/aqotable.pdf

BC Ministry of Healthy Living and Sport. 2009. Air Quality Objectives and Standards. Available at: http://www.bcairquality.ca/reports/pdfs/pm25-implement-guide.pdf

ICF Consulting. 2005. Best Practices in Preparing Port Emission Inventories. Available at http://www.epa.gov/oms/stateresources/rellinks/docs/bp_portemissions.pdf

Canadian Council of Ministers of the Environment. 2000. Canada-Wide Standards for Respirable Particulate Matter ($PM^{2.5}$), effective by 2010

CN. Pers. Communication. 2010. Correspondence between CN and Canpotex confirming the number of locomotives burning fuel at a regular duty cycle rate for one hour

CEA Agency, 2003. Incorporating Climate Change Considerations in Environmental Assessments: General Guidance for Practitioners. Prepared by the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment. Canadian Environmental Assessment Agency. Available at: http://www.ceaa-acee.gc.ca/012/014/index_e.htm

CEMA, 2005. Cumulative Environmental Management Association. NO_x Dispersion and Chemistry Assumptions in the CALPUFF Model. CEMA Contract 2003-0034. Prepared for CEMA by RWDI Air Inc.

Environment Canada, 2006. Canada's Fourth National Report on Climate Change: Actions to Meet Commitments Under the United Nations Framework Convention on Climate Change. ISBN 0-662-44443-4

Environment Canada, 2007a. Canadian Climate Normals 1971-2000. Available at: http://www.climate.weatheroffice.ec.gc.ca/climate_normals/index_e.html

Environment Canada, 2007b. National Inventory Report, 1990-2004 – Greenhouse Gas Sources and Sinks in Canada. Available at: http://www.ec.gc.ca/pdb/ghg/inventory_report/2004_report/ta12_12_e.cfm

Environment Canada, 2007c. Turning the Corner Plan. Available at: http://www.ec.gc.ca/default.asp?lang=En&n=4891B242-1

Environment Canada. 2011. Sulphur in Diesel Fuel Regulations. Available at http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=694C8126-1

Forest Products Association of Canada. 2007. Wood Product sector Particulate Emission Study

Government of BC. 2007. Bill 44: *The Greenhouse Gas Reduction Targets Act*. Available at: http://www.leg.bc.ca/38th3rd/1st_read/gov44-1.htm

Government of BC. 2008. Bill 18: *The Greenhouse Gas Reduction (Cap and Trade) Act*. Available at: http://www.leg.bc.ca/38th4th/1st_read/gov18-1.htm

Government of Canada. 2004. Climate Change Impacts and Adaptation: A Canadian Perspective. Available at: http://www.espp.msu.edu/climatechange/canadaadaptation.pdf

Health Canada. National Ambient Air Quality Objectives. Available at: http://www.hc-sc.gc.ca/ewh-semt/pubs/air/naaqo-onqaa/index-eng.php and http://www.hc-sc.gc.ca/ewh-semt/air/out-ext/reg-eng.php#a3

ICF Consulting. 2005. Best Practices in Preparing Port Emissions Inventories. Draft for Review. Prepared for the United States Environmental Protection Agency Office of Policy, Economics and Innovation by ICF Consulting

IPCC. 2000. Special Report on Emissions Scenarios. Intergovernmental Panel on Climate Change, Cambridge, UK, 2000. Available at: www.grida.no/climate/ipcc/emission/

IPCC. 2001. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden and D. Xiaosu (eds.) Cambridge University Press, 2001. Available at: http://www.grida.no/climate/ipcc%5Ftar/wg1/

Stantec. 2009. Fairview Terminal Phase II Expansion Project. Stantec Consulting Ltd.

Stantec. 2011. The Canpotex Potash Export Terminal and Ridley Island Road, Rail and Utility Corridor Project. Stantec Consulting Ltd.

US EPA. 1997. United States Environmental Protection Agency Emission Factors for Locomotives. Office of Mobile Sources. EPA420-F-97-051. Available at: http://www.epa.gov/otaq/regs/nonroad/locomotv/frm/42097051.pdf

US EPA. 1998. United States Environmental Protection Agency AP42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources. Section 1.3 Fuel Oil Combustion. Available at: http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s03.pdf

US EPA. 2000. United States Environmental Protection Agency Analysis of Commercial Marine Vessel Emissions and Fuel Consumption Data. Office of Transportation and Air Quality. EPA420-R-00-002. Available at: http://www.epa.gov/oms/models/nonrdmdl/c-marine/r00002.pdf

US EPA. 2004. United States Environmental Protection Agency Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition. Assessment and Standards Division. Office of Transportation and Air Quality. Report No. NR-009c, Revised April 2004.

Westmar. 2007. Canpotex Potash Shiploading Facility. repared by Westmar Consultants for Canpotex Terminals Limited.

APPENDIX A

CALPUFF and CALMET Methods and Assumptions

TABLE OF CONTENTS

List of Tables

List of Figures

1 INTRODUCTION

Appendix A provides technical details and assumptions regarding the CALPUFF modelling system used to predict the Project environmental effects. The information provided describes the CALPUFF implementation for the current Project, which may differ from other applications.

1.1 The CALPUFF Modelling System

The CALPUFF modelling system was used to assess the Project effects. The core of this system consists of the CALMET meteorological model, and the CALPUFF transport and dispersion model.

The CALMET meteorological model provides the meteorological and geophysical domain for the CALPUFF dispersion model. The two-dimensional geophysical environment describing the surface interface requires a characterization of the terrain and land use features. The three dimensional time-variant meteorological environment is described by both surface based and upper air data. Various user-defined parameters control both how the input meteorological data is interpolated to the grid, as well as which internal algorithms are applied to these input fields. More details regarding these options are provided in the following sections. Output from the CALMET model includes hourly temperature and wind fields on a user-specified three-dimensional domain formatted for input into CALPUFF.

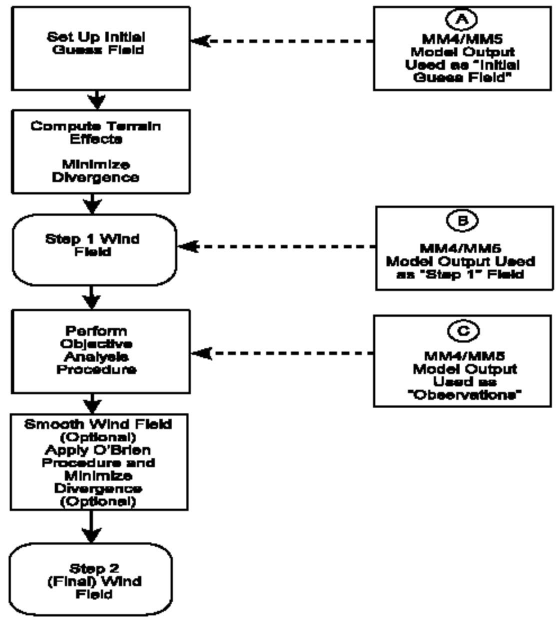
CALPUFF is a non-steady-state Gaussian puff dispersion model capable of simulating the effects of time and space-varying meteorological conditions on pollutant transport, transformation, and removal. Information characterizing the location and nature of each emission source is required. Output from CALPUFF includes ground-level concentrations of the species considered.

2 CALMET MODELLING

2.1 Model Description

The following description of the CALMET model's major model algorithms and options are all excerpts from the CALMET model's user manual (Scire et al. 2000a).

The CALMET meteorological model consists of a diagnostic wind field module and micrometeorological modules for overwater and overland boundary layers. The diagnostic wind field module uses a two-step approach to the computation of the wind fields (Douglas and Kessler 1988), as illustrated in Figure A-1.



Source: Scire et al. 2000a

Figure A-1: Flow Diagram of Diagnostic Wind Module in CALMET

An initial guess wind field is adjusted for kinematic effects of terrain, slope flows, and terrain blocking effects to produce a Step 1 wind field. The initial guess field is either a uniform field based on available observational data or the output from the NCAR/PSU Mesoscale Modelling System (MM4/MM5). The second step consists of an objective analysis procedure to introduce observational data into the Step 1 wind field to produce a Step 2 and final wind field. An option is provided to allow gridded prognostic wind fields to be used by CALMET, which may better represent regional flows and certain aspects of sea breeze circulations and slope/valley circulations. Wind fields generated by the prognostic wind field module can be input to CALMET as either the initial guess field or the Step 1 wind field.

2.1.1 Diagnostic Wind Field Module – Initial Guess Field

Options exist within CALMET to create an initial guess field either by interpolating observation data or by using output from a prognostic meteorological model, such as the NCAR/PSU Mesoscale Modelling System (MM4/MM5). The prognostic model data is usually run over a very large domain with much coarser resolution than that applied with CALMET. CALMET will interpolate the prognostic data to develop a 3-D fine scale first guess field of wind speeds and directions.

2.1.1.1 Step 1 Wind Field

The Step 1 wind field is adjusted for kinematic effects of terrain, slope flows, and blocking effects as follows:

- **Kinematic Effects of Terrain:** The approach of Liu and Yocke (1980) is used to evaluate kinematic terrain effects. The domain-scale winds are used to compute a terrain-forced vertical velocity, subject to an exponential, stability-dependent decay function. The kinematic effects of terrain on the horizontal wind components are evaluated by applying a divergence-minimisation scheme to the initial guess wind field. The divergence minimisation scheme is applied iteratively until the three-dimensional divergence is less than a threshold value.
- **Slope Flows:** An empirical scheme based on Allwine and Whiteman (1985) is used to estimate the magnitude of slope flows in complex terrain. The slope flow is parameterised in terms of the terrain slope, terrain height, domain-scale lapse rate, and time of day. The slope flow wind components are added to the wind field adjusted for kinematic effects.
- **Blocking Effects:** The thermodynamic blocking effects of terrain on the wind flow are parameterised in terms of the local Froude number (Allwine and Whiteman 1985). If the Froude number at a particular grid point is less than a critical value and the wind has an uphill component, the wind direction is adjusted to be tangent to the terrain.

2.1.1.2 Step 2 Wind Field

The wind field resulting from the adjustments of the initial-guess wind described above is the Step 1 wind field. The second step of the procedure involves the introduction of observational data into the Step 1 wind field through an objective analysis procedure. An inverse-distance squared interpolation scheme is used which weighs observational data heavily in the vicinity of the observational station, while the Step 1 wind field dominates the interpolated wind field in regions with no observational data. The resulting wind field is subject to smoothing, an optional adjustment of vertical velocities based on the O'Brien (1970) method, and divergence minimisation to produce a final Step 2 wind field.

2.1.2 Micrometeorology Modules

The CALMET model contains two boundary layer models for application to overland and overwater grid cells:

- **Overland Boundary Layer Model:** Over land surfaces, the energy balance method of Holtslag and van Ulden (1983) is used to compute hourly gridded fields of the sensible heat flux, surface friction velocity, Monin-Obukhov length, and convective velocity scale. Mixing heights are determined from the computed hourly surface heat fluxes and observed temperature soundings using a modified Carson (1973) method based on Maul (1980). Model also determines gridded fields of PGT stability class and optional hourly precipitation rates.
- **Overwater Boundary Layer Model:** The aerodynamic and thermal properties of water surfaces suggest that a different method is best suited for calculating the boundary layer parameters in the marine environment. A profile technique (Garratt 1977; Hanna et al. 1985),

using air-sea temperature differences, is used in CALMET to compute the micrometeorological parameters in the marine boundary layer.

2.2 Meteorological Domain

The CALMET meteorological domain adopted for this project is summarized below in Table A-1.

Table A-1: Map Projections and Horizontal Grid Parameters

Parameter	Value
Map Projection	UTM
UTM Zone	9N
Datum	WGS-84
Number of Grid Cells (nx,ny)	100, 100
SW Corner (Easting,Northing)	389 km, 5994 km
Grid Spacing	500 m

The meteorological domain was selected to cover the region surrounding the proposed Project. The communities of Prince Rupert and Port Edward fall within the boundaries of the modelled area.

Eight vertical levels were used to model the atmosphere up to a maximum cell face height of 2600m above ground level. Cell mid-points were chosen at heights of 20, 40, 80, 160, 320, 600, 1400, and 2600m above ground to allow for higher resolution in the layers nearest to the earth's surface than in the levels aloft.

2.3 Assessment Period

The CALMET meteorological model was run for one full year from January 1, 2002 to December 31, 2002. This year was chosen for assessment so that an available 12km MM5 prognostic dataset from Environment Canada (EC) could be input into CALMET. Two separate simulations were run to account for the different land use characteristics due to snow and ice during the winter months. For the purposes of modelling, winter was defined to span from December to February.

2.4 Terrain and Land Use

Terrain elevations in the model were initialized with data from the Shuttle Radar Topography Mission (SRTM). This data, a preliminary product from a joint project between the US National Aeronautics and Space Administration (NASA) and the US National Geospatial-Intelligence Agency (NGA), is available at 3 arc-second (approximately 90 m) resolution for the continent of North America.[1] The

[1] Data can be obtained at ftp://e0mss21u.ecs.nasa.gov/srtm/North_America_3arcsec/3arcsec/

CALPUFF terrain preprocessor (TERREL) extracts SRTM data over the domain of interest to produce terrain elevations at 500 m resolution.

The Project is located on Ridley Island off the northern mainland coast of British Columbia. Terrain in the region is complex with elevations ranging from sea level to heights greater than 950 m above sea level (masl). The base elevation at the proposed project site is approximately 40 masl or lower.

In addition to terrain elevation data, the CALMET model utilizes surface parameters such as surface roughness length, albedo, bowen ratio, leaf area index, soil heat flux, and anthropogenic heat flux to provide input to important subroutines which, in turn, estimate quantities such as surface heat flux and mechanical turbulence. CALMET's geophysical pre-processor (MAKEGEO) produces values for each of these surface parameters from input land use categories.

British Columbia Baseline Thematic Mapping (BTM) land-use data[2] was used to initialize land use categories in the CALMET model. BTM data is available in a polygonized format at a scale of 1:250000, with a minimum polygon size of about 10 ha for most land-use categories. This data was clipped to the assessment area then converted to a raster grid over the modelling domain. This information was then exported in a text format and converted into the fractional land-use format accepted by the CALMET MAKEGEO pre-processor. This conversion was accomplished by mapping the dominant BTM land-use category for each 500 m^2 grid cell into one of the Level I (and in a few cases, Level II) US Geological Survey (USGS) land-use categories typically used in the CALMET model (Table A-2). As the BTM land-use categories are generally more descriptive than most of the default CALMET categories, the approximations made in the Table A-2 mapping seem reasonable.

Table A-2: Mapping from BTM to CALMET Land-use Categories

BC Category	USGS Category	USGS Level	CALMET Code
Agriculture	Agricultural Land	I	20
Residential-Agricultural Mix	Agricultural Land	I	20
Alpine	Tundra	I	80
Sub-alpine Avalanche Shoots	Barren Land	I	70
Recent Burn	Forest Land	I	40
Old Forest	Forest Land	I	40
Young Forest	Forest Land	I	40
Recently Logged	Rangeland	I	30
Selectively Logged	Forest Land	I	40
Rangeland	Rangeland	I	30
Mining	Barren Land	I	70
Recreational Activities	Rangeland	I	30

[2] For more information or to order this product: http://srmwww.gov.bc.ca/dss/initiatives/ias/btm/index.htm

BC Category	USGS Category	USGS Level	CALMET Code
Barren Land	Barren Land	I	70
Urban	Urban or Built-up Land	I	10
Shrub	Rangeland	I	30
Glacier	Snow or Ice	I	90
Wetlands	Non-forested Wetland	II	62
Fresh Water	Fresh Water	II	51
Estuaries	Bays and Estuaries	II	54
Salt Water	Salt Water	II	55

Land use varies throughout the modelled domain, consisting primarily of forest and ocean. Urban areas, forested wetland, as well as barren land and tundra at higher elevations are also significant land use features near the site location.

To consider the case of snow and ice on the ground, a winter land-use scenario was also considered. This parameterization was applied to the months of December, January, and February, as these are the months when there is a good chance of having surface snow cover. Note that, as increased snow cover decreases model mixing heights and reduces the CALPUFF dispersion, the assumption that snow covers the ground for all three months results in conservative predictions of ground-level concentrations. The wintertime land use scenario was specified as follows:

1. Agricultural Land, Barren Land, Tundra, and Rangeland were all assumed to be covered with snow and assigned to have surface parameter values as defined by CALMET land use code 90.
2. Surface parameters for Forested Land and Forested Wetlands were left unchanged.
3. Salt Water, Fresh Water, and Estuaries were left unchanged.
4. For Urban, surface roughness was left unchanged.
5. For Urban, all other surface parameters were altered to have values compatible with CALMET land use code 90.

2.5 Meteorological Inputs

The CALMET model requires the input of surface and upper air meteorological fields. For this project, CALMET was initialized with surface station information from three surface weather stations in the domain and with upper air data from the MM5 meteorological model. While this model initialization approach allows for a more accurate depiction of mesoscale wind circulations in the layers aloft than would be provided by using radiosonde data, it simultaneously permits data from surface weather stations to provide valuable localized information and correct the biases that prognostic data often exhibits in the lower layers.

Year 2002 hourly output from the MM5 model at 12 km resolution was provided for use in this study by EC. The MM5 model was initialized with gridded analysis data purchased from the National Center for Atmospheric Research (NCAR). The data was prepared for CALMET use by using the CALMM5 pre-processor.

Observed hourly-averaged meteorological data from surface stations (Table A-3) during the modelling period was provided by EC and the British Columbia Ministry of the Environment (BC MOE). While the EC weather station at Prince Rupert Airport contained all fields necessary to initialize CALMET over the period of interest, the MOE stations did not. Furthermore, data was missing from both MOE stations from October to December for the year of 2002. Thus, the Prince Rupert Airport Station was the primary surface weather input used for modeling. The MOE stations were used to provide additional weather information near the site location whenever possible.

Table A-3: Input Surface Meteorological Stations

Station Name	Type	Easting (km)	Northing (km)	Elevation (masl)	Surface Input Data Used
Port Edward Mill	MOE	415.773	6010.285	30	Temperature, Wind Speed (Jan – Sept)
Galloway Rapids	MOE	417.491	6013.160	1	Temperature, Wind Speed and Direction (Jan – Sep)
Prince Rupert Airport	EC	406.688	6015.994	35	Temperature, Wind Speed and Direction, Cloud Cover and Ceiling Height, Station Pressure, Relative Humidity

Singular missing values were interpolated from the previous and following hour values for select meteorological variables in the surface station input file wherever possible.[3] For larger gaps, data were flagged as missing and, in general, not included as input for CALMET. However, as CALMET requires at least one non-missing value for each mandatory input surface meteorological field, the following treatments were necessary:

- Filled one singular missing wind direction in October with previous hour value
- Filled two missing ceiling height variables with interpolation from the previous and following hour values, and two others with the previous hour data (periods with unlimited ceiling heights)
- Filled six sequential missing relative humidity values via linear interpolation from the temporally nearest data points.

[3] Automated interpolation of singular missing values from was done for wind-speed, relative humidity, temperature, station pressure, and cloud cover. Hourly missing wind direction and ceiling height data were not filled.

2.5.1 Surface Wind Input

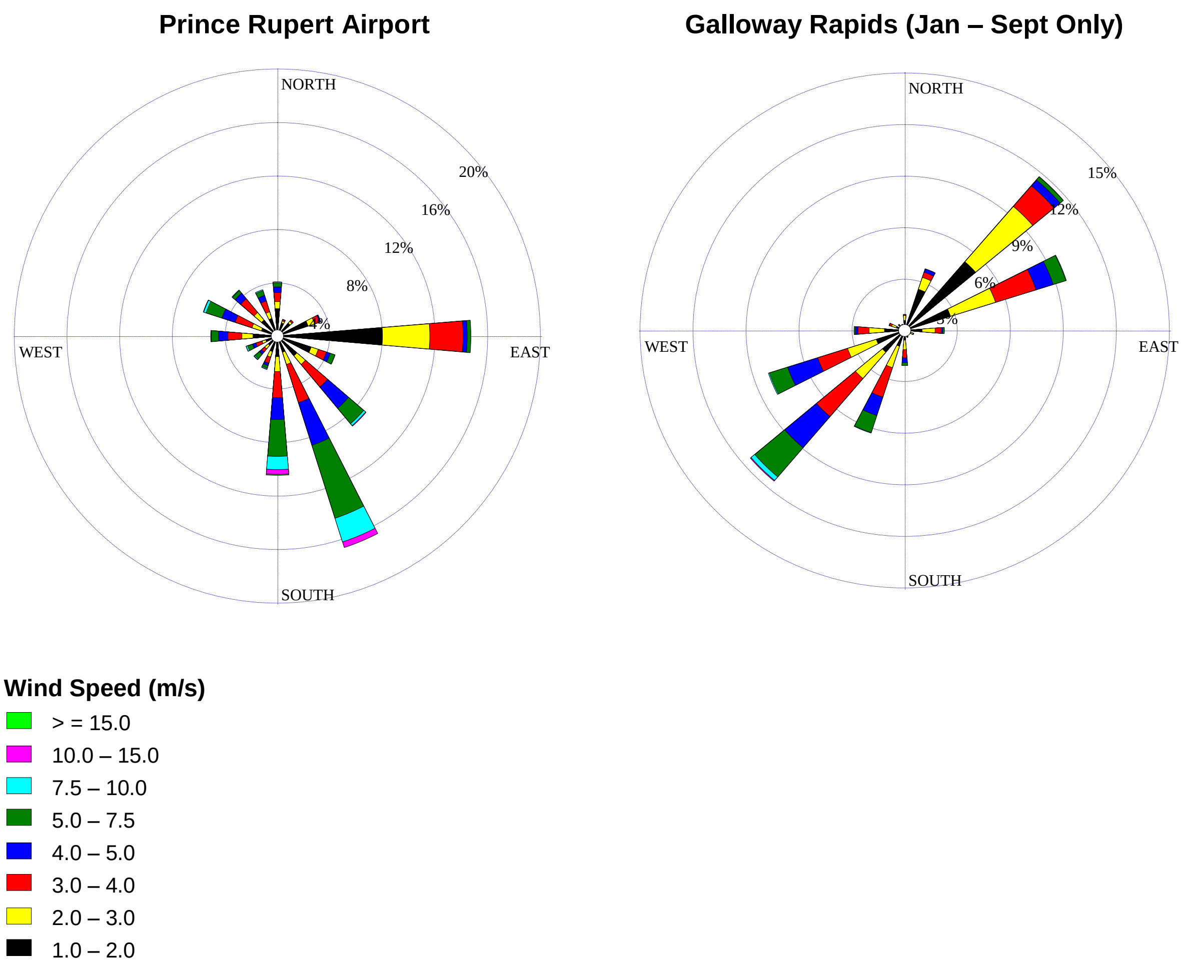


Figure A-2: Wind Roses Depicting Hourly Surface Winds at Input Stations (2002)

Wind roses are an efficient and convenient means of presenting wind data. The length of the radial barbs gives the total percent frequency of winds from the indicated direction while portions of the barbs of different widths indicate the frequency of associated wind speed categories. Wind roses summarizing hourly year-2002 10m wind measurements are shown for both Prince Rupert Airport and Galloway Rapids surface stations in Figure A-2.

As seen in Table A-3, wind direction data from Port Edward Mill was not used as input in the model as a very high frequency of year-2002 wind data hours were missing. Subsequently, no wind rose diagram is provided for this station. Also note that the wind rose for Galloway Rapids includes only the year-2002 months of January through September (inclusive). Very little data was missing from the Prince Rupert Airport wind data.

Although the two surface stations used as inputs are less than 25 km from each other, the differences shown by the wind roses in Figure A-2 are markedly different from one another, especially with respect to wind orientation. This is largely due to the differences in terrain surrounding each meteorological station. Due to terrain-blocking effects near the monitoring site, Galloway Rapids sees a much lower proportion of high wind speed events than does Prince Rupert Airport. Hourly wind speeds less than 1 m/s were seen no more than 8% of the time at the Airport station during 2002, while Galloway Rapids saw more than 37% of winds in this wind speed category from January to September of the same year.

The wind flow in the vicinity of the Project site location is probably somewhere between the patterns seen at the two surface stations. The Project site location is more exposed to larger-scale synoptic flow.

2.5.2 Prognostic MM5 Wind Input

CALMET has traditionally been initialized with meteorological inputs from surface stations within the region of interest as well as information from nearby twice-daily radiosonde stations. However, meteorological field output from models such as MM5 is increasingly being used for CALMET input. The primary advantages of using MM5 data to help initialize CALMET are as follows:

- MM5 model output can provide input data at higher spatial resolution than can radiosonde data and is potentially better able to represent mesoscale meteorological circulations.
- In remote locations without nearby surface stations, MM5 data can provide reasonable estimates of local surface meteorological conditions.
- While radiosonde data is only available twice daily, MM5 models can provide CALMET with initialization data at hourly increments.

2.6 CALMET Output

2.6.1 Stability and Mixing Heights

Atmospheric turbulence near the earth's surface is often described in terms of atmospheric stability, which is governed by both thermal and mechanical factors. Very broadly, atmospheric stability can be classified as stable, neutral, or unstable.

Stable atmospheric conditions occur when vertical motion in the atmosphere is suppressed. With respect to air quality, this means pollutants emitted near ground-level are not well-dispersed and have a larger effect on local ambient levels. This type of situation frequently occurs at night, when the earth's surface emits thermal radiation and cools. Air in contact with the ground becomes cooler and denser than the air aloft. This phenomenon is referred to as a ground-based temperature inversion and is often associated with poor air quality conditions.

Unstable atmospheric conditions are also highly dependent on radiation at the earth's surface, and most frequently occur during day-time hours. During such times, as short-wave energy from the sun heats the ground, air in contact with the ground becomes warmer and less dense than the air aloft. Subsequently, vertical motion in the atmosphere is enhanced and the atmosphere is said to be unstable.

When a balance exists between incoming and outgoing radiation, there is no net heating or cooling of the air in contact with the ground and vertical motions of the atmosphere are neither enhanced nor suppressed. Such an atmosphere is described as neutral and exists during overcast skies or during transition from unstable to stable conditions.

Mechanical mixing, which is mostly a function of lower level wind speeds (and surface roughness), can also influence atmospheric stability. Higher wind speeds (and a greater surface roughness) promote higher levels of turbulence in the region of discussion. This, in turn, leads to more mechanical mixing, which means that the atmosphere becomes more unstable. Mechanical mixing plays a more important role in determining stability during stormy conditions when wind speeds are very high and at night, when convective vertical motion is suppressed.

The relative stability of the earth's boundary layer is often expressed in terms of the Pasquill-Gifford (PG) stability classes (Pasquill 1961), as estimated by CALMET near the Project site location (Table A-4).

Table A-4: Output CALMET PG Class Frequency (%) near the Project Location

Case	Number of Hours	A	B	C	D	E	F
		Very Unstable	Moderately Unstable	Slightly Unstable	Neutral	Moderately Stable	Very Stable
Winter	2,160	0.0	0.0	5.2	68.9	25.8	0.0
Spring	2,208	0.0	0.0	20.5	56.9	22.6	0.0
Summer	2,208	0.0	0.0	25.1	59.7	15.2	0.0
Fall	2,184	0.0	0.0	14.4	57.6	28.0	0.0
Year	8,760	0.0	0.0	16.3	60.8	22.9	0.0

The letters A through F each denote a different stability condition and are determined from cloud (or radiation) data as well as wind speeds and time of day. Atmospheric conditions at the proposed site location are neutral at most times during the year. This is due to the combination of high winds and persistent cloud cover which are present in the assessment area for most of the year. Stable conditions occur less frequently in winter than in many other airsheds due to the strong wind events which occur during this time of year. Unstable conditions occur more frequently during the summer months than during winter as convective conditions are more prominent during this time of year.

The mixing height is the depth of the unstable air in the atmospheric boundary layer, as influenced by the mechanical and buoyant forces previously described. The height of the mixing layer is an extremely important factor in determining the dispersion of pollution in the atmosphere. Under low mixing heights, a relatively small emission amounts can have a marked effect on local air quality.

The CALMET model calculates a maximum mixing height, as determined by either convective or mechanical forces. The convective mixing height is the height to which an air package will rise under the buoyant forces created by the heating of the earth's surface. The convective mixing height is dependent on solar radiation amount, wind speed, as well as the vertical temperature structure of the atmosphere. Mechanical mixing heights are, similarly, the height to which an air package will rise under the influence of mechanical-invoked turbulence. The mechanical mixing height is proportional to low-level wind speeds and surface roughness.

During summer months, more convective mixing is expected than in winter due to different surface radiation budgets. Maximum mixing heights usually occur during mid-afternoon hours when the effects of solar heating are greatest; minimum heights occur most frequently at night. For the assessment area daytime mean mixing height values during the summer months can be much lower than in other regions in Canada during this time of year. This can be attributed to two factors:

- Advection of the more stable summer marine boundary layer into the assessment area
- Less surface heating due to cooler climate, higher wind speeds, and persistent cloud cover.

2.7 CALMET Model Options

Table A-5 provides a detailed summary of all CALMET model user options selected for the modelling done for this study. Model default values, as recommended by the United States Environmental Protection Agency (U.S. EPA 1998a), are presented for comparative purposes. In most cases, these default values were used.

Table A-5: CALMET Parameters Used for the Project

Input Group	Parameter	USEPA Default	Value Used	Selection Description
Group 1: General Run Control Parameters	IBYR	–	2002	Starting year
	IBMO	–	1	Starting month
	IBDY	–	1	Starting day
	IBHR	–	0	Starting hour
	IBSEC	–	0	Starting second
	IEYR	–	2003	Ending year
	IEMO	–	1	Ending month
	IEDY	–	1	Ending day
	IEHR	–	0	Ending hour
	IBSEC	–	0	Ending second
	ABTZ	–	8	Time zone
	NSECDT	–	3600	Model Time Step (seconds)
	IRTYPE	1	1	Run type
	LCALGRD	T	T	Special data fields are computer
	ITEST	2	2	Flag to not stop run after setup phase

Input Group	Parameter	USEPA Default	Value Used	Selection Description
Group 2: Map Projection and Grid Control Parameters	PMAP	UTM	UTM	Map Projection is UTM
	FEAST	0.0	0.0	False Easting (Not Used)
	FNORTH	0.0	0.0	False Northing (Not Used)
	IUTMZN	–	9	UTM Zone
	UTMHEM	N	N	Northern Hemisphere for UTM Projection
	RLAT0	–	0N	Latitude of Projection Origin (Not Used)
	RLON0	–	0E	Longitude of Projection Origin (Not Used)
	XLAT1	–	0N	Latitude of 1st Parallel (Not Used)
	XLAT2	–	0N	Latitude of 2nd Parallel (Not Used)
	DATUM	WGS-84	WGS-84	WGS-84 Reference Ellipsoid and Geoid, Global coverage (WGS84)
	NX	–	100	Number of X grid cells
	NY	–	100	Number of Y grid cells
	DGRIDKM	–	0.5	Grid spacing in X and Y directions (km)
	XORIGKM	–	389	Reference Easting of SW corner of SW grid cell in UTM (km)
	YORIGKM	–	5994	Reference Northing of SW corner of SW grid cell in UTM (km)
	NZ	–	8	Number of vertical grid cells
	ZFACE	–	0, 20, 40, 80, 160, 320, 600, 1400, 2600	Vertical cell face heights of the NZ vertical layers (m)
Group 3: Output Options	LSAVE	T	T	Save met data in unformatted output files
	IFORMO	1	1	Type of unformatted output file
	LPRINT	F	T	Print meteorological fields
	IPRINF	1	12	Print interval in hours
	IUVOUT	0	0	Do not print u, v wind components
	IWOUT	0	0	Do not print w wind component
	ITOUT	0	0	Do not print 3-D temperature fields
	Specify Meteorological Fields to Print			
	STABILITY	1		Print PGT stability class
	USTAR	0		Do not print friction velocity
	MONIN	0		Do not print Monin-Obukhov length

Input Group	Parameter	USEPA Default	Value Used	Selection Description
	MIXHT	1		Print mixing height
	WSTAR	0		Do not print convective velocity scale
	PRECIP	1		Do not print precipitation rate
	SENSHEAT	0		Do not print sensible heat flux
	CONVZI	0		Do not print convective mixing height
	Testing and Debugging Options			
	LDB	F	F	Print input and internal variables
	NN1	1	1	First time step to print data
	NN2	1	1	Last time step to print data
	LDBCST	F	F	Do not print distance to land internal variables
	IOUTD	0	0	Control variable to note write test data to disk
	NZPRN2	1	0	Number of levels to print
	IPR0	0	0	Do not print interpolated wind components
	IPR1	0	0	Do not print the terrain adjusted wind components
	IPR2	0	0	Do not print smoothed wind components and initial divergence fields
	IPR3	0	0	Do not print final wind speed and direction
	IPR4	0	0	Do not print final divergence fields
	IPR5	0	0	Do not print winds after kinematic effects are added
	IPR6	0	0	Do not print winds after the Froude number adjustment
	IPR7	0	0	Do not print wind after slope flow adjustment
	IPR8	0	0	Do not print final wind field components

Input Group	Parameter	USEPA Default	Value Used	Selection Description
Group 4: Meteorological Data Options	NOOBS	0	1	Use surface and overwater stations. Use MM4/MM5/3D for upper air data.
	NSSTA	–	3	Number of surface stations
	NPSTA	–	1	Number of precipitation stations
	ICLOUD	0	0	Gridded cloud data not used
	IFORMS	2	2	Surface meteorological data file format
	IFORMP	2	2	Precipitation data file format
	IFORMC	2	2	Cloud data file format
Group 5: Wind Field Options and Parameters	IWFCOD	1	1	Wind field diagnostic model selected
	IFRADJ	1	1	Use Froude number adjustment
	IKENE	0	0	Do not use Kinematic effects adjustment
	IOBR	0	1	Use O'Brien procedure to adjust vertical velocity
	ISLOPE	1	1	Compute slope flow effects
	IEXTRP	-4	-4	Extrapolate surface wind data to upper layers using similarity theory.
	ICALM	0	0	Do not extrapolate surface winds if calm
	BIAS	8*0	8*0	Layer dependent bias in vertical interpolation between surface and upper air data in first guess field. Prognostic data is used, therefore the model ignores this option.
	RMIN2	-1	-1	Minimum distance from nearest upper air station to surface station for which extrapolation of surface winds at surface station be allowed. Not Used if NOOBS=1
	IPROG	0	14	Use gridded prognostic wind field model output as input to the diagnostic wind field model
	ISTEPPG	1	1	Time step (hours) of input prognostic data
	IGFMET	0	0	Use coarse CALMET fields as initial guess fields
	LVARY	F	F	Use varying radius of influence. if no stations are found within RMAX1,RMAX2, or RMAX3, then the closest station will be used.

Input Group	Parameter	USEPA Default	Value Used	Selection Description
	RMAX1	–	10	Maximum radius of influence over land in the surface layer (km)
	RMAX2	–	10	Maximum radius of influence over land aloft (km)
	RMAX3	–	10	Maximum radius of influence over water (km)
	RMIN	0.1	0.1	Minimum radius of influence used in the wind field interpolation (km)
	TERRAD	15	5	Radius of influence of terrain features (km)
	R1	–	5	Relative weighting of the first guess field and observations in the surface layer (km)
	R2	–	5	Relative weighting of the first guess field and observations in the upper layer (km)
	RPROG	–	0	Relative weighting of the prognostic wind field data (km) (Not Used)
	DIVLIM	5 E-6	5 E-6	Maximum acceptable divergence in divergence minimization procedure
	NITER	50	50	Maximum number of iterations in the divergence minimization procedure
	NITER2	99*8	99*8	Maximum number of stations used in each layer for the interpolation of data to a grid point
	NSMTH	2, (nz - 1)*4	2,7*4	Number of passes in the smoothing procedure
	CRITFN	1	1	Critical Froude number
	ALPHA	1	1	Empirical factor controlling Kinematic effects
	FEXTR2	0*8	0*8	Multiplicative scaling factor for extrapolation of surface observations to upper layers (Not Used)
	NBAR	0	0	Number of barriers to interpolation of wind
	KBAR	NZ	8	Level (1 to NZ) up to which barriers apply
	XBBAR	–	0	X coordinate of beginning of barrier (Not Used)
	YBBAR	–	0	Y coordinate of beginning of barrier (Not Used)

Input Group	Parameter	USEPA Default	Value Used	Selection Description
	XEBAR	–	0	X coordinate of end of barrier (Not Used)
	YEBAR	–	0	Y coordinate of end of barrier (Not Used)
	IDIOPT1	0	0	Computer surface temperature internally from surface monitoring data for Diagnostic Wind Module
	ISURFT	–	3	Surface meteorological station to use for the surface temperature in Diagnostic Wind Module
	IDIOPT2	0	0	Domain-averaged temperature lapse rate computed internally from upper air soundings
	IUPT	–	0	Upper air station to use for the domain-scale lapse rate (not used).
	ZUPT	200	200	Depth through which the domain-scale lapse rate is computer (m)
	IDIOPT3	0	0	Domain-averaged wind components calculated internally
	IUPWND	-1	-1	Upper air station to use for the domain scale winds
	ZUPWND	1, 1000	1, 2500	Bottom and top of layer through which domain-scale winds are computed (m)
	IDIOPT4	0	0	Observed surface wind components read from surface data file
	IDIOPT5	0	0	Observed upper wind components read from upper air data file
	LLBREZE	F	F	Do not use lake breeze module
	NBOX	–	0	Number of lake breeze regions
	XG1	–	0	X grid line 1 of region of interest
	XG2	–	0	X grid line 2 of region of interest
	YG1	–	0	Y grid line 1 of region of interest
	YG2	–	0	Y grid line 2 of region of interest
	XBCST	–	0	X point defining coast line
	YBCST	–	0	Y point defining coast line
	XECST	–	0	X point defining coast line
	YECST	–	0	Y point defining coast line
	NLB	–	0	Number of station in the region
	METBXID	–	0	Station’s ID in the region

Input Group	Parameter	USEPA Default	Value Used	Selection Description
Group 6: Mixing Height, Temperature and Precipitation	CONSTB	1.41	1.41	Empirical mixing height equation constant, neutral conditions
	CONSTE	0.15	0.15	Empirical mixing height equation constant, convective conditions
	CONSTN	2400	2400	Empirical mixing height equation constant, stable conditions
	CONSTW	0.16	0.16	Empirical mixing height equation constant, over water conditions
	FCORIO	1.0E-4	1.2E-4	Coriolis Parameters, adjusted for latitude
	IAVEZI	1	1	Use spatial averaging of mixing heights
	MNMDAV	1	2	Maximum search radius (grid cells)
	HAFANG	30	30	Half-angle upwind looking cone for averaging
	ILEVZI	1	1	Layer of winds used in upwind averaging
	IMIXH	1	1	Use the Maul-Carson method for land and water cells to compute convective mixing height
	THRESHL	0.05	0.05	Threshold buoyancy flux to sustain convective mixing height growth overland (W/m^2)
	THRESHW	0.05	0.05	Threshold buoyancy flux to sustain convective mixing height growth overwater (W/m^2)
	ITWPROG	0	0	Use SEA.DAT to determine overwater lapse rates and deltaT (or assume neutral conditions if missing)
	ILUOC3D	16	16	Land Use category for ocean in 3D.DAT datasets
	DPTMIN	0.001	0.001	Minimum potential temperature lapse rate in thestable layer above the current convective mixing height (K/m)
	DZZI	200	200	Depth of layer above current convective mixing height through which lapse rate is computed (m)
	ZIMIN	50	50	Minimum overland mixing height (m)
	ZIMAX	3000	3000	Maximum overland mixing height (m)
	ZIMINW	50	50	Minimum over water mixing height (m)
	ZIMAXW	3000	3000	Maximum over water mixing height (m)

Input Group	Parameter	USEPA Default	Value Used	Selection Description
	ICOARE	10	10	COARE Method with no wave parameterization used to determine overwater surface flux
	DSHELF	0	0	Coastal/Shallow water length scale (km)
	IWARM	0	0	COARE warm layer computation turned off
	ICOOL	0	0	COARE cool skin layer computation turned off
	IRHPROG	0	0	Relative humidity from surface observations
	ITPROG	0	1	Compute surface temperatures from observed stations, upper air temperatures from MM5 data
	IRAD	1	1	Use 1/R interpolation scheme
	TRADKM	500	500	Radius of influence for temperature interpolation (km)
	NUMTS	5	5	Maximum number of stations to include in interpolation
	IAVET	1	1	Use spatial averaging of temperature data
	TGDEFB	-0.0098	-0.0098	Default temperature gradient below the mixing height, over water (K/m)
	TGDEFA	-0.0045	-0.0045	Default temperature gradient above the mixing height, over water (K/m)
	JWAT1	–	999	Beginning land use category for temperature interpolation over water. Make bigger than largest land use to disable.
	JWAT2	–	999	Ending land use category for temperature interpolation over water. Make bigger than largest land use to disable.
	NFLAGP	2	2	Use $1/R^2$ interpolation scheme for precipitation interpolation
	SIGMAP	100	100	Radius of influence for interpolation from precipitation stations (km)
	CUTP	0.01	0.01	Minimum precipitation rate cut off (mm/hr)

<table>
<tr><th>Input Group</th><th>Parameter</th><th>USEPA Default</th><th>Value Used</th><th colspan="3">Selection Description</th></tr>
<tr><td rowspan="5">Group 7:
Surface meteorological station parameters</td><td colspan="6">Surface Meteorological Stations Used</td></tr>
<tr><td>Name</td><td>ID</td><td>X Coordinate (km)</td><td>Y Coordinate (km)</td><td>Time Zone</td><td>Anemometer Height (m)</td></tr>
<tr><td>PEM</td><td>243949</td><td>415.773</td><td>6010.285</td><td>8</td><td>10</td></tr>
<tr><td>PRGR</td><td>231838</td><td>417.491</td><td>6013.160</td><td>8</td><td>10</td></tr>
<tr><td>PRAR</td><td>166481</td><td>406.688</td><td>6015.994</td><td>8</td><td>10</td></tr>
<tr><td>Group 8:
Upper Air Meteorological Station Parameters</td><td colspan="6">No Upper Air Radiosonde Stations Used</td></tr>
<tr><td rowspan="3">Group 9:
Upper Air Meteorological Station Parameters</td><td colspan="6">Precipitation Stations Used</td></tr>
<tr><td>Name</td><td>ID</td><td colspan="2">X Coordinate (km)</td><td colspan="2">Y Coordinate (km)</td></tr>
<tr><td>PRAR</td><td>166481</td><td colspan="2">406.688</td><td colspan="2">6015.994</td></tr>
</table>

3 CALPUFF MODELLING

3.1 Model Description

The following description of the CALPUFF model's major model algorithms and options are all excerpts from the CALPUFF model's user manual (Scire et al. 2000b).

The CALPUFF model is a non-steady-state Gaussian puff dispersion model which incorporates simple chemical transformation mechanisms, wet and dry deposition, complex terrain algorithms and building downwash. The CALPUFF model is suitable for estimating ground-level air quality concentrations on both local and regional scales, from tens of meters to hundreds of kilometers. It can accommodate arbitrarily varying point sources and gridded area source emissions. Most of the algorithms contain options to treat the physical processes at different levels of detail depending on the model application.

The major features and options of the CALPUFF model are summarized in Table A-6. Some of the technical algorithms are briefly described below.

Chemical Transformation: CALPUFF includes options for parameterizing chemical transformation effects using the five species scheme (SO_2, SO, NOx, HNO_3, and NO) employed in the MESOPUFF II model, the six species RIVAD/ARM3 scheme, or a set of user-specified, diurnally-varying transformation rates. The RIVAD/ARM3 reactions separately model NO and NO_2 rather than NOx. Calculations of chemical transformations require, among other information, a knowledge of background concentrations of ozone and ammonia.

Table A-6: Summary of Major Features of CALPUFF

- **Source types**
  - Point sources (constant or variable emissions)
  - Line sources (constant or variable emissions)
  - Volume sources (constant or variable emissions)
  - Area sources (constant or variable emissions)

- **Non-steady-state emissions and meteorological conditions**
  - Gridded 3-D fields of meteorological variables (winds, temperature)
  - Spatially-variable fields of mixing height, friction velocity, convective velocity scale, Monin-Obukhov length, precipitation rate
  - Vertically and horizontally-varying turbulence and dispersion rates
  - Time-dependent source and emissions data

- **Efficient sampling functions**
  - Integrated puff formulation
  - Elongated puff (slug) formulation

- **Dispersion coefficient (σ_y, σ_z) options**
  - Direct measurements of σ_v and σ_w
  - Estimated values of σ_v and σ_w based on similarity theory
  - Pasquill-Gifford (PG) dispersion coefficients (rural areas)
  - McElroy-Pooler (MP) dispersion coefficients (urban areas)
  - CTDM dispersion coefficients (neutral/stable)

- **Vertical wind shear**
  - Puff splitting
  - Differential advection and dispersion

- **Plume rise**
  - Partial penetration
  - Buoyant and momentum rise
  - Stack tip effects
  - Vertical wind shear
  - Building downwash effects

- **Building downwash**
  - Huber-Snyder method
  - Schulman-Scire method

(Continued)

Table A-6: Summary of Major Features of CALPUFF (*Continued…*)

- **Subgrid scale complex terrain**
  - Dividing streamline, H_d:
    - Above H_d, puff flows over the hill and experiences altered diffusion rates
    - Below H_d, puff deflects around the hill, splits, and wraps around the hill
- **Interface to the Emissions Production Model (EPM)**
  - Time-varying heat flux and emissions from controlled burns and wildfires
- **Dry Deposition**
  - Gases and particulate matter
  - Three options:
    - Full treatment of space and time variations of deposition with a resistance model
    - User-specified diurnal cycles for each pollutant
    - No dry deposition
- **Overwater and coastal interaction effects**
  - Overwater boundary layer parameters
  - Abrupt change in meteorological conditions, plume dispersion at coastal boundary
  - Plume fumigation
  - Option to introduce subgrid scale Thermal Internal Boundary Layers (TIBLs) into coastal grid cells
- **Chemical transformation options**
  - Pseudo-first-order chemical mechanism for SO_2, $SO_4^=$, NO_x, HNO_3, and NO_3^- (MESOPUFF II method)
  - User-specified diurnal cycles of transformation rates
  - No chemical conversion
- **Wet Removal**
  - Scavenging coefficient approach
  - Removal rate a function of precipitation intensity and precipitation type
- **Graphical User Interface**
  - Point-and-click model setup and data input
  - Enhanced error checking of model inputs
  - On-line Help files

Subgrid Scale Complex Terrain: The complex terrain module in CALPUFF is based on the approach used in the Complex Terrain Dispersion Model (CTDMPLUS) (Perry et al., 1989). Plume impingement on subgrid scale hills is evaluated using a dividing streamline (Hd) to determine which pollutant material is deflected around the sides of a hill (below Hd) and which material is advected over the hill (above Hd). Individual puffs are split in up to three sections for these calculations.

Puff Sampling Functions: A set of accurate and computationally efficient puff sampling routines are included in CALPUFF which solve many of the computational difficulties with applying a puff model to near-field releases. For near-field applications during rapidly varying meteorological conditions, an elongated puff (slug) sampling function can be used. An integrated puff approach is used during less demanding conditions. Both techniques reproduce continuous plume results exactly under the appropriate steady state conditions.

Wind Shear Effects: CALPUFF contains an optional puff splitting algorithm that allows vertical wind shear effects across individual puffs to be simulated. Differential rates of dispersion and transport occur on the puffs generated from the original puff, which under some conditions can substantially increase the effective rate of horizontal growth of the plume.

Building Downwash: The Huber-Snyder and Schulman-Scire downwash models are both incorporated into CALPUFF. An option is provided to use either model for all stacks, or make the choice on a stack-by-stack and wind sector-by-wind sector basis. Both algorithms have been implemented in such a way as to allow the use of wind direction specific building dimensions.

Overwater and Coastal Interaction Effects: Because the CALMET meteorological model contains both overwater and overland boundary layer algorithms, the effects of water bodies on plume transport, dispersion, and deposition can be simulated with CALPUFF. The puff formulation of CALPUFF is designed to handle spatial changes in meteorological and dispersion conditions, including the abrupt changes that occur at the coastline of a major body of water.

Dispersion Coefficients: Several options are provided in CALPUFF for the computation of dispersion coefficients, including the use of turbulence measurements (σ_v and σ_w), the use of similarity theory to estimate σ_v and σ_w from modelled surface heat and momentum fluxes, or the use of Pasquill-Gifford (PG) or McElroy-Pooler (MP) dispersion coefficients, or dispersion equations based on the Complex Terrain Dispersion Model (CTDM). Options are provided to apply an averaging time correction or surface roughness length adjustment to the PG coefficients.

Dry Deposition: A full resistance model is provided in CALPUFF for the computation of dry deposition rates of gases and particulate matter as a function of geophysical parameters, meteorological conditions, and pollutant species. Options are provided to allow user-specified, diurnally varying deposition velocities to be used for one or more pollutants instead of the resistance model (e.g., for sensitivity testing) or to by-pass the dry deposition model completely.

Wet Deposition: An empirical scavenging coefficient approach is used in CALPUFF to compute the depletion and wet deposition fluxes due to precipitation scavenging. The scavenging coefficients are specified as a function of the pollutant and precipitation type (i.e., frozen vs. liquid precipitation).

3.2 Model Initialization

3.2.1 Computational Domain

Dispersion modeling was conducted using CALPUFF over a computational domain equal to the CALMET meteorological grid defined in Section 2.0 of this Appendix. The CALPUFF computational domain is the area in which the transport and dispersion of puffs are considered for the modelling.

3.2.2 Meteorological Data

Meteorological data such as mixing heights, stability and winds determine the transport and dispersion of pollutants within the CALPUFF model. To capture puff behaviour under a variety of meteorological conditions, one year of modelling was considered for this application. Hourly three-dimensional meteorological fields for the year 2002 were prepared using the CALMET model, as described in Section 2.0 of this Appendix.

3.2.3 Emissions and Source Characteristics

CALPUFF was used to model the dispersion of emissions from the source combinations specified for each of the four distinct cases presented in the Project Air Quality Technical Data Report (TDR). Rates of emission for each species of concern as well as source characteristics used in the modelling are discussed in the main body of the Project Air Quality TDR.

3.2.4 Terrain Effects

The CALPUFF model was used to estimate concentrations, for each species considered, at each receptor locations. Since, some of these receptors were located in terrain at elevations greater than puff release points, terrain effects were considered. To account for the possible distortion of the plume trajectory over elevated terrain, the Partial Plume Path Adjustment Method (PPPAM) was used to modify the height of the plume.

The PPPAM employs a plume path coefficient (PPC) to adjust the height of the plume above the ground. Default PPC values of 0.5, 0.5, 0.5, 0.5, 0.35, and 0.35 for Pasquill-Gifford (PG) stability classes A, B, C, D, E, and F, respectively were used as recommended by the CALPUFF authors.

3.2.5 Dispersion Coefficients

A fundamental parameter controlling plume dispersion in a Gaussian model such as CALPUFF are the dispersion coefficients. These values, which must be specified for both the horizontal as well as the vertical directions in the model, can be estimated using several different methods in CALPUFF. For this application, dispersion coefficients were internally computed from turbulence estimates based on micrometeorological data from CALMET (MDISP=2). This method was chosen over the more simplistic default method (MDISP=3) to allow for a better characterization of dispersion in the model.

3.3 Model Options

Table A-7 provides a detailed summary of all CALPUFF model user options selected for one of the numerous CALPUFF simulations done for this assessment. Model default values, as recommended by the United States Environmental Protection Agency (U.S. EPA 1998a), are presented for comparative purposes. In most cases, these default values were used. Model options for CALPUFF Input Group 2 are in accordance with the recommended values specified by the BC MOE in their current Guidelines for Air Quality Dispersion Modelling in British Columbia (BC MOE 2008).

Table A-7: CALPUFF Dispersion Model User Options

Input Group	Parameter	USEPA Default	Project	Description
Group 1: General Run Control Parameters	METRUN	0	0	Run all period in met file
	IBYR	–	2002	Used only if METRUN=0
	IBMO	–	1	Used only if METRUN=0
	IBDY	–	1	Used only if METRUN=0
	IBHR	–	0	Used only if METRUN=0
	XBTZ	–	8	Time Zone, Pacific Standard Time
	IRLG	–	8760	Length of run in hours
	NSPEC	5	6	Number of chemical species modelled
	NSE	3	6	Number of chemical species emitted
	ITEST	2	2	Continue with model execution after setup
	MRESTART	0	0	Do not write a restart file
	NRESPD	0	24	File updated every 24 periods
	METFM	1	1	CALMET binary type of meteorological file
	AVET	60	60	Averaging time is 60 minutes
	PGTIME	60	60	PG Averaging time is 60 minutes
Group 2: Technical Options	MGAUSS	1	1	Gaussian distribution used in the near field
	MCTADJ	3	3	Partial Plume Path Adjustment Method of terrain adjustment
	MCTSG	0	0	Subgrid-scale complex terrain not modelled
	MSLUG	0	0	Near field puffs not elongated
	MTRANS	1	1	Transitional plume rise applied
	MTIP	1	1	Stack tip downwash applied
	MBDW	1	2	PRIME method
	MSHEAR	0	0	Vertical wind shear not modelled
	MSPLIT	0	0	No puff splitting allowed
	MCHEM	1	0	Chemical transformation not modelled
	MAQCHEM	0	0	Aqueous phase transformation not modelled

Input Group	Parameter	USEPA Default	Project	Description
	MWET	1	0	Wet removal modelled
	MDRY	1	0	Dry removal modelled
	MDISP	3	2	Dispersion coefficients calculated from CALMET micrometeorological variables
	MTURBVW	3	3	Use direct turbulence measurements to estimate dispersion (Not Used)
	MDISP2	3	3	Use PG coefficients when turbulence measurements not available
	MROUGH	0	0	Sigma Y and Z are not adjusted for roughness
	MPARTL	1	1	Model partial plume penetration of elevated inversion
	MTINV	0	0	Strength of temperature inversion is computed from default gradients
	MPDF	0	0	Use PDF to compute near-field dispersion under convective conditions
	MSGTIBL	0	0	Sub-grid TIBL module is not used
	MBCON	0	0	Boundary conditions are not modelled
	MFOG	0	0	Not configured for fog model output
	MREG	1	0	Do not test options against defaults
Group 3: Species List	CSPEC	–	SO_2, NO_x, CO, PM_{10}, $PM_{2.5}$, VOC	List of chemical species
	–	SO_2		Modelled, Emitted
	–	NO_x		Modelled, Emitted
	–	CO		Modelled, Emitted
	–	PM_{10}		Modelled, Emitted
	–	$PM_{2.5}$		Modelled, Emitted
	–	VOC		Modelled, Emitted
Group 4: Grid Control Parameters	PMAP	UTM	UTM	Universal Transverse Mercator for Projection of all X, Y
	FEAST	0	0	False Easting (Not Used)
	FNORTH	0	0	False Northing (Not Used)
	IUTMZN	–	9	UTM Zone
	UTMHEM	N	N	Northern Hemisphere
	RLAT0	–	0N	Latitude of Projection Origin (Not Used)
	RLON0	–	0E	Longitude of Projection Origin (Not Used)
	XLAT1	–	0N	Latitude of 1st Parallel (Not Used)

Input Group	Parameter	USEPA Default	Project	Description
	XLAT2	–	0N	Latitude of 2nd Parallel (Not Used)
	DATUM	WGS-84	WGS-84	WGS-84 Reference Ellipsoid and Geoid, Global coverage (WGS84)
	NX	–	100	Number of X grid cells
	NY	–	100	Number of Y grid cells
	NZ	–	8	Number of vertical grid cells
	DGRIDKM	–	0.5	Grid spacing in X and Y directions (km)
	ZFACE	–	0, 20, 40, 80, 160, 320, 600, 1400, 2600	Vertical cell face heights of the NZ vertical layers
	XORIGKM	–	389	Reference Easting of SW corner of SW grid cell in UTM (km)
	YORIGKM	–	5994	Reference Northing of SW corner of SW grid cell in UTM (km)
	IBCOMP	–	1	X index of lower left grid cell for computation
	JBCOMP	–	1	Y index of lower left grid cell for computation
	IECOMP	–	100	X index of upper right grid cell for computation
	JECOMP	–	100	Y index of upper right grid cell for computation
	LSAMP	T	F	Sampling grid is not used
	IBSAMP	–	1	X index of lower left grid cell for sampling
	JBSAMP	–	1	Y index of lower left grid cell for sampling
	IESAMP	–	100	X index of upper right grid cell for sampling
	JESAMP	–	100	Y index of upper right grid cell for sampling
	MESHDN	1	1	Nesting factor of sampling grid
Group 5: Output Options	ICON	1	1	Create binary concentration output file
	IDRY	1	0	Create binary dry flux output file
	IWET	1	0	Create binary wet flux output file
	IVIS	1	0	Output file containing relative humidity is not created
	LCOMPRS	T	T	Apply data compression
	IMFLX	0	0	Diagnostic mass flux option not applied
	IMBAL	0	0	Do not report hourly mass balance for each species
	ICPRT	0	0	Do not print concentrations to list file
	IDPRT	0	0	Do not print dry fluxes to list file
	IWPRT	0	0	Do not print wet fluxes to list file

Input Group	Parameter	USEPA Default	Project	Description
	ICFRQ	1	24	Concentration print interval in hours
	IDFRQ	1	24	Dry flux print interval in hours
	IWFRQ	1	24	Wet flux print interval in hours
	IPRTU	1	3	Output units are $\mu g/m^3$ for concentration and $\mu g/m^2/s$ for fluxes
	IMESG	2	2	Track progress of run on screen
	–	SO_2		Concentrations are saved to the hard disk. Concentrations are not printed hourly.
	–	NO_x		
	–	CO		
	–	PM_{10}		
	–	$PM_{2.5}$		
	–	VOC		
	LDEBUG	F	F	Do not print debug data
	IPFDEB	1	1	Debug options – First puff to track
	NPFDEB	1	1	Debug options – Number of puffs to track
	NN1	1	1	Debug options – Met period to start output
	NN2	10	10	Debug options – Met period to end output
Group 6: Subgrid Scale Complex Terrain Inputs	NHILL	0	0	Number of terrain features
	NCTREC	0	0	Number of complex terrain receptors
	MHILL	–	2	Hill data created by OPTHILL (Not Used)
	XHILL2M	1	1	Horizontal conversion factor to meters
	ZHILL2M	1	1	Vertical conversion factor to meters
	XCTDMKM	–	0	CTDM X origin relative to CALPUFF grid
	YCTDMKM	–	0	CTDM Y origin relative to CALPUFF grid

Input Group		Diffusivity	Alpha Star	Reactivity	Mesophyll Resistance	Henry's Law Coefficient
Group 7: Chemical Parameters for Dry Deposition of Gases	–	–	–	–	–	–

Input Group		Geometric Mass Mean	Geometric Standard Deviation
Group 8: Size Parameters for Dry Deposition of Particles	–	–	–

Input Group	Parameter	USEPA Default	Project	Description
Group 9: Miscellaneous Dry Deposition Parameters	RCUTR	30	30	Reference cuticle resistance
	RGR	10	10	Reference ground resistance
	REACTR	8	8	Reference pollutant reactivity
	NINT	9	9	Number of particle size intervals used to evaluate effective particle deposition velocity
	IVEG	1	1	Vegetation in unirrigated areas is active and unstressed
Group 10: Wet Deposition Parameters		**Liquid Precip Coef.**		**Frozen Precip Coef.**
	–	–		–
Group 11: Chemistry Parameters	MOZ	1	1	Monthly ozone values are used in chemistry
	BCKO3	12*80	12*80	Monthly ozone values are used in chemistry
	BCKNH3	12*10	12*10	Constant background concentration in ppb
	RNITE1	0.2	0.2	Night time SO_2 loss rate (% per hour)
	RNITE2	2	2	Night time NOx loss rate (% per hour)
	RNITE3	2	2	Night time HNO_3 formation rate (% per hour)
	BCKH2O2	12*1	12*1	Background H2O2 (Not Used)
	BCKPMF	12*1	12*1	Background fine particulate matter (Not Used)
	OFRAC	12*0.20	12*0.20	Organic fraction of fine particulate matter (Not Used)
	VCNX	12*50	12*50	VOC/NOx ratio for chemistry (Not Used)
Group 12: Miscellaneous Dispersion and Computational Parameters	SYTDEP	550	550	Horizontal size of puff in meters beyond which Heffer dispersion is applied
	MHFTSZ	0	0	Do not use Heffer formulas for sigma Z
	JSUP	5	5	Stability class used to determine plume growth rates for puff above the boundary layer
	CONK1	0.01	0.01	Vertical dispersion constant for stable conditions
	CONK2	0.1	0.1	Vertical dispersion constant for neutral/unstable conditions
	TBD	0.5	0.5	Transition factor between Huber-Snyder and Schulman-Scire downwash schemes
	IURB1	10	10	Lower range of land use categories for which urban dispersion is assumed
	IURB2	19	19	Upper range of land use categories for which urban dispersion is assumed
	ILANDUIN	20	Varies Spatially	Land use category for modelling domain

Input Group	Parameter	USEPA Default	Project	Description
	ZOIN	0.25	Varies Spatially	Roughness length in meters for domain
	XLAIIN	3	Varies Spatially	Leaf area index for domain
	ELEVIN	0	Varies Spatially	Elevation above sea level in meters
	XLATIN	-999	-999	Latitude of met location in degrees
	XLONIN	-999	-999	Longitude of met location in degrees
	ANEMHT	10	10	Anemometer height in meters
	ISIGMAV	1	1	Read sigma-v from profile file (Not Used)
	IMIXCTDM	0	0	Predicted mixing heights are used
	XMXLEN	1	1	Maximum slug length
	XSAMLEN	1	10	Maximum travel distance of a puff in grid units during one sampling step
	MXNEW	99	60	Maximum number of puffs released from one source during one sampling step
	MXSAM	99	60	Maximum number of sampling steps during one time step for a puff
	NCOUNT	2	2	Number of iterations used when computing the transport wind for a sampling step that includes transitional plume rise
	SYMIN	1	1	Minimum sigma Y in metres for a new puff
	SZMIN	1	1	Minimum sigma Z in metres for a new puff
	SVMIN	0.5,0.5,0.5 0.5,0.5,0.5	0.5,0.5,0.5 0.5,0.5,0.5	Default minimum turbulence velocities for each stability class (Sigma-V)
	SWMIN	0.2, 0.12 0.08, 0.06 0.03, 0.016	0.2, 0.12 0.08, 0.06 0.03, 0.016	Default minimum turbulence velocities for each stability class (Sigma-W)
	WSCALM	0.5	0.5	Minimum wind speed allowed for non-calm conditions in m/s
	XMAXZI	3000	3000	Maximum mixing height in meters
	XMINZI	50	50	Minimum mixing height in meters
	CDIV	0, 0	0, 0	Divergence criteria for dw/dz in meters
	PLX0	0.07, 0.07, 0.10, 0.15, 0.35, 0.55	0.07, 0.07, 0.10, 0.15, 0.35, 0.55	Wind speed profile power-law exponents for stabilities 1 to 6
	PTG0	0.02, 0.035	0.02, 0.035	Potential temperature gradient for stable classes

Input Group	Parameter	USEPA Default	Project	Description
	PPC	0.5, 0.5, 0.5, 0.5, 0.35, 0.35	0.5, 0.5, 0.5, 0.5, 0.35, 0.35	Plume path coefficients for partial plume path adjustment terrain method.
	SL2PF	10	10	Slug to puff transition factor (Not used)
	NSPLIT	3	3	Number of puffs that result everytime a puff is split (Not used)
	IRESPLIT	0,0,0,0,0,0,0 0,0,0,0,0,0,0 0,0,0,1,0,0,0 0,0,0	0,0,0,0,0,0,0 0,0,0,0,0,0,0 0,0,0,1,0,0,0 0,0,0	Times of day when puff can be split after being split previously (Not used)
	ZISPLIT	100	100	Puff split only occurs if previous hours mixing height exceeds this value (Not used)
	ROLDMAX	0.25	0.25	Maximum allowable ratio previous hour mixing height to maximum mixing height experience by puff (Not used)
	NSPLITH	5	5	Number of puffs that result from each split (not used)
	SYSPLITH	1	1	Minimum sigma-y off puff before it may be split (Not used)
	SHSPLITH	2	2	Minimum puff elongation rate due to wind shear, before it may be split (Not used)
	CNSPLITH	$1e^{-7}$	$1e^{-7}$	Minimum concentration (g/m3) of each species in puff before it may be split (Not used)
	EPSSLUG	$1e^{-4}$	$1e^{-4}$	Fraction convergence criterion for numerical slug sampling integration
	EPSAREA	$1e^{-6}$	$1e^{-6}$	Fraction convergence criterion for numerical area sources integration
	DSRISE	1	1	Trajectory step-length (m) used for numerical rise integration
	HTMINBC	500	500	Minimum height to mix boundary condition puffs (m)
	RSAMPBC	10	15	Search radius (BC length segments) about a receptor for sampling nearest BC puff.
	NDEPBC	1	0	Near surface depletion adjustment when sampling BC puffs
Group 13: Point Source Parameters	NPT1	–	70	Number of point sources modelled (Application Case)
	IPTU	1	1	Units used for emissions (g/s)
	NSPT1	0	0	Number of source-species combinations with variable emissions scaling factors
	NPT2	–	0	Number of point sources with variable emissions

Input Group	Parameter	USEPA Default	Project	Description
Group 14: Area Source Parameters	NAR1	–	7	Number of polygon area sources modelled
	IARU	1	1	Units used for emissions (g/m2/s)
	NSAR1	0	0	Number of source-species combinations with variable emissions scaling factors
	NAR2	–	0	Number of area sources with variable emissions
Group 15: Line Source Parameters	NLN2	–	0	Number of buoyant line sources with variable location and emission parameters
	NLINES	–	0	Number of buoyant line sources
	ILNU	1	1	Units for line source emission rates is g/s
	NSLN1	0	0	Number of source-species combinations with variable emission scaling factors
	MXNSEG	7	7	Maximum number of segments used to model each line
	NLRISE	6	6	Number of distances at which transitional rise computed
	XL	–	0	Average building length
	HBL	–	0	Average building height
	WBL	–	0	Average building width
	WML	–	0	Average line sources width
	DXL	–	0	Average separation between buildings
	FPRIMEL	–	0	Average buoyancy parameter
Group 16: Volume Source Parameters	NVL1	–	0	Number of volume sources applied
	IVLU	1	1	Units used for volume sources (g/s)
	NSVL1	0	0	Number of source-species combinations with variable emission scaling factors
	NSVL2	–-	0	Number of volume sources with variable location and emission parameters
Group 17: Non-Gridded Receptor Information	NREC	–	3558	Number of non-gridded discrete receptors that compose the series of nested grids, property boundary and sensitive receptors

4 NO_X TO NO_2 CONVERSION

Oxides of nitrogen (NO_x) are comprised of nitric oxide (NO) and nitrogen dioxide (NO_2). Ambient air quality guidelines exist for NO_2 rather than total NO_x. Therefore, it is important to be able to estimate the portion of predicted ground-level NO_x comprised of NO_2. One way that this can be done is the Ambient Ratio Method (ARM), which is recommended by BC MOE (2008).

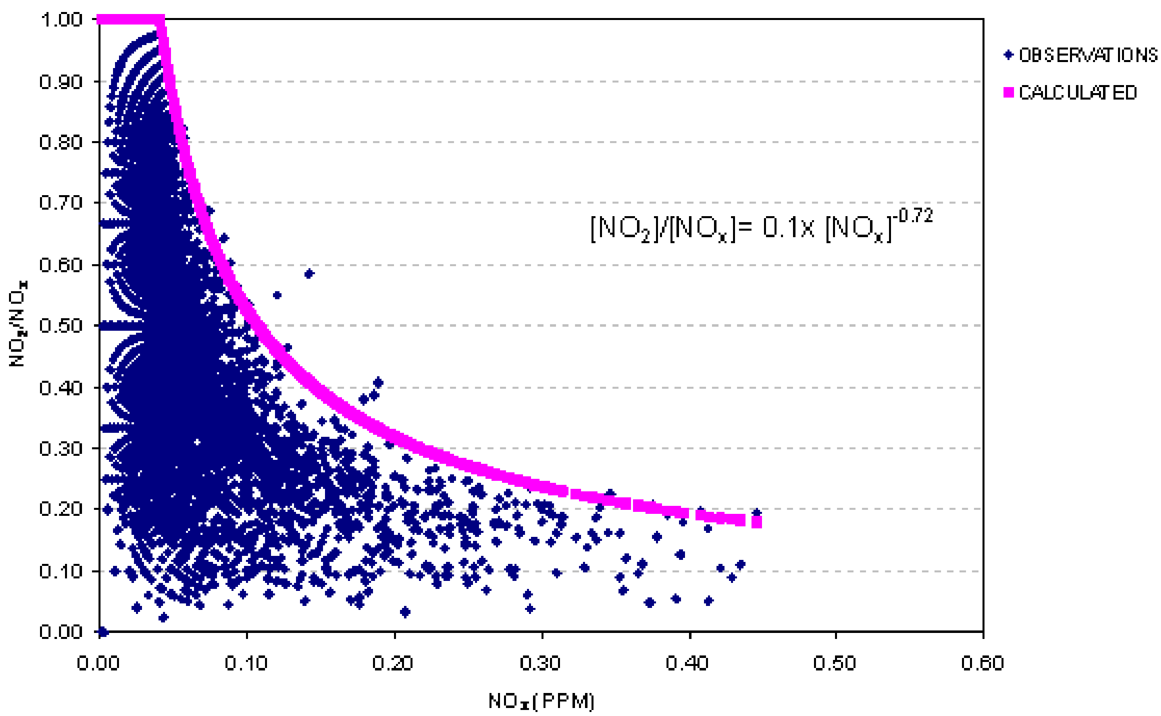


Figure A-3: Hourly NO_X and NO_2 Concentrations Applied in the ARM Conversion

ARM provides a realistic prediction of NO_2 concentrations based on actual monitored concentrations of NO_2 and NO_x from representative ambient air quality monitoring. Two separate non-linear regressions were developed based on NO_X and NO_2 measurements from the Smithers St. Josephs and Kitimat Rail continuous ambient monitoring stations from 2001 to 2005. However, it was determined that due to the low observed values at both sites, an accurate relationship that holds for all concentrations could not be developed. Therefore, to ensure a conservative approach, observed data from Wood Buffalo Environmental Association (WBEA) monitoring stations at several oil sands mines (CEMA 2005) were investigated. The data from the Albian Mine site was used to develop the ARM equation that was applied to relate NO_x and NO_2 predictions for all averaging periods. This data was selected as being representative of average conditions in the oil sands area.

The following equation and coefficients were used to relate NO_x and NO_2 predictions:

$$[NO_2]/[NO_x] = 0.100*[NO_x]^{-0.72}$$

Where:

$[NO_2]$ = Concentration of nitrogen dioxide (ppm)
$[NO_x]$ = Concentration of oxides of nitrogen (ppm)

The non-linear regression curve associated with hourly data at Albian Mine are presented in Figure A-3.

The above relationship was used to calculate NO_2 levels for predicted one-hour average NO_x concentrations obtained through dispersion modelling. The 24-hour and annual NO_2 concentrations were then determined by averaging the one-hour results for NO_2.

5 PREDICTION CONFIDENCE

The evaluation of potential changes in air quality depends primarily upon air dispersion models that are used to predict the change in expected ambient air concentrations. Air quality models, such as CALPUFF, are as accurate as the inputs and assumptions employed in the model and the inputs.

Emission rates used in the modelling were estimated based on a combination of maximum permitted emission limits, emission factors, engineering estimates, and amounts specified in the BC MOE 2000 Emissions Inventory. In reality, actual emissions vary from hour to hour and day to day. Due to the nature of this approach, there is a high degree of confidence that estimated emissions over-estimate actual emissions.

Air quality dispersion models such as CALPUFF also employ assumptions to simplify the random behaviour of the atmosphere into short periods of average behaviour. These assumptions limit the capability of the model to replicate individual meteorological events. To compensate for these simplifications, one full year of meteorological data is applied to evaluate a wide range of possible conditions. Additionally, regulatory models, such as CALPUFF, are designed to have a bias towards over estimation of contaminant concentrations (i.e. to be conservative under most conditions).

6 REFERENCES

Allwine, K.J., and C.D. Whiteman. (1985). MELSAR: A mesoscale air quality model for complex terrain: Volume 1 – Overview, technical description and user's guide. Pacific Northwest Laboratory, Richland, Washington.

Carson, D.J. (1973). The development of a dry, inversion-capped, convectively unstable boundary layer. Quart. J. Roy. Meteor. Soc., **99**: 450-467.

Douglas, S., and R. Kessler. (1988). User's guide to the diagnostic wind model. California Air Resources Board, Sacramento, CA.

Garratt, J.R. (1977). Review of drag coefficients over oceans and continents. Mon. Wea. Rev., **105**: 915-929.

Hanna, S.R., L.L. Schulman, R.J. Paine, J.E. Pleim, and M. Baer. (1985). Development and evaluation of the Offshore and Coastal Dispersion Model. JAPCA, **35**: 1039-1047.

Holtslag, A.A.M., and A.P. van Ulden. (1983): A simple scheme for daytime estimates of the surface fluxes from routine weather data, J. Clim. and Appl. Meteor., **22**: 517-529.

Liu, M. K. and M. A. Yocke. (1980). Siting of wind turbine generators in complex terrain. Journal of Energy, **4**: 10:16.

Maul, P.R. (1980). Atmospheric transport of sulfur compound pollutants. Central Electricity Generating Bureau MID/SSD/80/0026/R. Nottingham, England.

O'Brien, J.J. (1970). A note on the vertical structure of eddy exchange coefficient in the planetary boundary layer. J. Atmos. Sci., **27**: 1213-1215.

Pasquill F. (1961). The estimation of the dispersion of wind-borne material. Meteorological Magazine, **90**: 33-48.

Perry, S.G., D.J. Burns, L.H. Adams, R.J. Paine, M.G. Dennis, M.T. Mills, D.G. Strimaitis, R.J. Yamartino, E.M. Insley. (1989). User's Guide to the Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS) Volume 1: Model Description and User Instructions. EPA/600/8-89/041, U.S. Environmental Protection Agency, Research Triangle Park, NC.

Scire, J.S., F.R. Robe, M.E. Fernau, and R.J. Yamartino. (2000a). A User's Guide for the CALMET Meteorological Model (Version 5). Earth Tech, Inc., Concord, MA.

Scire, J.S., D.G. Strimaitis, and R.J. Yamartino. (2000b). A User's Guide for the CALPUFF Dispersion Model (Version 5). Earth Tech, Inc., Concord, MA.

U.S. EPA. (1998a). United States Environmental Protection Agency. Interagency Workgroup on Air Quality Modelling (IWAQM) Phase 1 Summary Report and Recommendations for Modelling Long Range Transport Impacts. EPA-454/R-98-019.

APPENDIX B

Isopleths of Maximum Predicted Concentrations

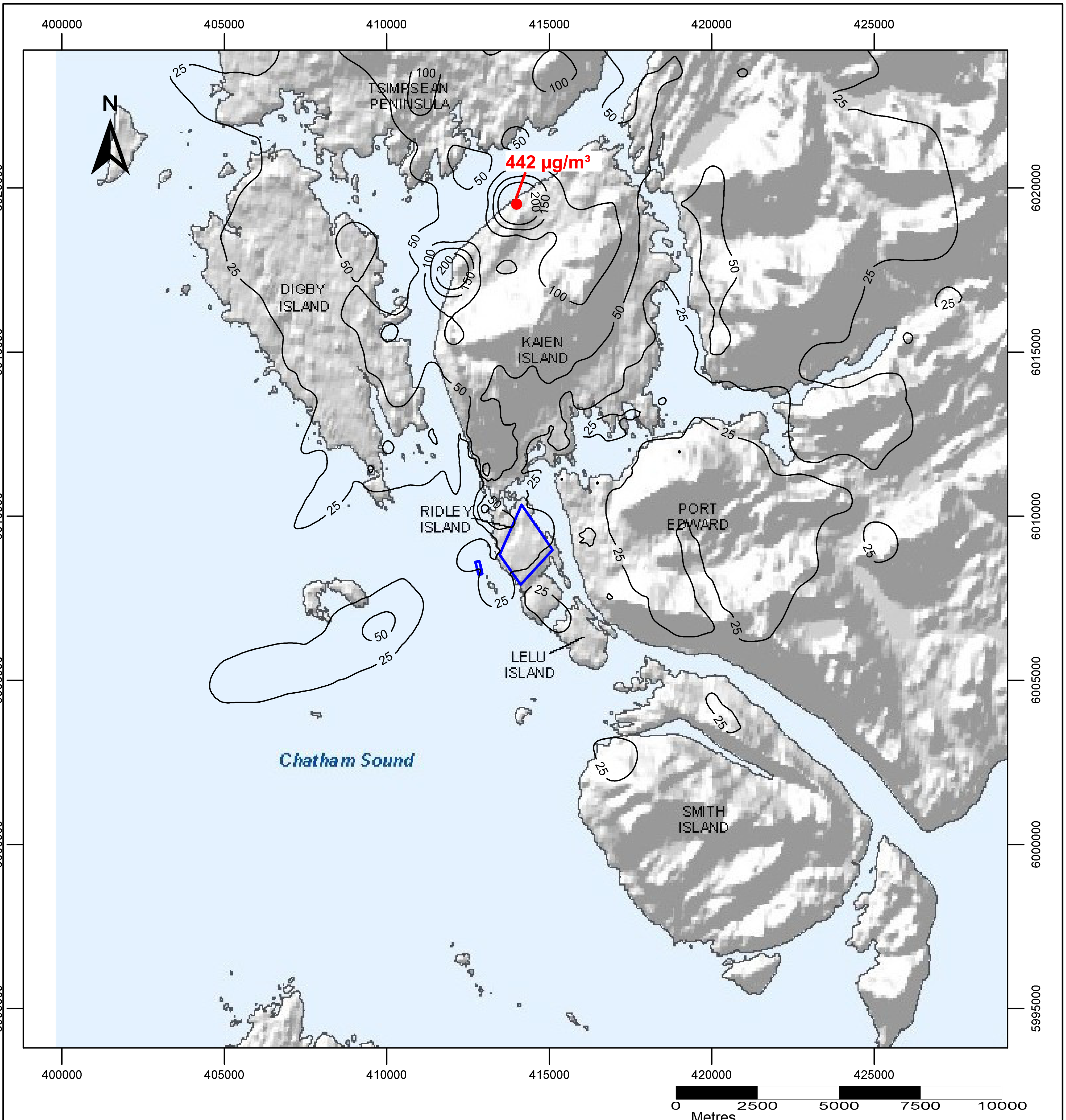
LIST OF FIGURES

Baseline Case

Project Case

Application Case

CEA Case



Legend

- Air Quality Modeling Fenceline
- SO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

British Columbia Level A Air Quality Objective
One-hour Average SO_2 : 450 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752
Stantec

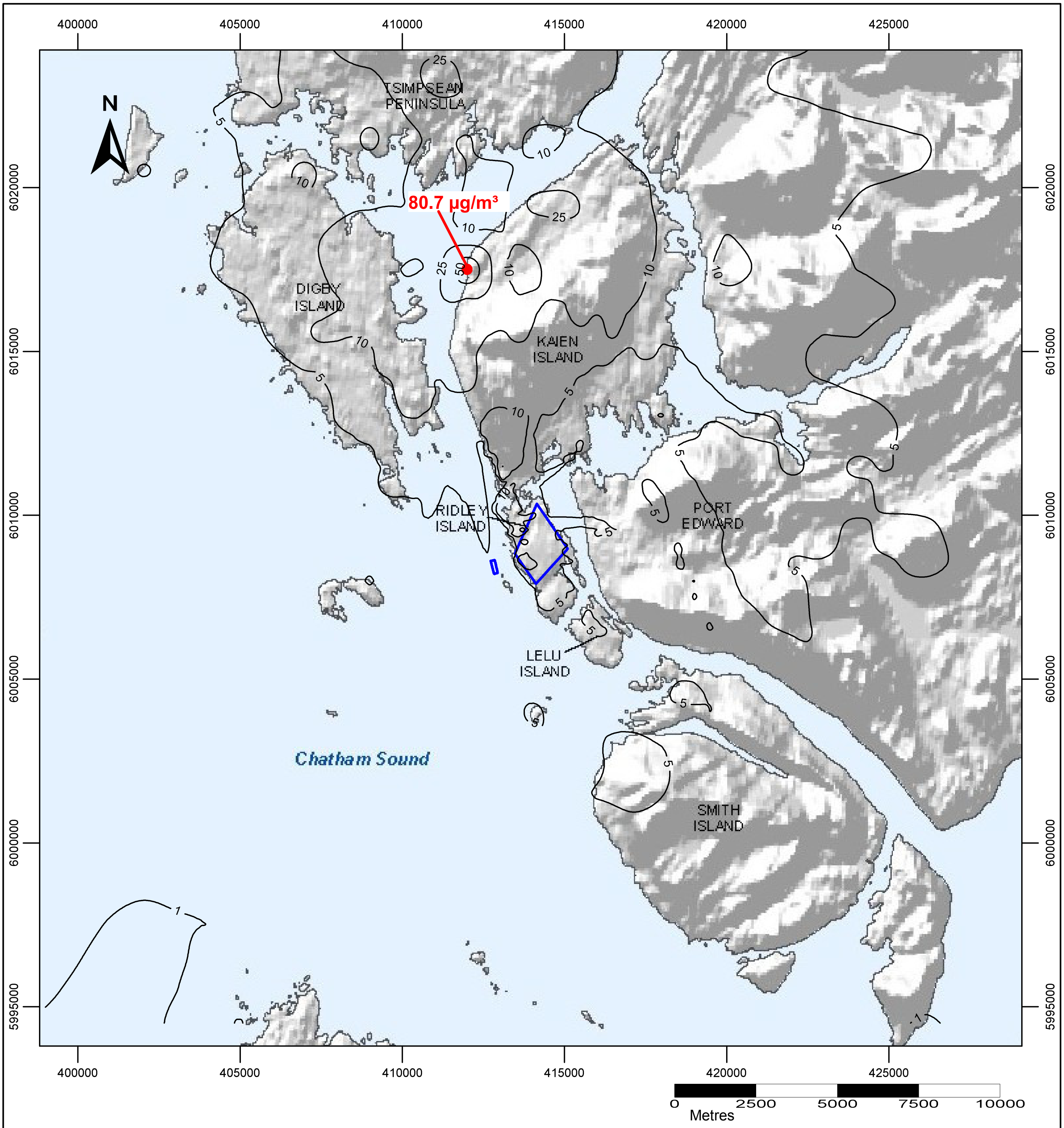
Canpotex
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted One-hour Average Ground-level SO_2 Concentrations (µg/m³) Associated with the Baseline Case

PROJECTION UTM	DRAWN BY MK
DATUM NAD 83	CHECKED BY BK
DATE 2010-Jul-12	FIGURE NO. B-1

P:/../c0057srf/Bas/hd/Fig B-1 Base_SO2_h.srf

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- SO_2 Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Level A Air Quality Objective
24-hour Average SO_2 : 160 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

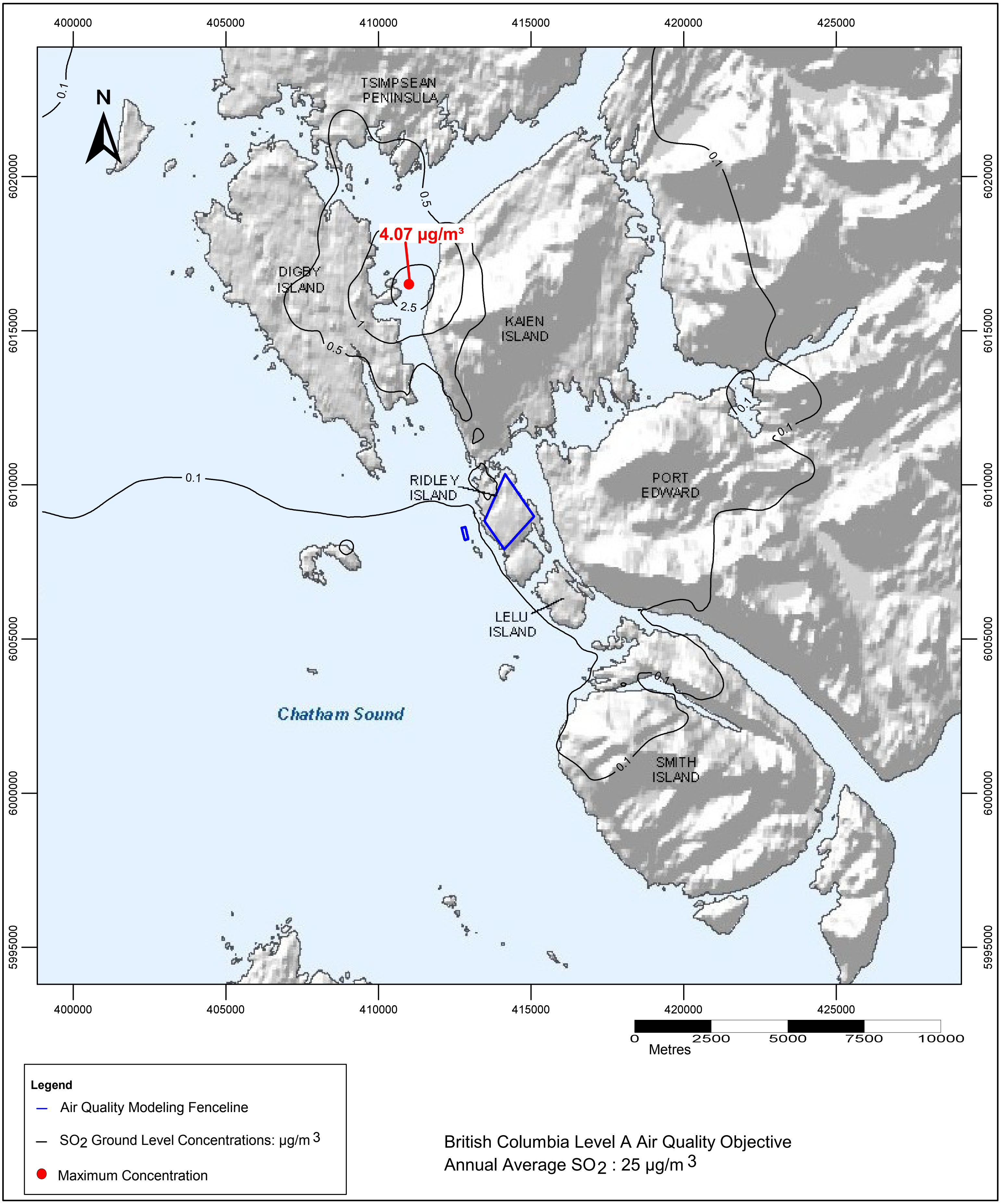
Canpotex
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted 24-hour Average Ground-level SO_2 Concentrations (µg/m³) Associated with the Baseline Case

PROJECTION	DRAWN BY
UTM	MK
DATUM: NAD 83	CHECKED BY: BK
DATE: 2010-Jul-12	FIGURE NO.: B-2

Job No: 1231-10264

P:/...c0057srf/Bas/hd/Fig B-2 Base_SO2_d.srf



British Columbia Level A Air Quality Objective
Annual Average SO_2 : 25 µg/m^3

Stantec Consultants Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752
Stantec

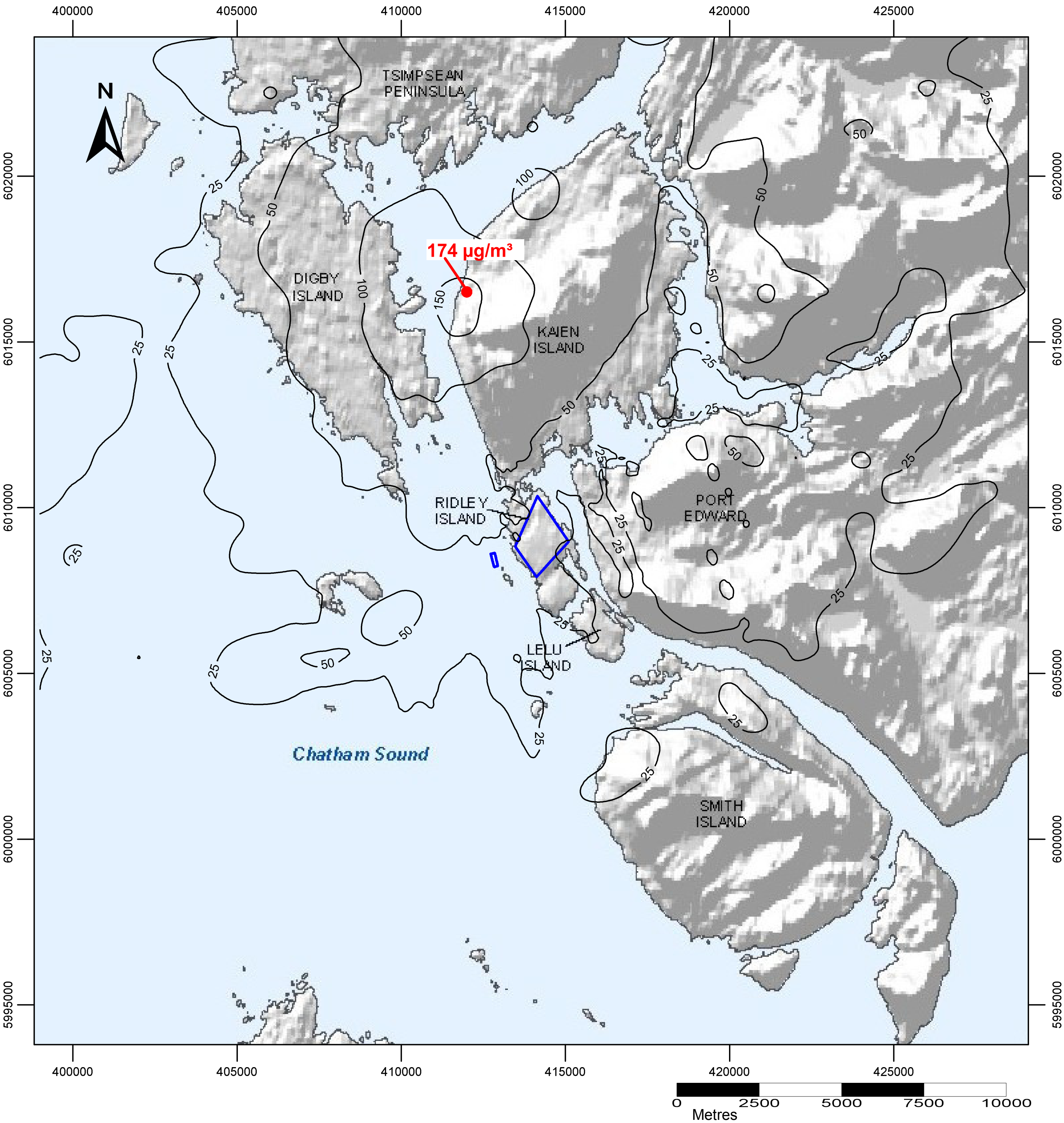
Canpotex
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted Annual Average Ground-level SO_2 Concentrations (µg/m³) Associated with the Baseline Case

PROJECTION UTM	DRAWN BY MK
DATUM NAD 83	CHECKED BY BK
DATE 2010-Jul-19	FIGURE NO. B-3

P:\..\c0057srf\Bas\a\Fig B-3 Base_SO2_a.srf

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- NO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

National Level A Air Quality Objective
One-hour Average NO_2 : 400 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

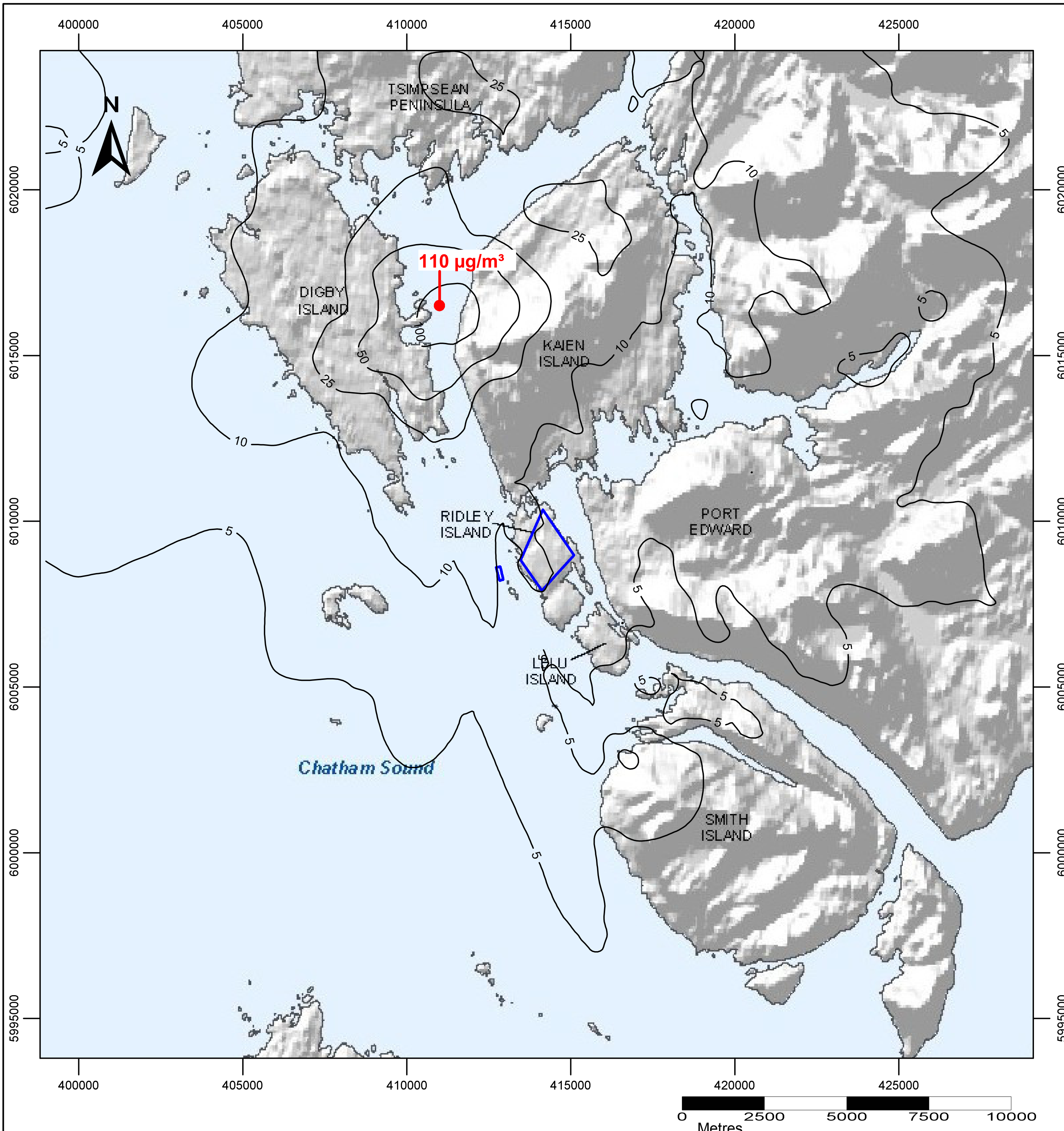
Canpotex

PRINCE RUPERT PORT AUTHORITY

Maximum Predicted One-hour Average Ground-level NO_2 Concentrations (µg/m³) Associated with the Baseline Case

PROJECTION	UTM	DRAWN BY	MK
DATUM	NAD 83	CHECKED BY	BK
DATE	2010-Jul-19	FIGURE NO.	B-4

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- NO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

National Level A Air Quality Objective
24-hour Average NO_2 : 200 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

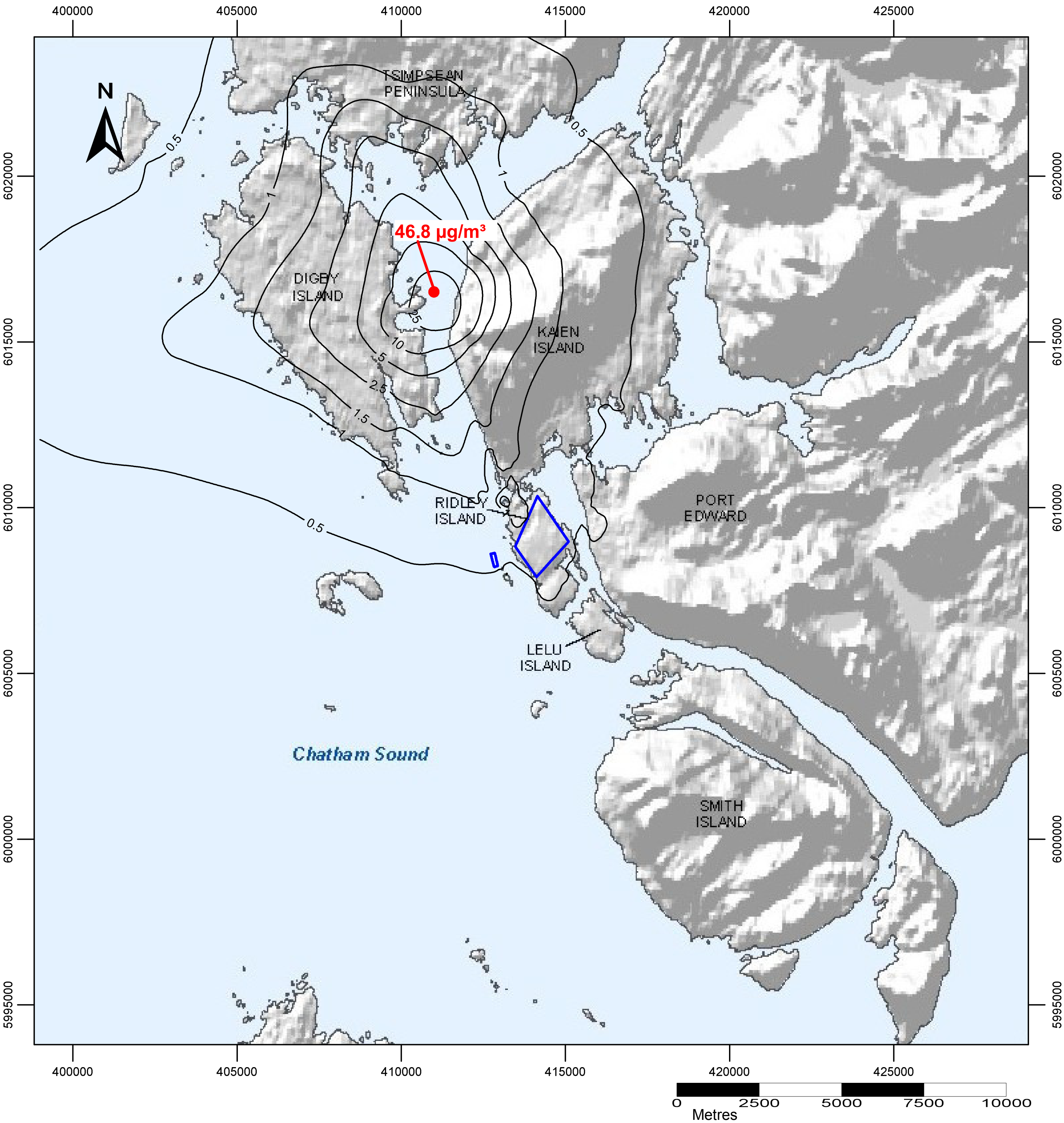
Canpotex
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted 24-hour Average Ground-level NO_2 Concentrations (µg/m³) Associated with the Baseline Case

PROJECTION	DRAWN BY
UTM	MK
DATUM	CHECKED BY
NAD 83	BK
DATE	FIGURE NO.
2010-Jul-19	B-5

Job No: 1231-10264

P:/...c0057srf/Bas/hd/Fig B-5 Base_NO2_d.srf



Legend

- Air Quality Modeling Fenceline
- NO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

National Level D Air Quality Objective
Annual Average NO_2 : 60 µg/m^3

P:/...c0057srf/Bas/a/Fig B-6 BaseR_NO2_a.srf

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Stantec

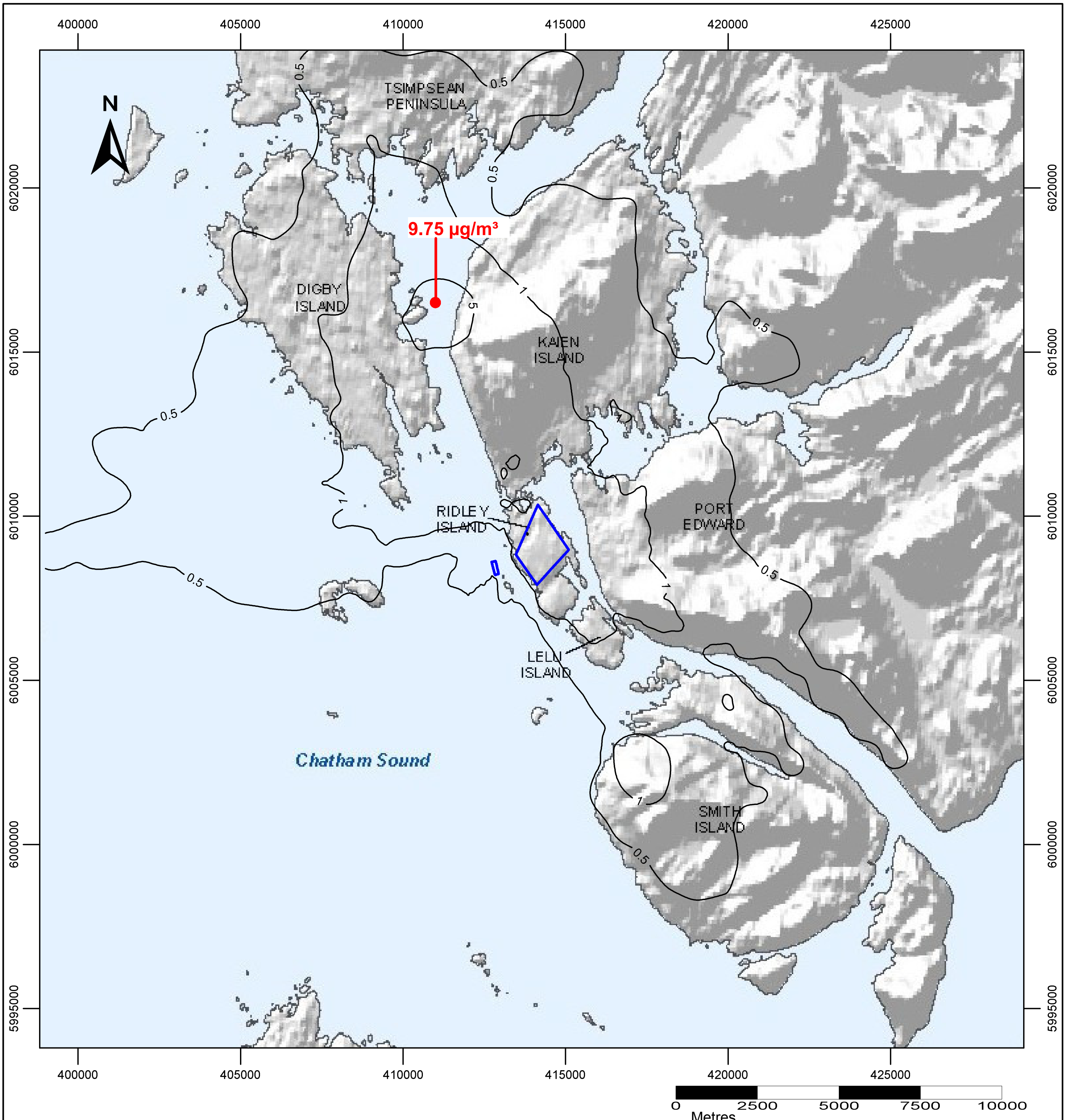
Canpotex

PRINCE RUPERT PORT AUTHORITY

Maximum Predicted Annual Average Ground-level NO_2 Concentrations (µg/m³) Associated with the Baseline Case

PROJECTION	UTM	DRAWN BY	MK
DATUM	NAD 83	CHECKED BY	BK
DATE	2010-Jul-19	FIGURE NO.	B-6

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- PM_{10} Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Level B Air Quality Objective
24-hour Average PM_{10} : 50 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

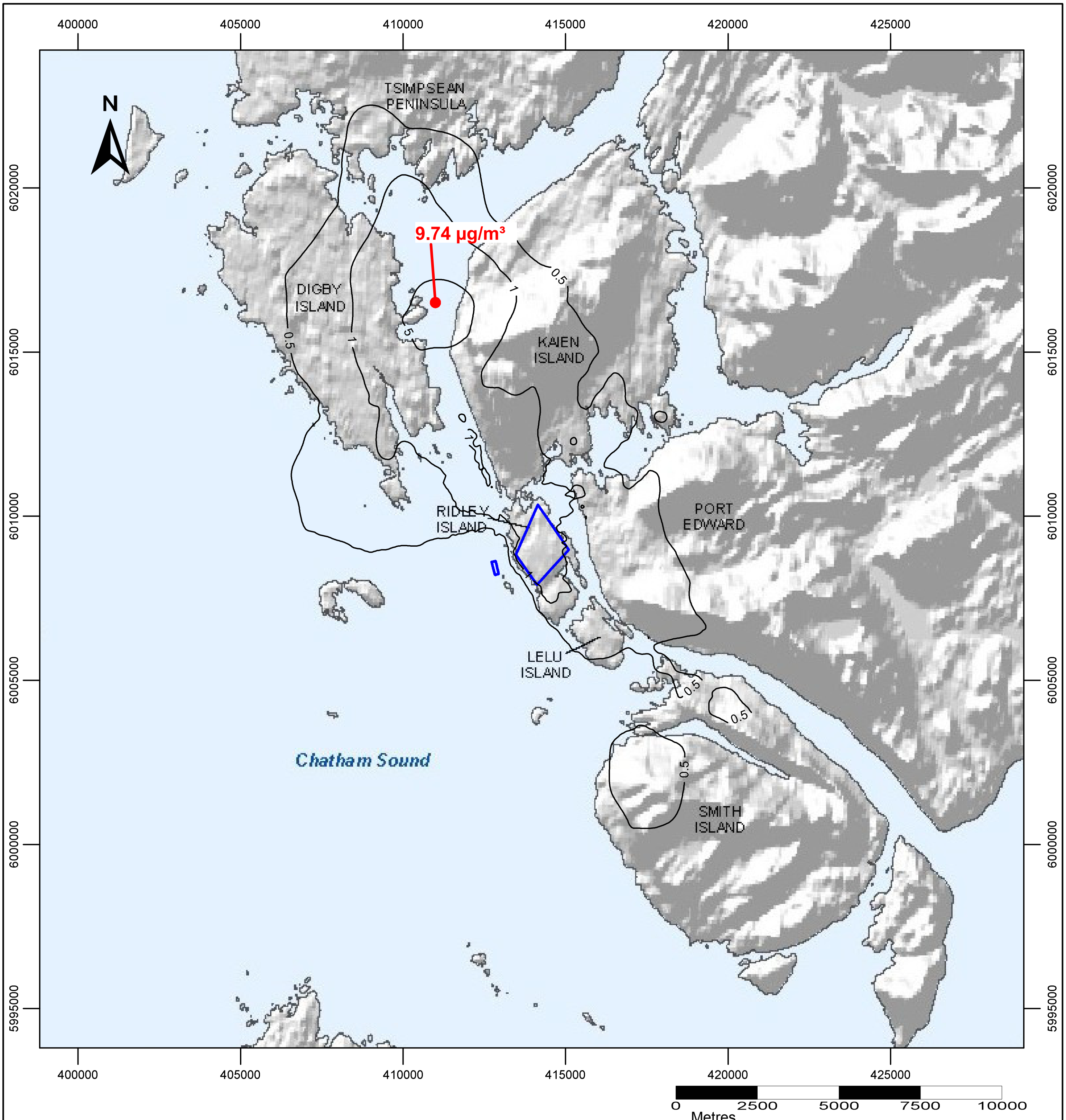
Canpotex
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted 24-hour Average Ground-level PM_{10} Concentrations (µg/m³) Associated with the Baseline Case

PROJECTION	UTM	DRAWN BY	MK
DATUM	NAD 83	CHECKED BY	BK
DATE	2010-Jul-12	FIGURE NO.	B-7

P:/../c0057srf/Bas/hd/Fig B-7 Base_PM10_d.srf

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- $PM_{2.5}$ Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Air Quality Objective
Annual 98th Percentile 24-Hour $PM_{2.5}$: 25 $\mu g/m^3$

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Stantec

Canpotex

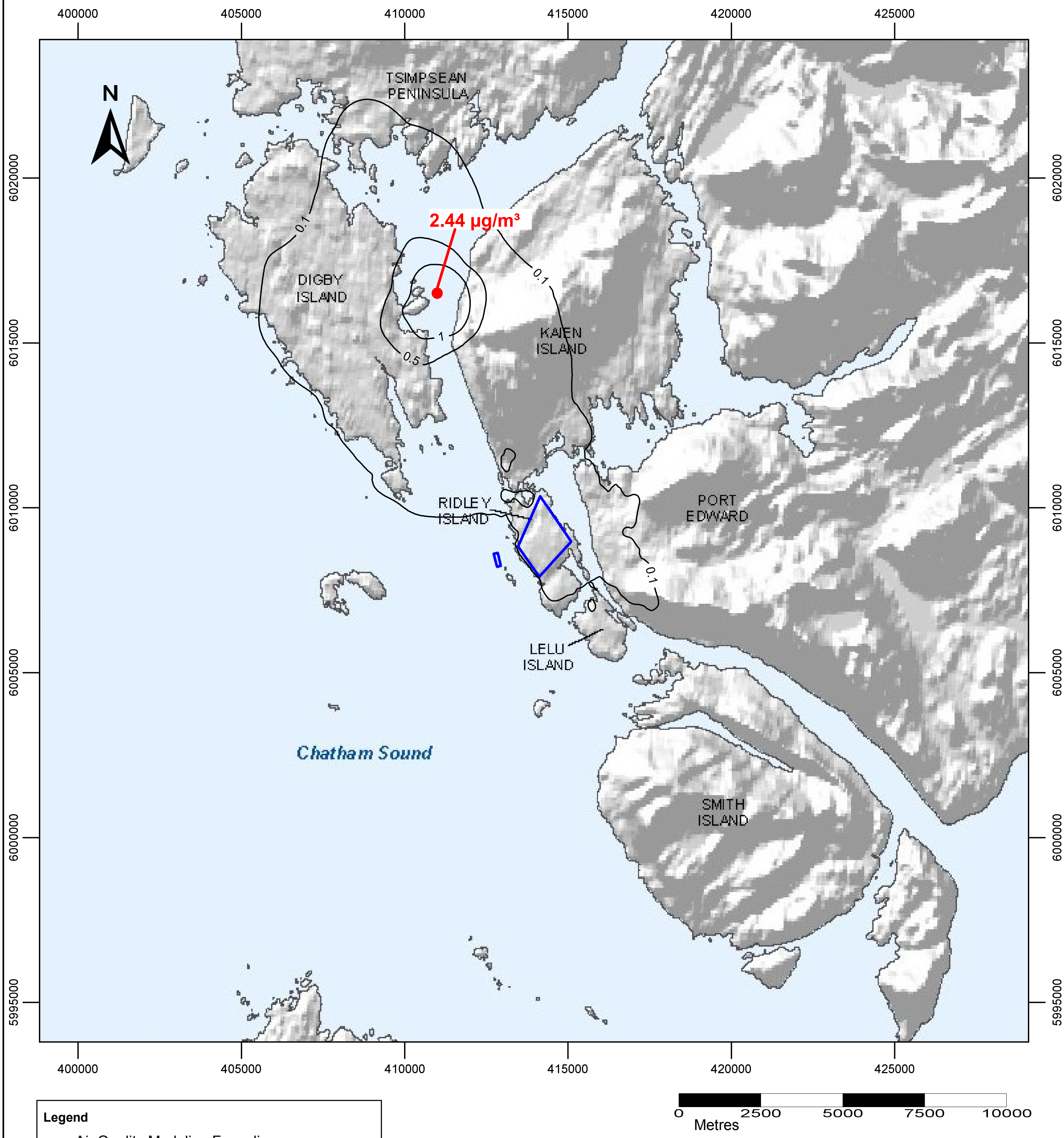
PRINCE RUPERT PORT AUTHORITY

Predicted 98th Percentile 24-hour Average Ground-level $PM_{2.5}$ Concentrations ($\mu g/m^3$) Associated with the Baseline Case

PROJECTION UTM	DRAWN BY MK
DATUM NAD 83	CHECKED BY BK
DATE 2010-Jul-12	FIGURE NO. B-8

Job No: 1231-10264

P:/...c0057srf/Bas/hd/Fig B-8 Base_PM2.5_d.srf



Legend

- Air Quality Modeling Fenceline
- $PM_{2.5}$ Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Air Quality Objective
Annual Average $PM_{2.5}$: 8 µg/m^3

P:/.../c0057srf/Bas/a/Fig B-9 Base_PM2.5_a.srf

Stantec Consultants Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Stantec

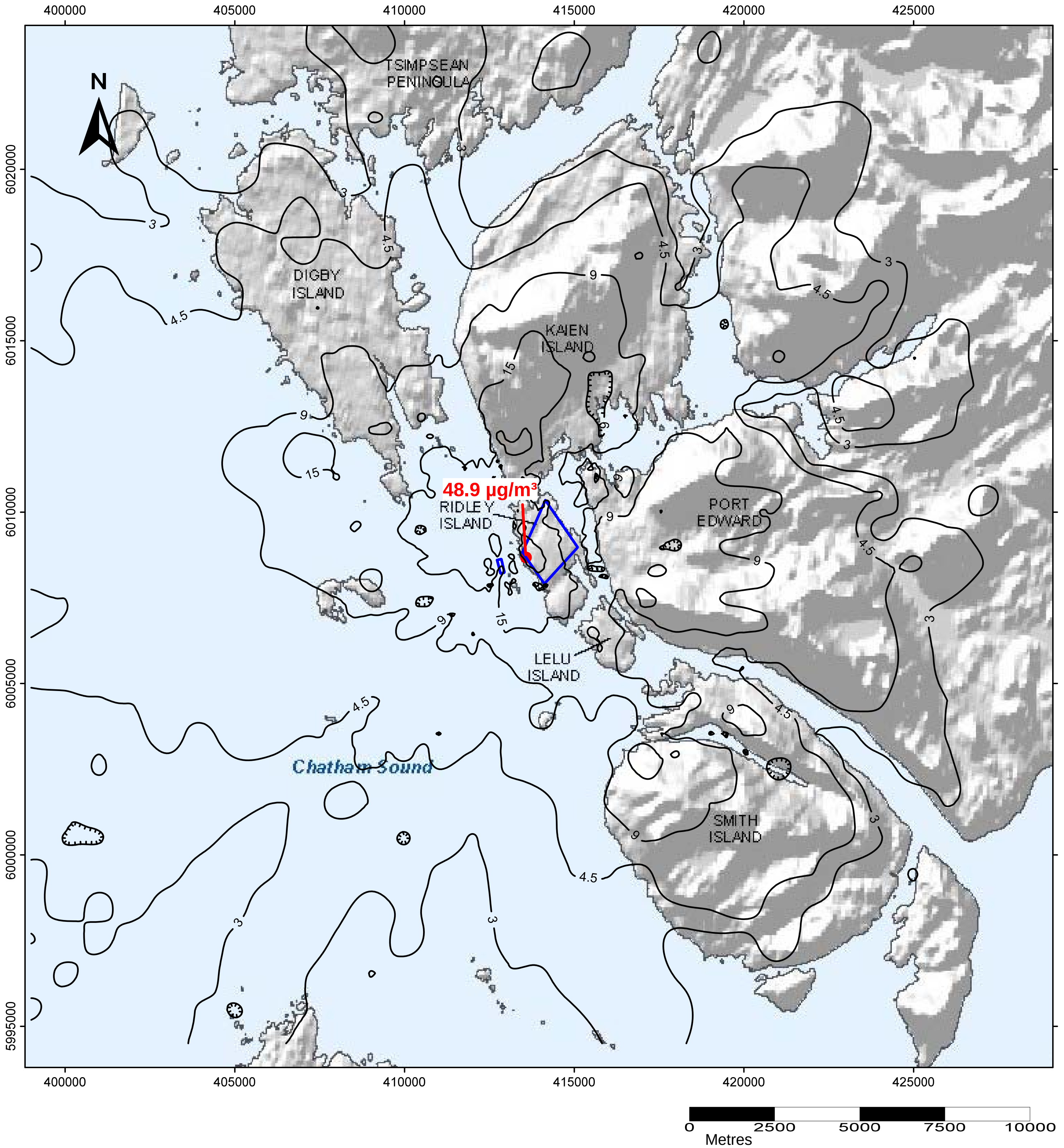
Canpotex

PRINCE RUPERT PORT AUTHORITY

Maximum Predicted Annual Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) Associated with the Baseline Case

PROJECTION UTM	DRAWN BY MK
DATUM NAD 83	CHECKED BY BK
DATE 2010-Jul-12	FIGURE NO. **B-9**

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- SO_2 Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Level A Air Quality Objective
One-hour Average SO_2 : 450 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Canpotex

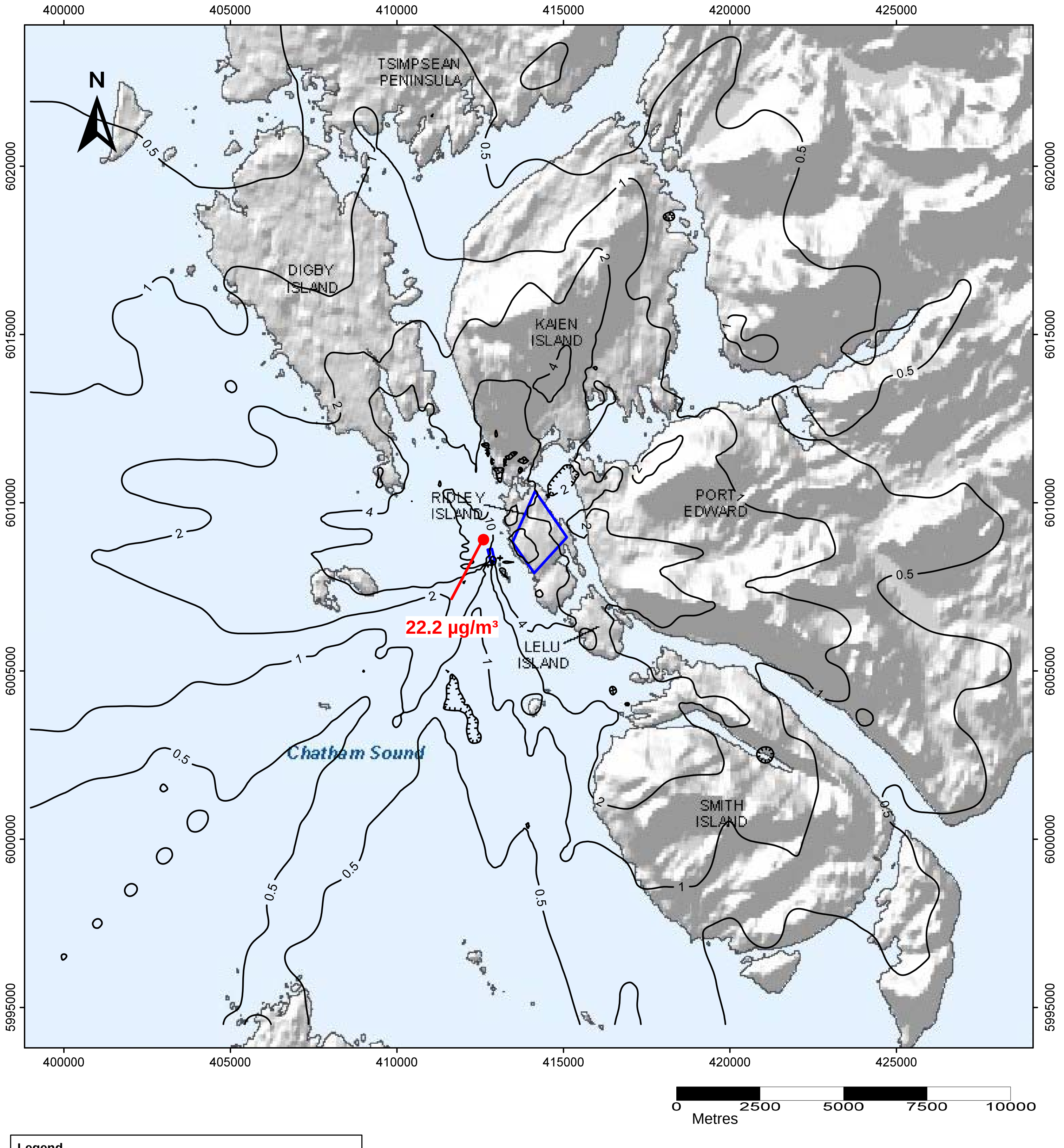
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted One-hour Average Ground-level SO_2 Concentrations (µg/m³) Associated with the Project Case

PROJECTION	DRAWN BY
UTM	LG
DATUM	CHECKED BY
NAD 83	JS
DATE	FIGURE NO.
2011-Oct-31	B-10

Job No: 1231-10264

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/Pro/hd/Figure B-10 Pro_SO2_h.srf



Legend

- Air Quality Modeling Fenceline
- SO_2 Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Level A Air Quality Objective
24-hour Average SO_2 : 160 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

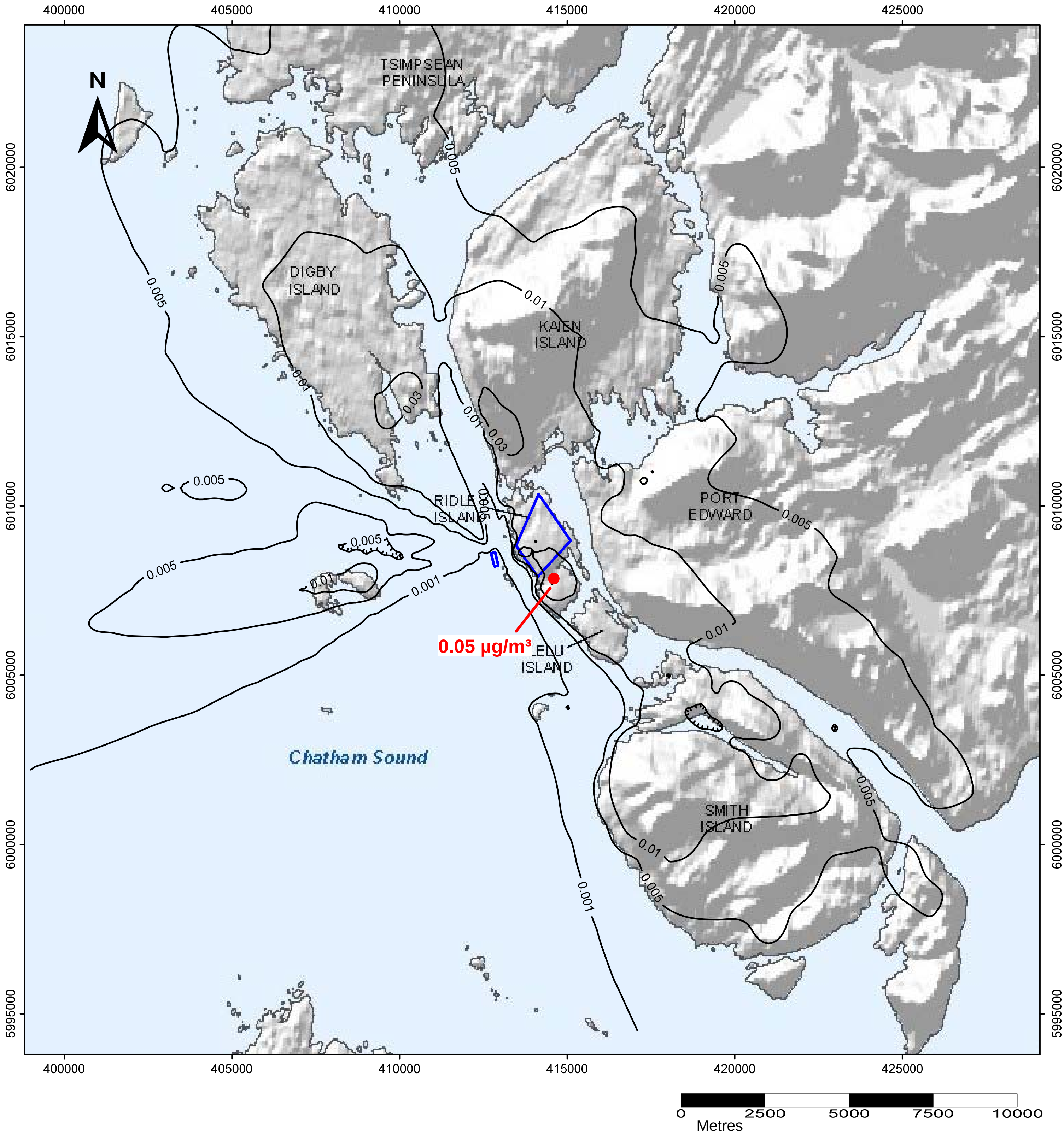
Canpotex
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted 24-hour Average Ground-level SO_2 Concentrations (µg/m³) Associated with the Project Case

PROJECTION	UTM	DRAWN BY	LG
DATUM	NAD 83	CHECKED BY	JS
DATE	2011-Oct-31	FIGURE NO.	B-11

Job No: 1231-10264

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/Pro/hd/Figure B-11 Pro_SO2_d.srf



Legend

- Upland Air Quality Modeling Fenceline
- SO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

British Columbia Level A Air Quality Objective
Annual Average SO_2 : 25 µg/m^3

Stantec

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Canpotex

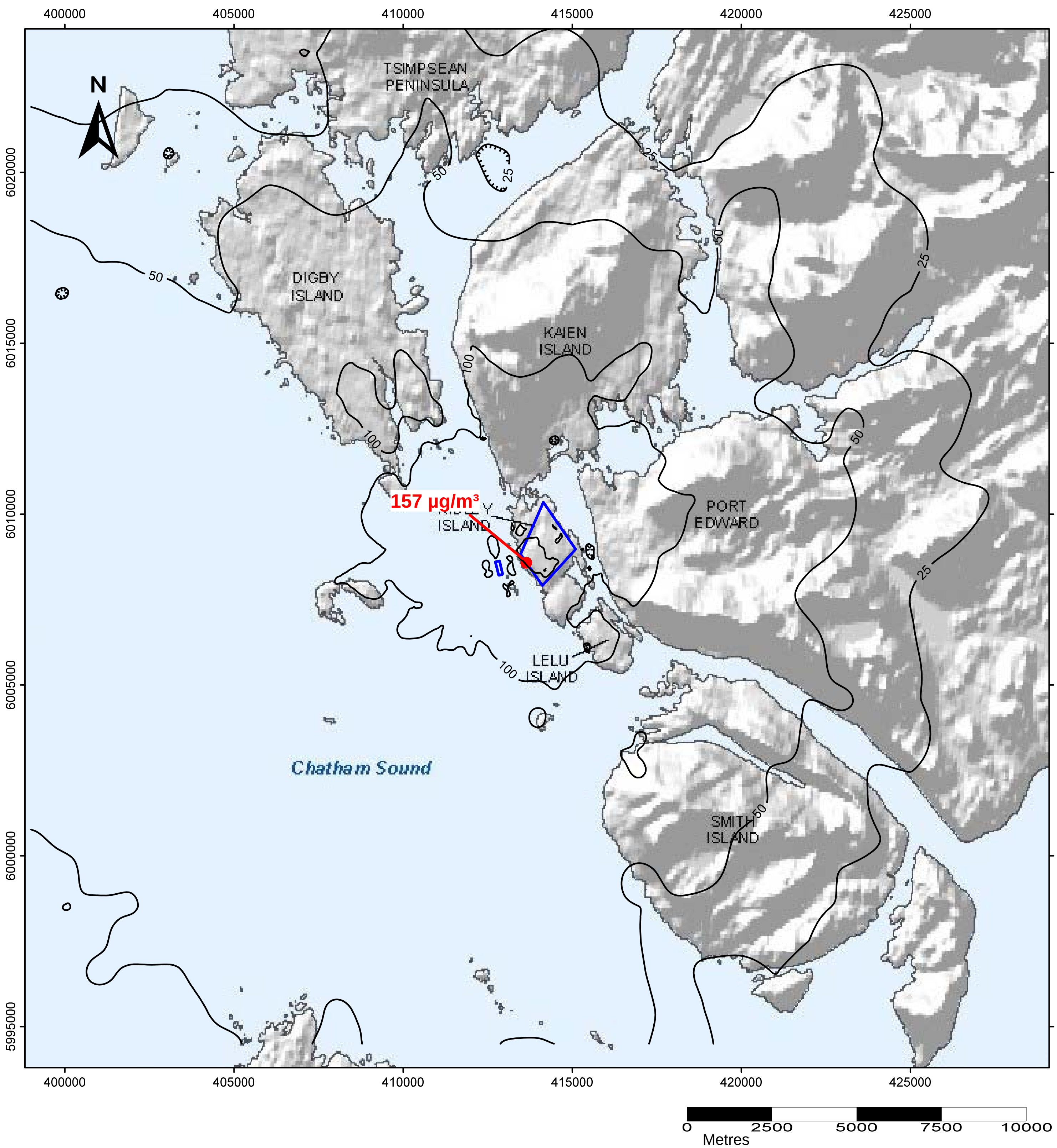
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted Annual Average Ground-level SO_2 Concentrations (µg/m³) Associated with the Project Case

PROJECTION UTM	DRAWN BY LG
DATUM NAD 83	CHECKED BY JS
DATE 2011-Oct-31	FIGURE NO. B-12

Job No: 1231-10264

N:\1_Projects\123110264_Canpotex\01 - Ridley Island\srf\updated work\Pro\a\Figure B-12 Pro_SO2_a.srf



Legend

- Air Quality Modeling Fenceline
- NO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

National Level A Air Quality Objective
One-hour Average NO_2 : 400 µg/m^3

Stantec
Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Canpotex

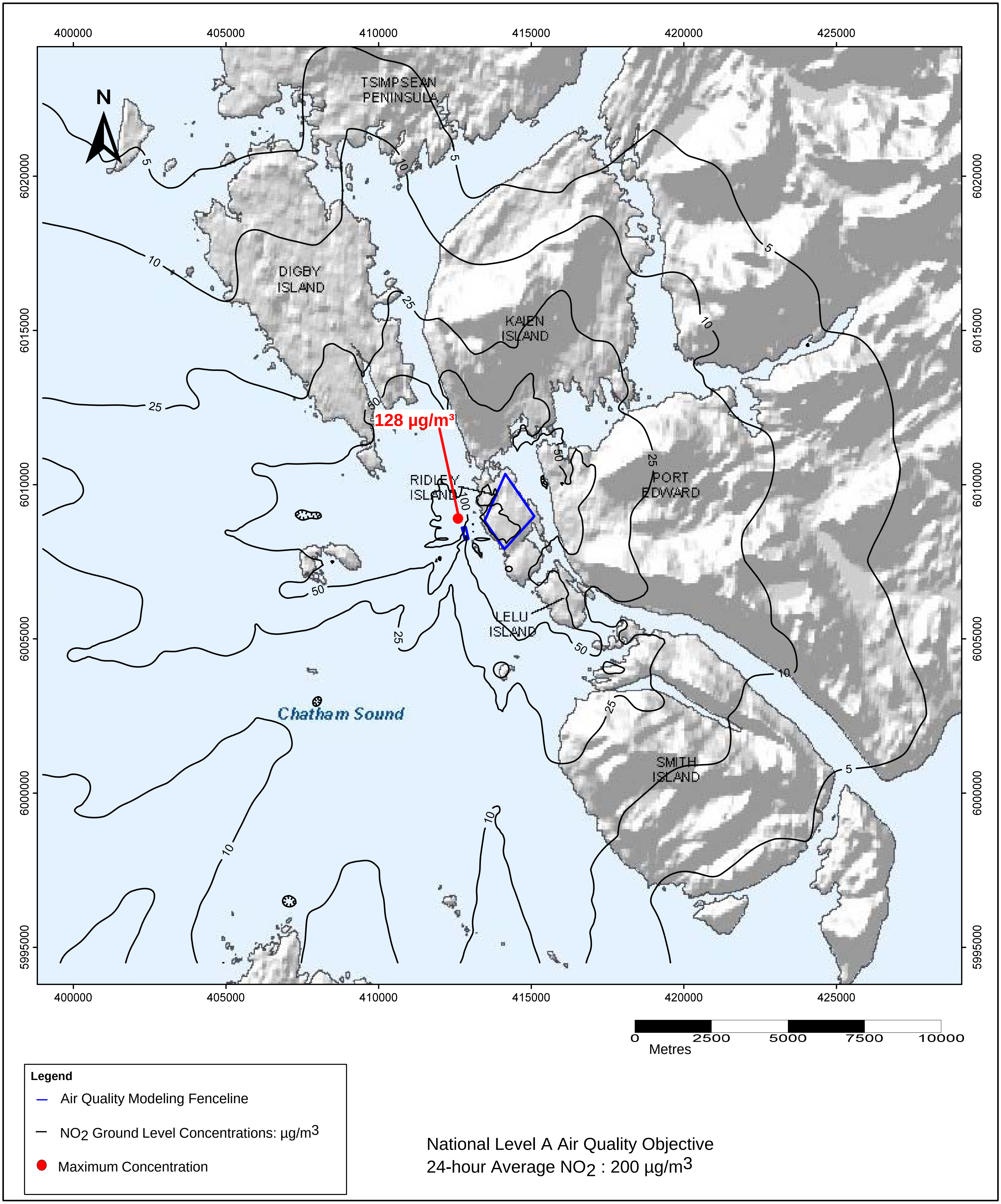
PRINCE RUPERT
PORT AUTHORITY

Maximum Predicted One-hour Average Ground-level NO_2 Concentrations (µg/m³) Associated with the Project Case

PROJECTION	DRAWN BY
UTM	LG
DATUM	CHECKED BY
NAD 83	JS
DATE	FIGURE NO.
2011-Oct-31	B-13

Job No: 1231-10264

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/Pro/hd/Figure B-13 Pro_NO2_h.srf



Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Stantec

Canpotex

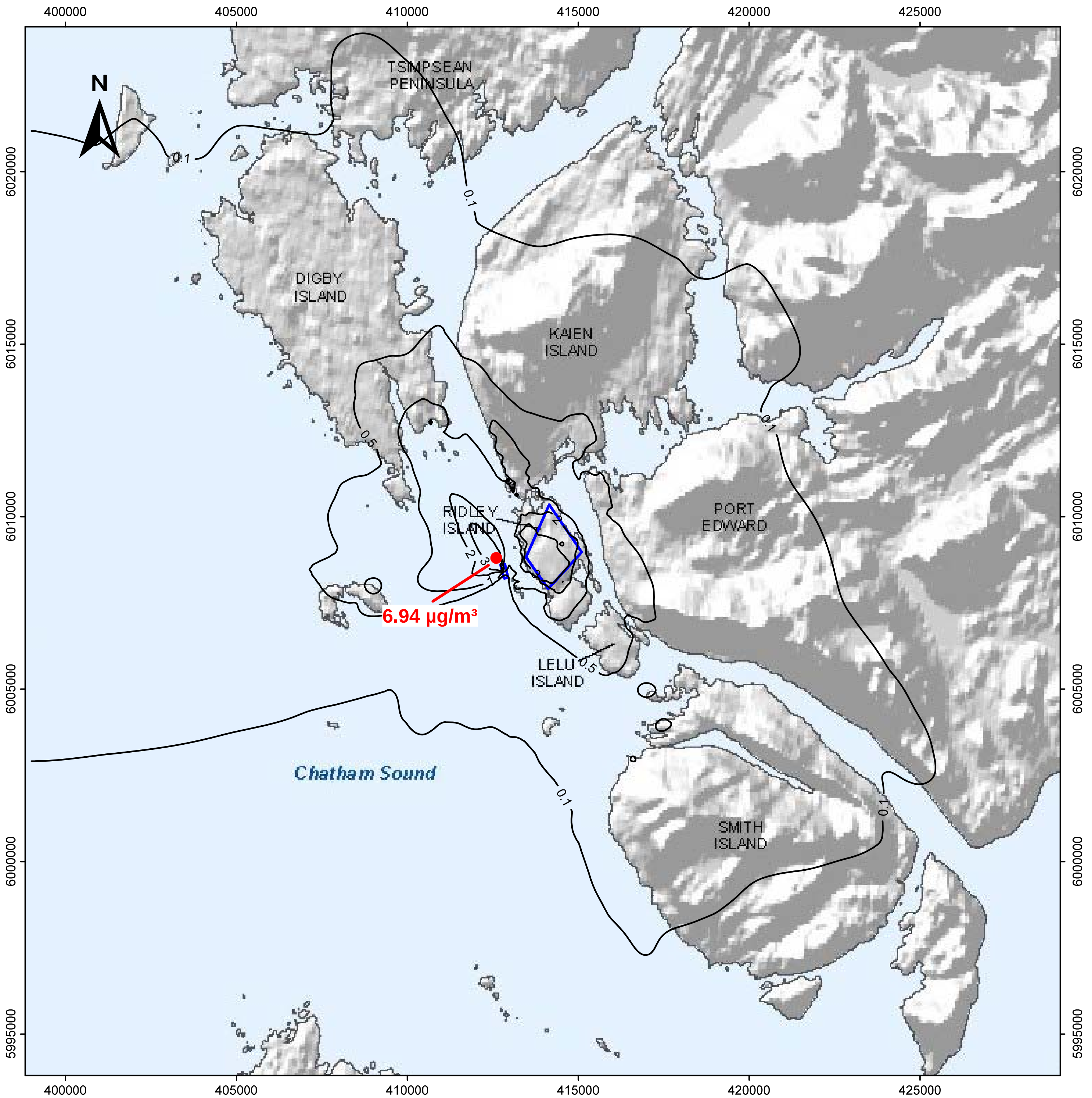
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted 24-hour Average Ground-level NO_2 Concentrations (µg/m³) Associated with the Project Case

PROJECTION	UTM	DRAWN BY	LG
DATUM	NAD 83	CHECKED BY	JS
DATE	2011-Oct-31	FIGURE NO.	B-14

Job No: 1231-10264

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/Pro/hd/Figure B-14 Pro_NO2_d.srf



Legend

- Upland Air Quality Modeling Fenceline
- NO_2 Ground Level Concentrations: $\mu g/m^3$
- Maximum Concentration

National Level D Air Quality Objective
Annual Average NO_2 : 60 $\mu g/m^3$

Stantec
Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

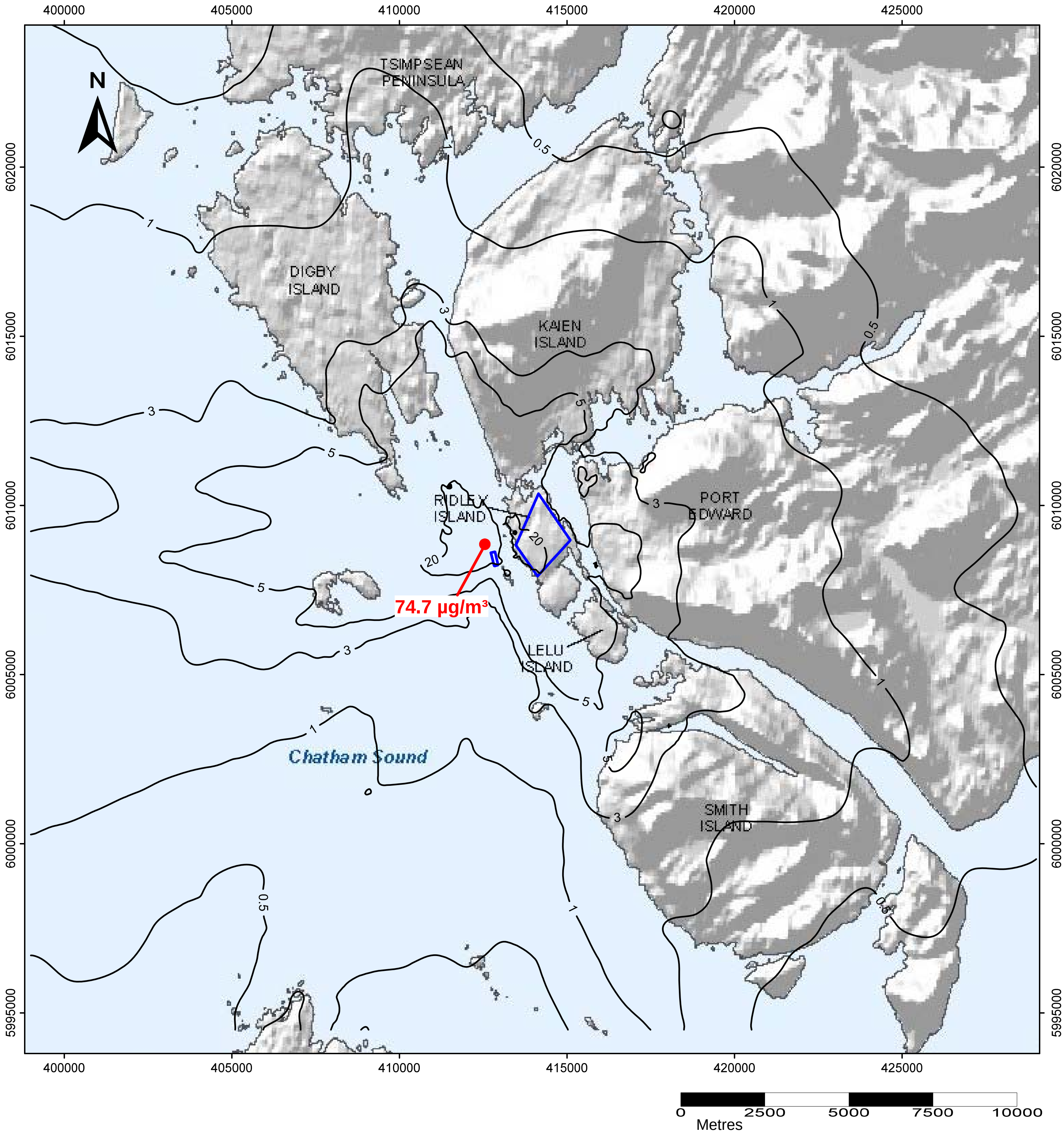
Canpotex
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted Annual Average Ground-level NO_2 Concentrations ($\mu g/m^3$) Associated with the Project Case

PROJECTION	UTM	DRAWN BY	LG
DATUM	NAD 83	CHECKED BY	JS
DATE	2011-Oct-31	FIGURE NO.	B-15

Job No: 1231-10264

N:/1_Projects/12310264_Canpotex/01 - Ridley Island/srf/updated work/Pro/a/Figure B-15 Pro_NO2_a.srf



Legend

- Air Quality Modeling Fenceline
- PM_{10} Ground Level Concentrations: ug/m3
- Maximum Concentration

British Columbia Level B Air Quality Objective
24-hour Average PM_{10} : 50 µg/m3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Canpotex

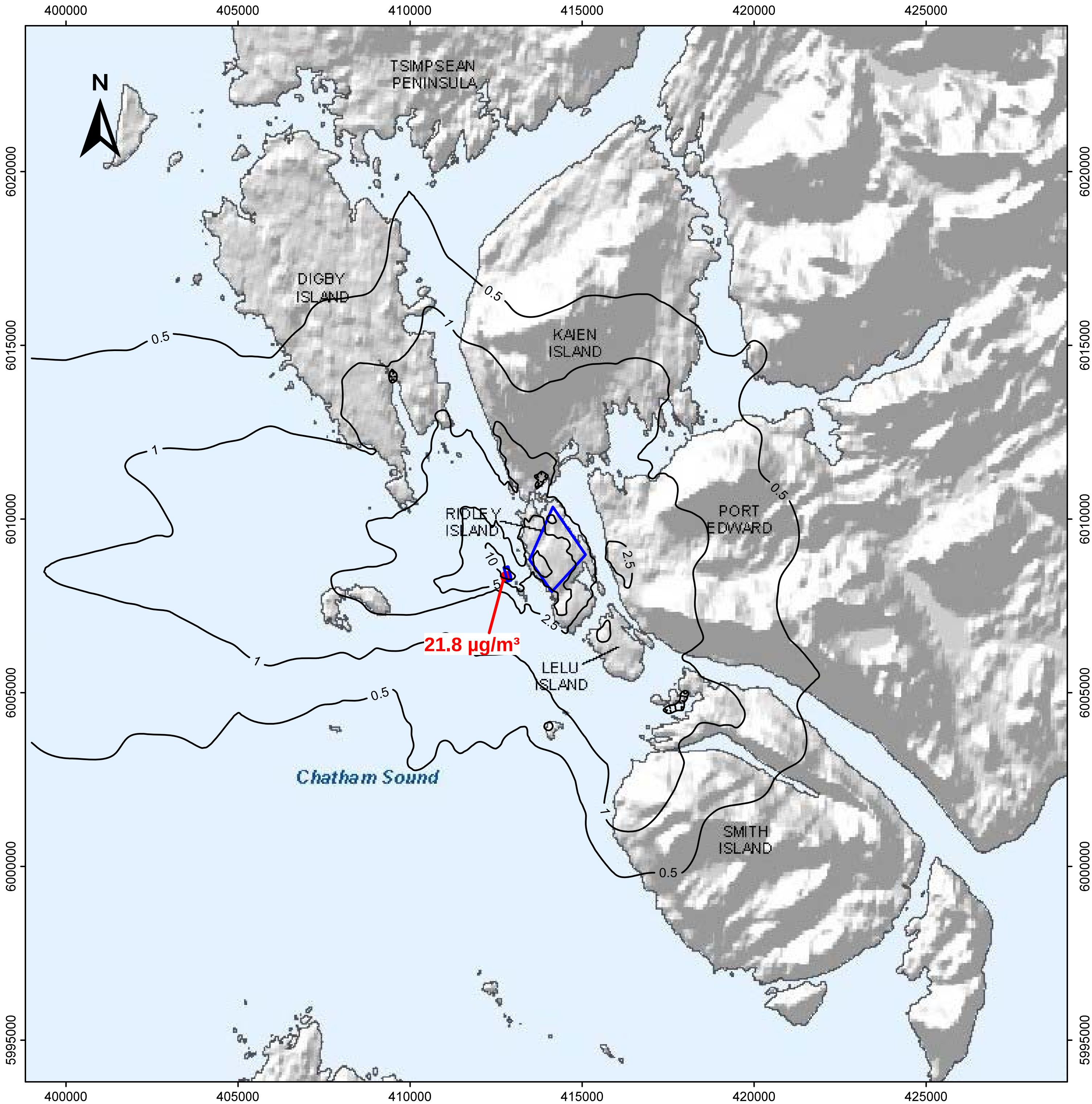
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted 24-hour Average Ground-level PM_{10} Concentrations (µg/m³) Associated with the Project Case

PROJECTION UTM	DRAWN BY LG
DATUM NAD 83	CHECKED BY JS
DATE 2011-Oct-31	FIGURE NO. B-16

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/Pro/hd/Figure B-16 Pro_PM10_d.srf

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- $PM_{2.5}$ Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Air Quality Objective
Annual 98th Percentile 24-Hour $PM_{2.5}$: 25 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Stantec

Canpotex

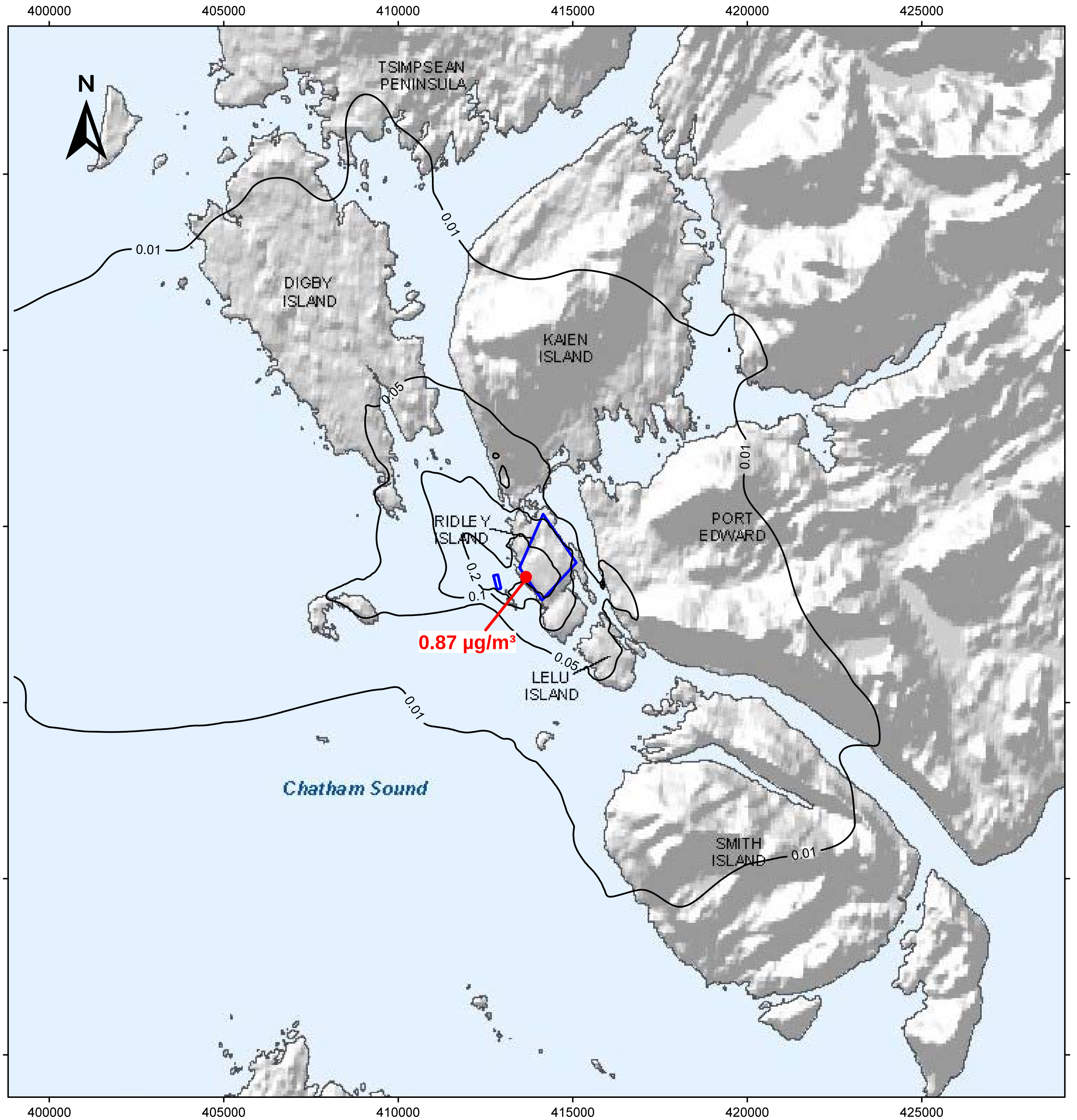
PRINCE RUPERT PORT AUTHORITY

Predicted 98th Percentile 24-hour Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) Associated with the Project Case

PROJECTION UTM	DRAWN BY LG
DATUM NAD 83	CHECKED BY JS
DATE 2011-Oct-31	FIGURE NO. B-17

Job No: 1231-10264

N:\1_Projects\123110264_Canpotex\01 - Ridley Island\srf\updated work\Pro\hd\Figure B-17 Pro_PM2.5_d.srf



Legend

- Upland Air Quality Modeling Fenceline
- $PM_{2.5}$ Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Air Quality Objective
Annual Average $PM_{2.5}$: 8 µg/m^3

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/Pro/a/Figure B-18 Pro_PM2.5_a.srf

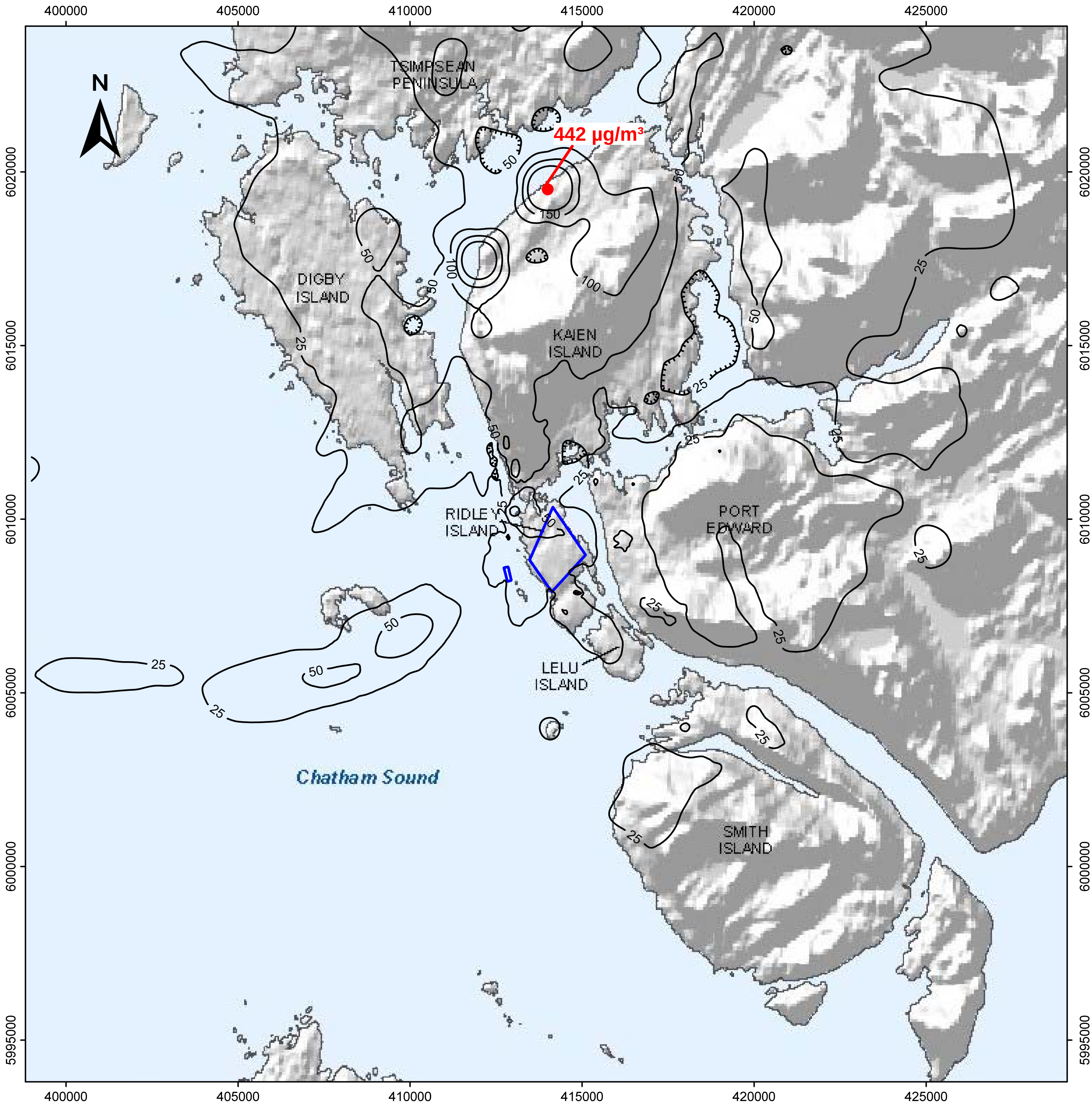
Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Canpotex
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted Annual Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) Associated with the Project Case

PROJECTION	UTM	DRAWN BY	LG
DATUM	NAD 83	CHECKED BY	JS
DATE	2011-Oct-31	FIGURE NO.	B-18

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- SO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

British Columbia Level A Air Quality Objective
One-hour Average SO_2 : 450 µg/m^3

N:/1_Projects/12311026_Canpotex/01 - Ridley Island/srf/updated work/App/hd/Figure B-19 App_SO2_h.srf

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

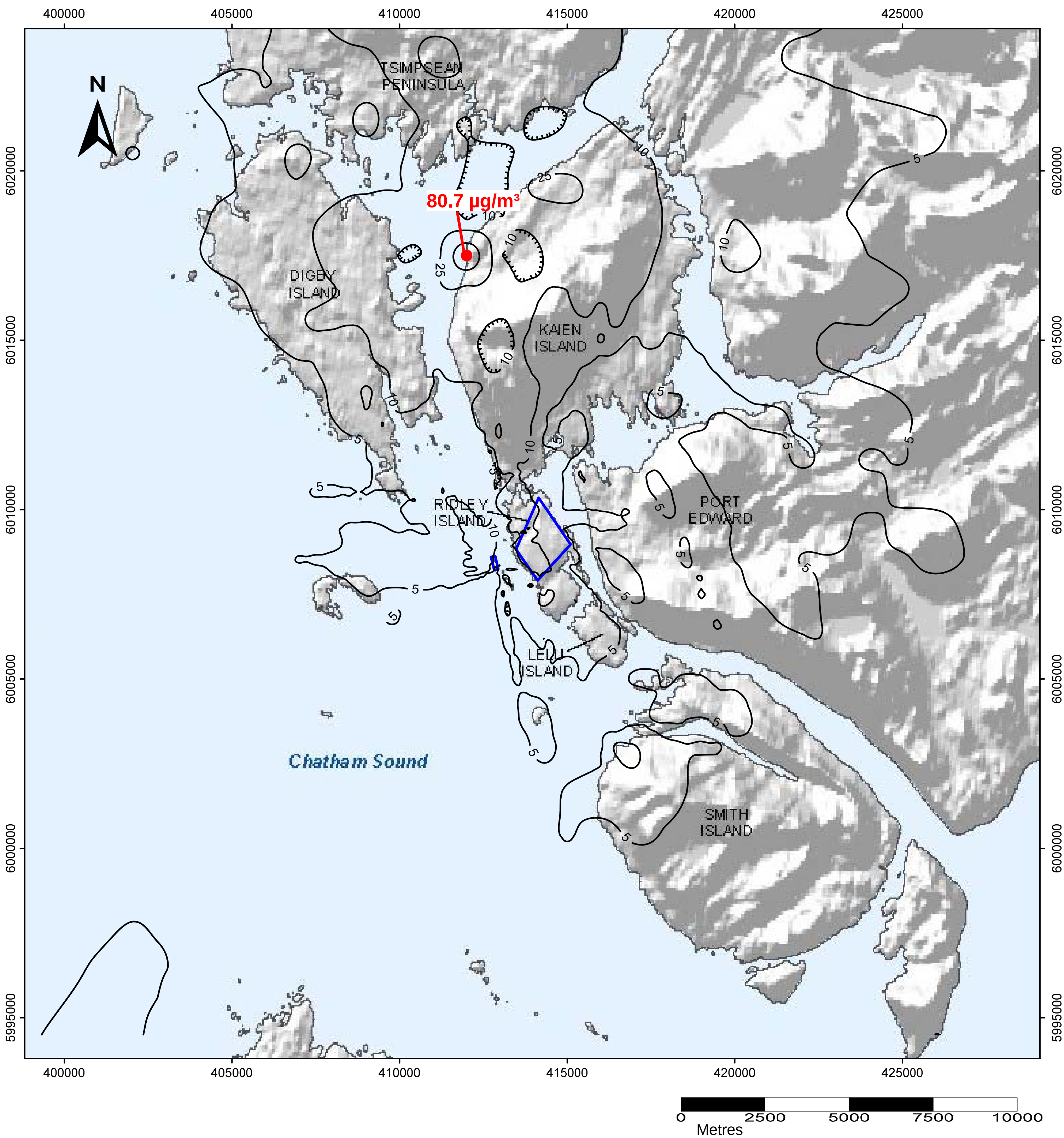
Canpotex

PRINCE RUPERT PORT AUTHORITY

Maximum Predicted One-hour Average Ground-level SO_2 Concentrations (µg/m³) Associated with the Application Case

PROJECTION: UTM	DRAWN BY: LG
DATUM: NAD 83	CHECKED BY: JS
DATE: 2011-Oct-31	FIGURE NO. B-19

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- NO_2 Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Level A Air Quality Objective
24-hour Average SO_2 : 160 µg/m^3

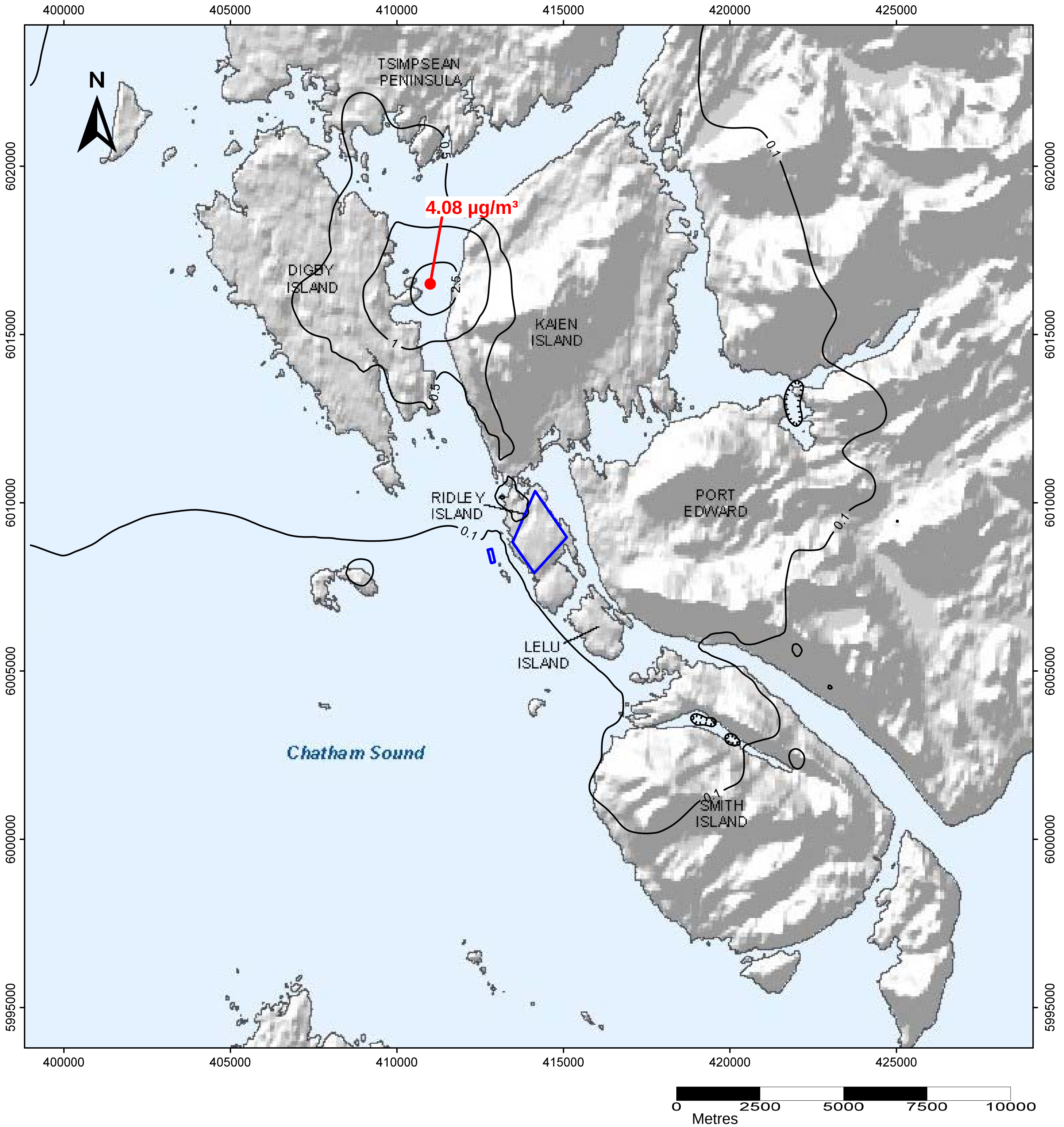
Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Maximum Predicted 24-hour Average Ground-level SO_2 Concentrations (µg/m³) Associated with the Application Case

PROJECTION	UTM	DRAWN BY	LG
DATUM	NAD 83	CHECKED BY	JS
DATE	2011-Oct-31	FIGURE NO.	B-20

Job No: 1231-10264

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/App/hd/Figure B-20 App_SO2_d.srf



Legend

- Air Quality Modeling Fenceline
- SO_2 Ground Level Concentrations: μg/m³
- Maximum Concentration

British Columbia Level A Air Quality Objective
Annual Average SO_2 : 25 μg/m³

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

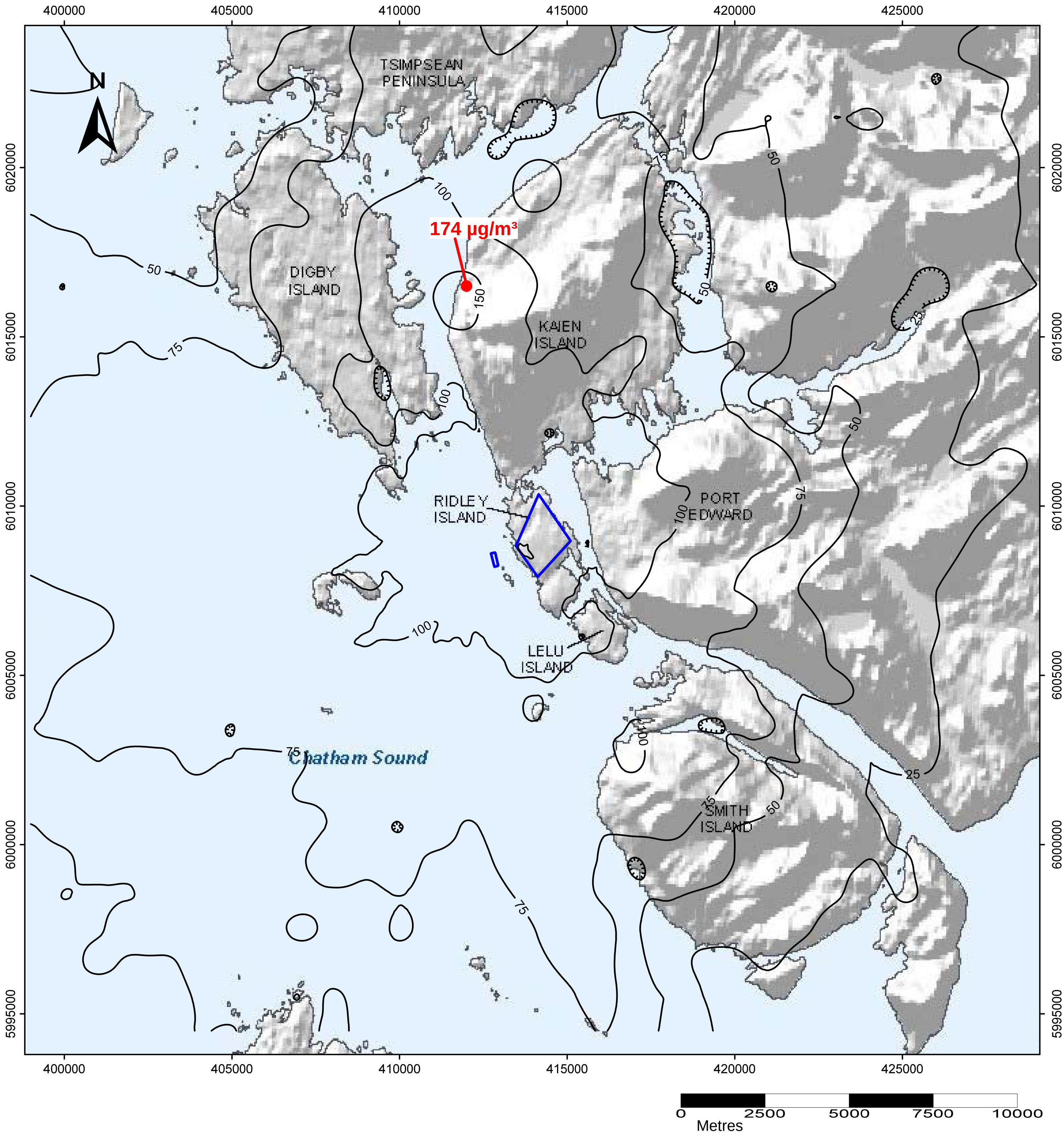
Canpotex
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted Annual Average Ground-level SO_2 Concentrations (μg/m³) Associated with the Application Case

PROJECTION	UTM	DRAWN BY	LG
DATUM	NAD 83	CHECKED BY	JS
DATE	2011-Oct-31	FIGURE NO.	B-21

Job No: 1231-10264

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/App/a/Figure B-21 App_SO2_a.srf



Legend

- Air Quality Modeling Fenceline
- NO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

National Level A Air Quality Objective
One-hour Average NO_2 : 400 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

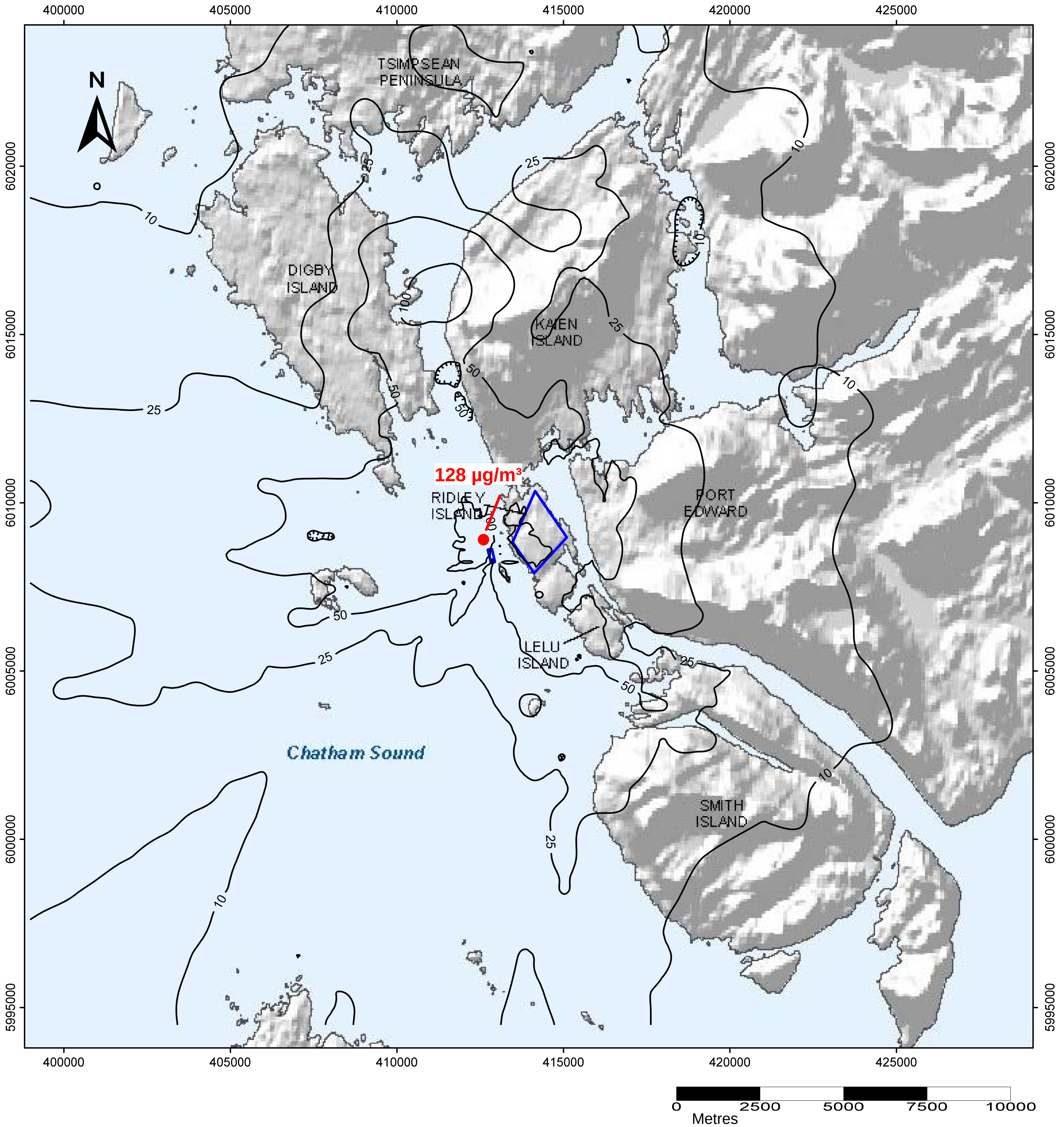
Canpotex
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted One-hour Average Ground-level NO_2 Concentrations (µg/m³) Associated with the Application Case

PROJECTION UTM	DRAWN BY LG
DATUM NAD 83	CHECKED BY JS
DATE 2011-Oct-31	FIGURE NO. B-22

Job No: 1231-10264

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/App/hd/Figure B-22 App_NO2_h.srf



Legend

- Air Quality Modeling Fenceline
- NO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

National Level A Air Quality Objective
24-hour Average NO_2 : 200 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Canpotex

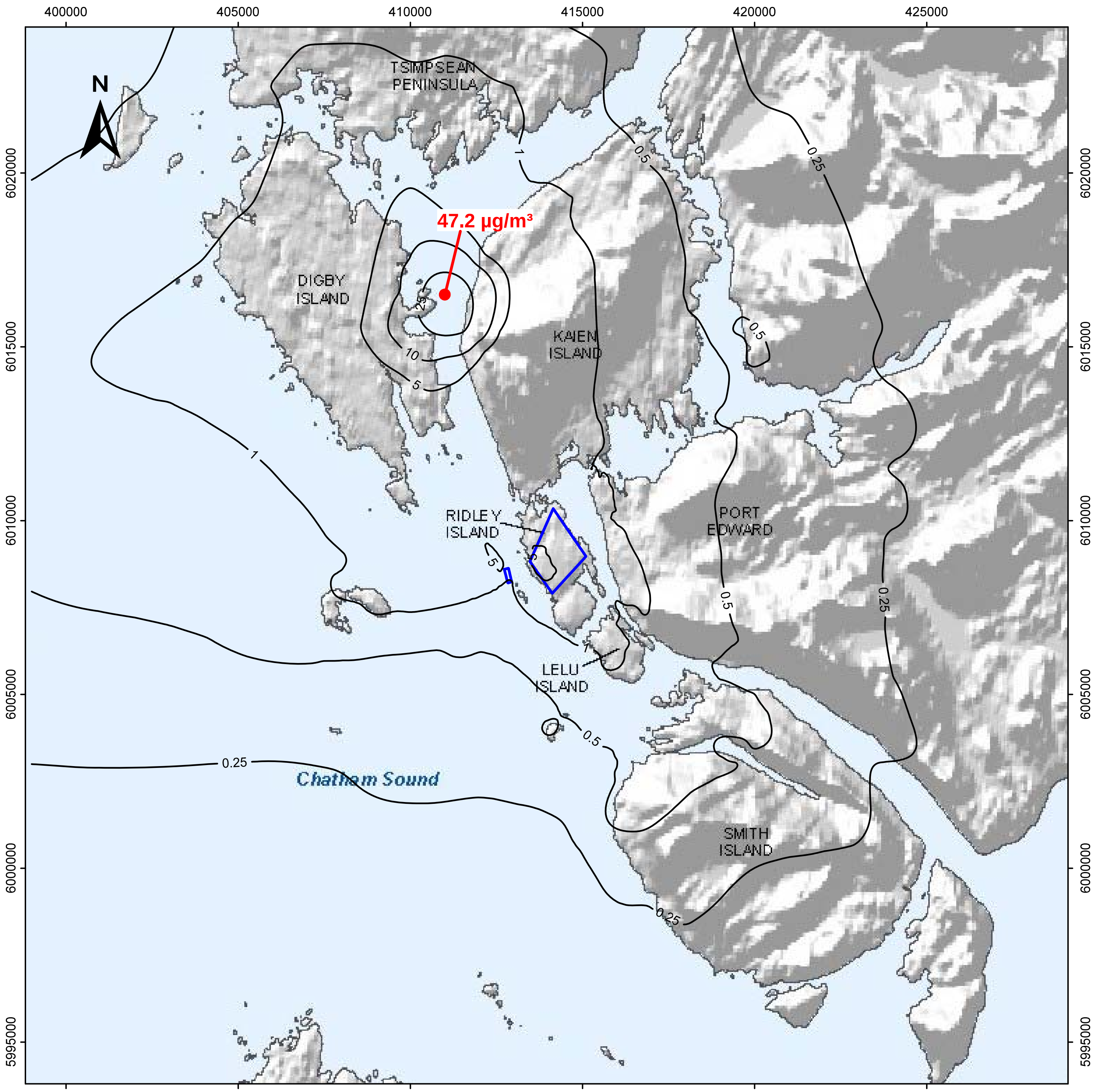
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted 24-hour Average Ground-level NO_2 Concentrations (µg/m³) Associated with the Application Case

PROJECTION	UTM	DRAWN BY	LG
DATUM	NAD 83	CHECKED BY	JS
DATE	2011-Oct-31	FIGURE NO.	B-23

Job No: 1231-10264

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/App/hd/Figure B-23 App_NO2_d.srf



Legend

- Air Quality Modeling Fenceline
- NO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

National Level D Air Quality Objective
Annual Average NO_2 : 60 µg/m^3

N:/1_Projects/12311026 4_Canpotex/01 - Ridley Island/srf/updated work/App/a/Figure B-24 App_NO2_a.srf

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

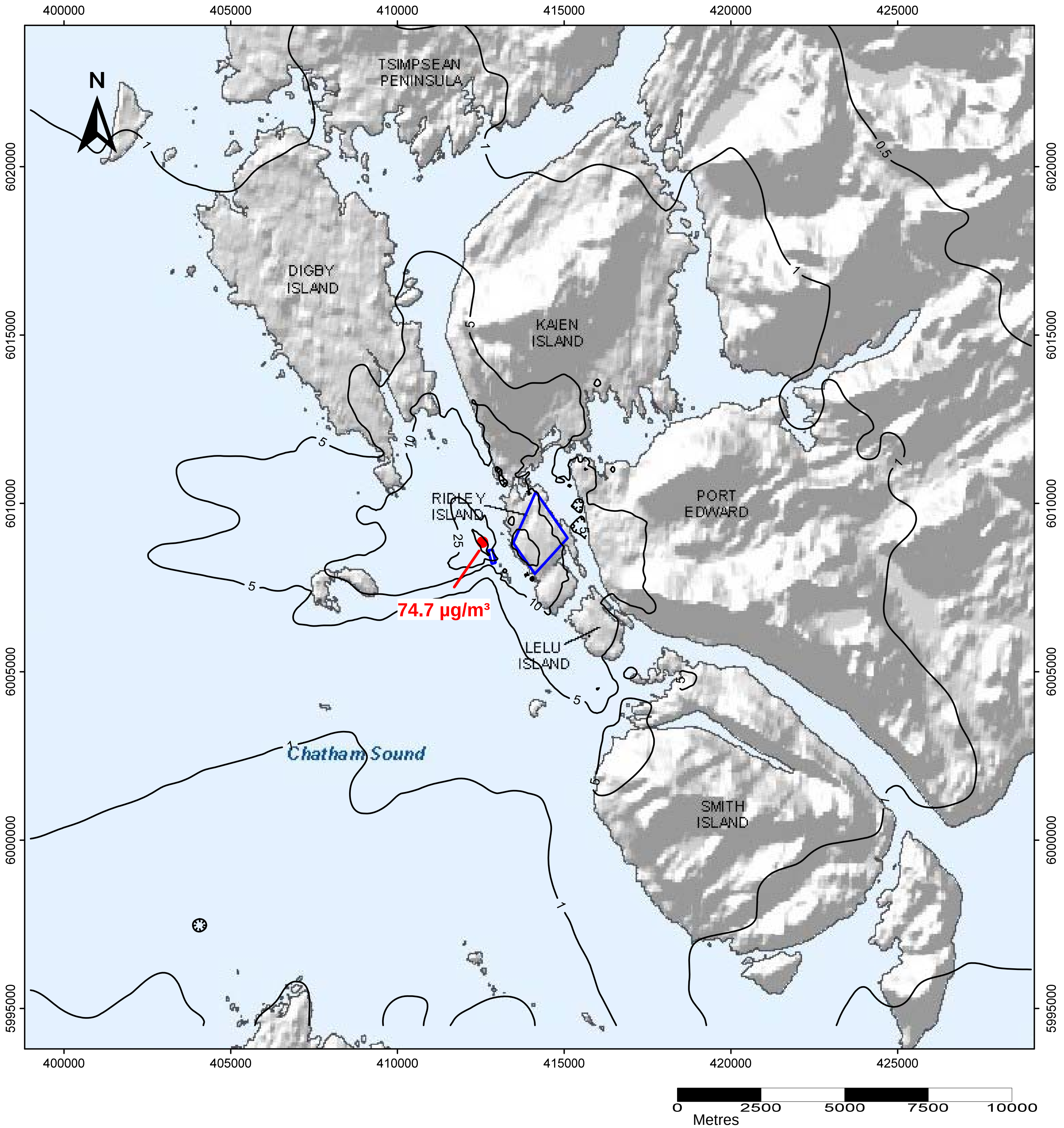
Canpotex

PRINCE RUPERT PORT AUTHORITY

Maximum Predicted Annual Average Ground-level NO_2 Concentrations (µg/m³) Associated with the Application Case

PROJECTION: UTM	DRAWN BY: LG
DATUM: NAD 83	CHECKED BY: JS
DATE: 2011-Oct-31	FIGURE NO. B-24

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- PM_{10} Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Level B Air Quality Objective
24-hour Average PM_{10} : 50 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

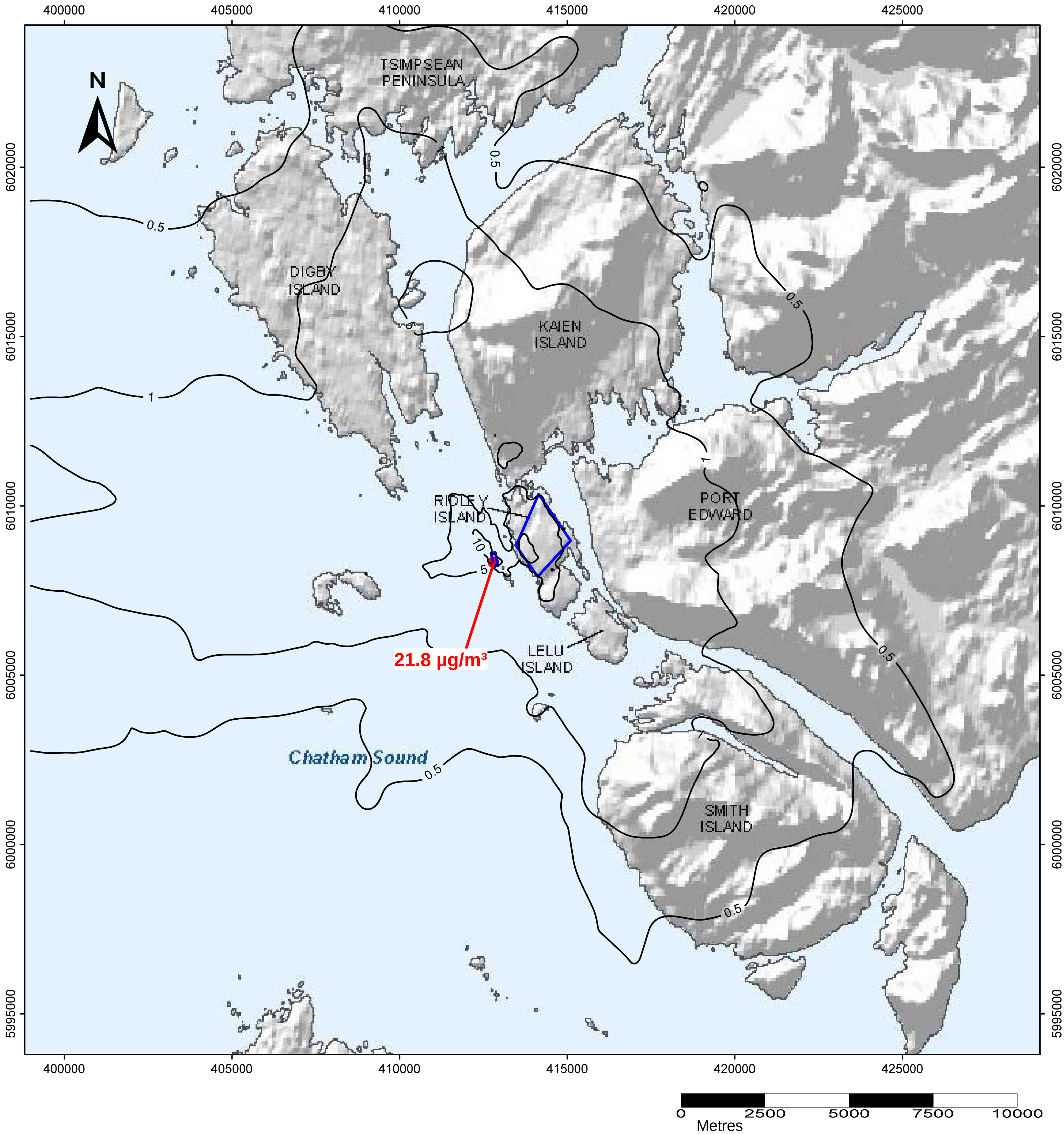
Canpotex

PRINCE RUPERT PORT AUTHORITY

Maximum Predicted 24-hour Average Ground-level PM_{10} Concentrations (µg/m³) Associated with the Application Case

PROJECTION	UTM	DRAWN BY	LG
DATUM	NAD 83	CHECKED BY	JS
DATE	2011-Oct-31	FIGURE NO.	B-25

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- PM2.5 Ground Level Concentrations: ug/m3
- Maximum Concentration

British Columbia Air Quality Objective
Annual 98th Percentile 24-Hour PM2.5 : 25 μg/m3

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/App/hd/Figure B-26 App_PM2.5_d.srf

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Stantec

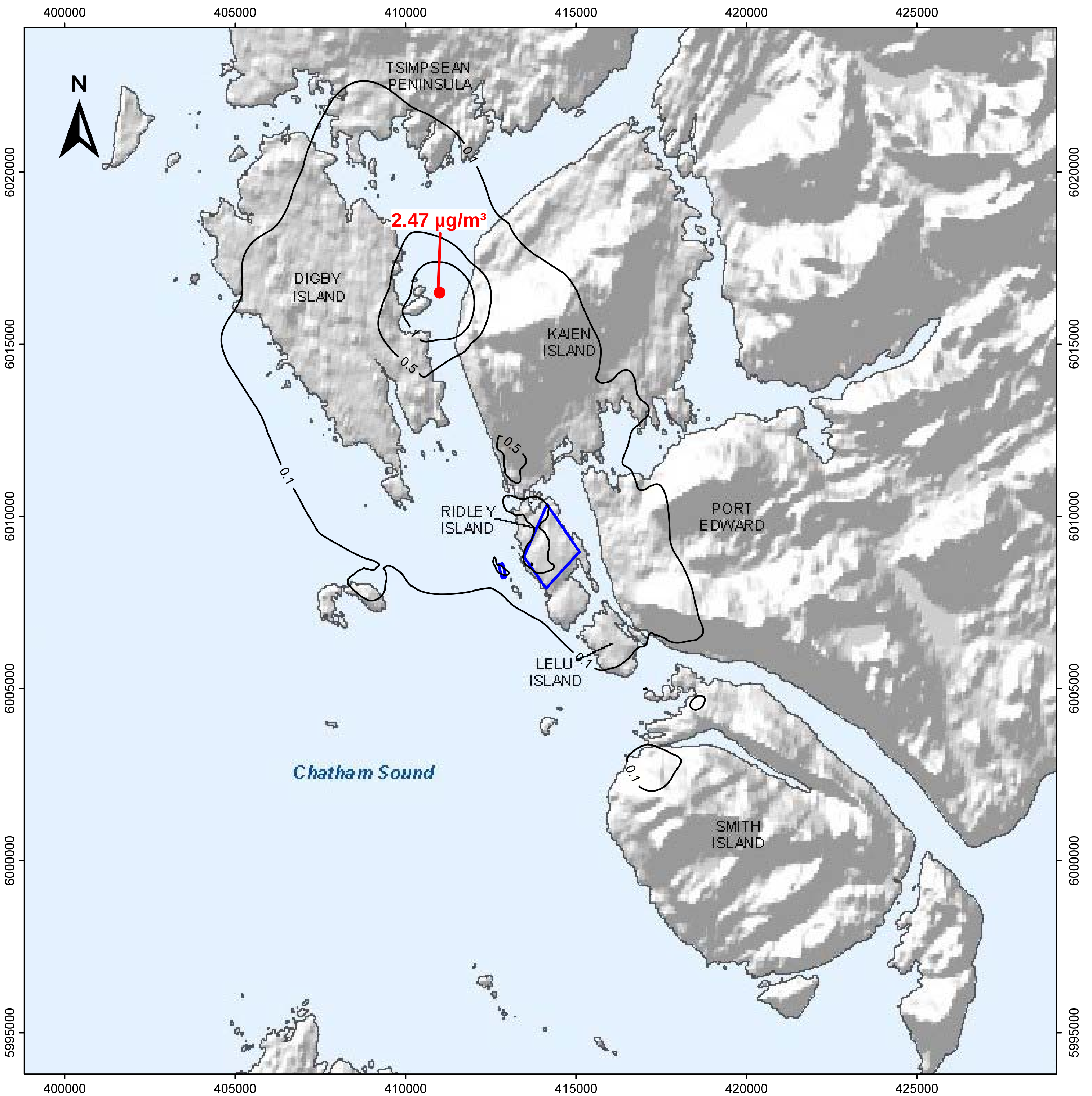
Canpotex

PRINCE RUPERT PORT AUTHORITY

Predicted 98th Percentile 24-hour Average Ground-level PM2.5 Concentrations (μg/m³) Associated with the Application Case

PROJECTION UTM	DRAWN BY LG
DATUM NAD 83	CHECKED BY JS
DATE 2011-Oct-31	FIGURE NO. B-26

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- $PM_{2.5}$ Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Air Quality Objective
Annual Average $PM_{2.5}$: 8 $\mu g/m^3$

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Stantec

Canpotex

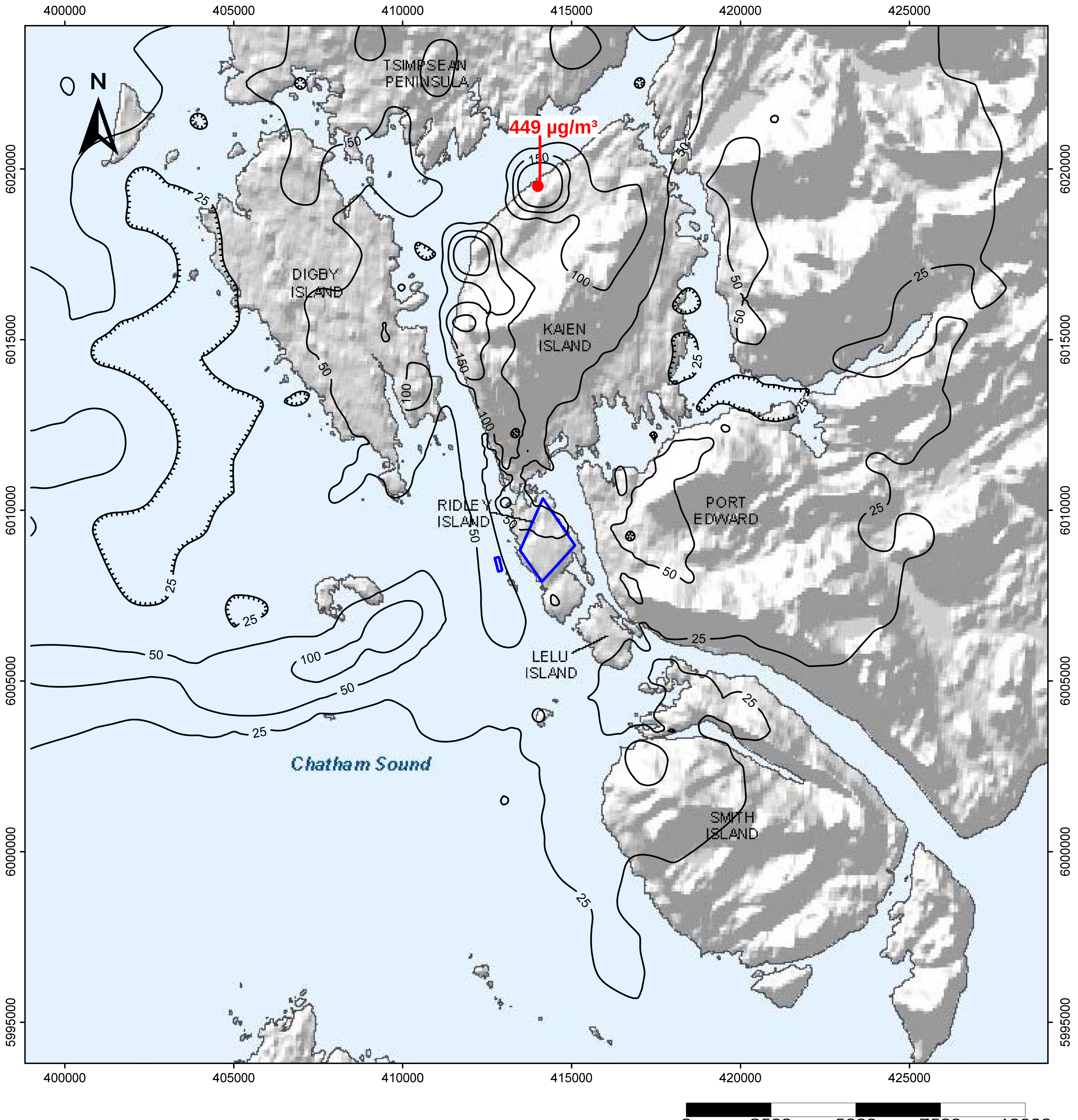
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted Annual Average Ground-level $PM_{2.5}$ Concentrations ($\mu g/m^3$) Associated with the Application Case

PROJECTION	UTM	DRAWN BY	LG
DATUM	NAD 83	CHECKED BY	JS
DATE	2011-Oct-31	FIGURE NO.	B-27

Job No: 1231-10264

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/App/a/Figure B-27 App_PM2.5_a.srf



Legend

- Air Quality Modeling Fenceline
- SO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

British Columbia Level A Air Quality Objective
One-hour Average SO_2 : 450 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Canpotex

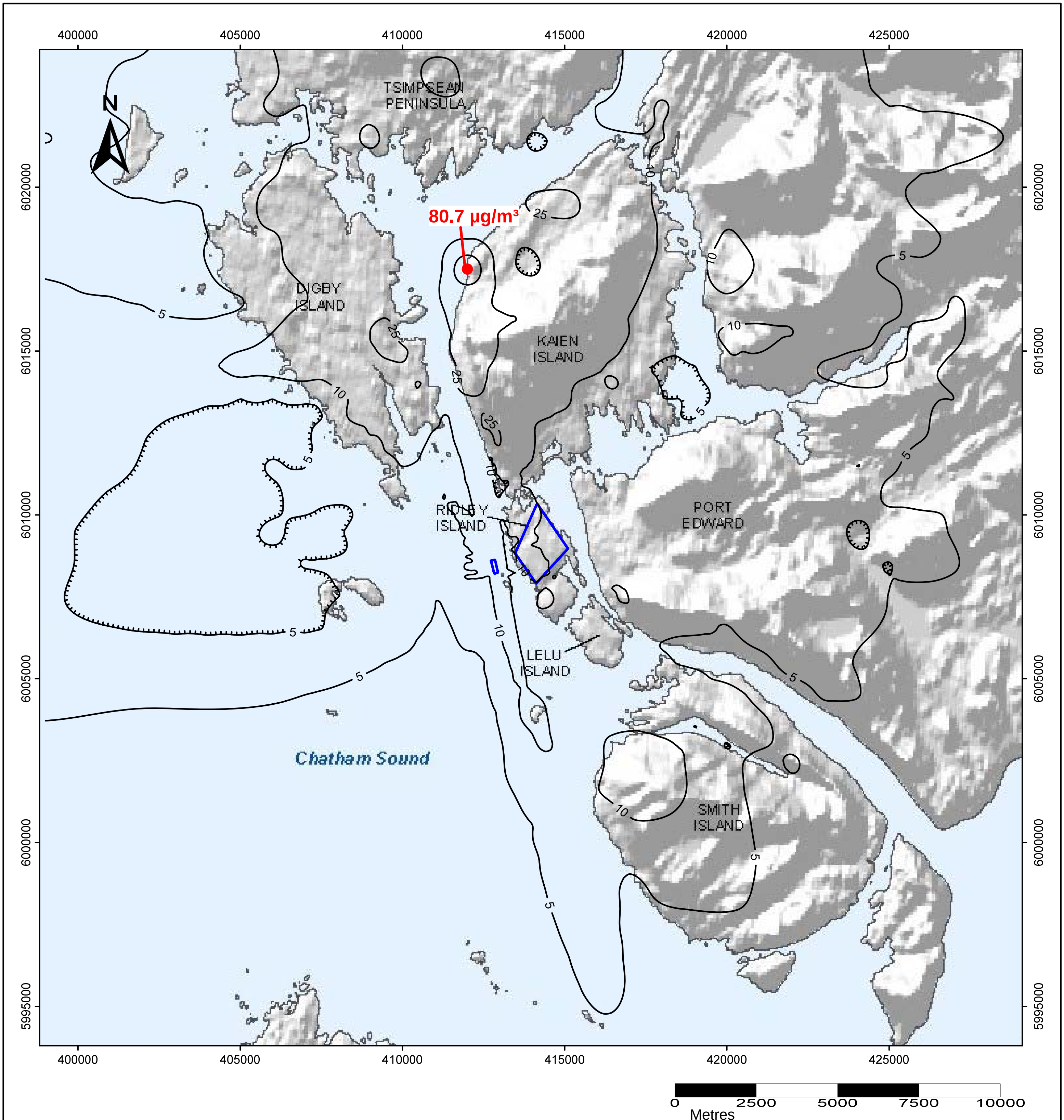
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted One-hour Average Ground-level SO_2 Concentrations (µg/m³) Associated with the CEA Case

PROJECTION	DRAWN BY
UTM	LG
DATUM: NAD 83	CHECKED BY: JS
DATE: 2011-Oct-31	FIGURE NO. B-28

N:\1_Projects\12310264_Canpotex\01 - Ridley Island\srf\updated work\cea\hd\Figure B-28 cea_SO2_h.srf

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- NO_2 Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Level A Air Quality Objective
24-hour Average SO_2 : 160 µg/m^3

Stantec

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Canpotex

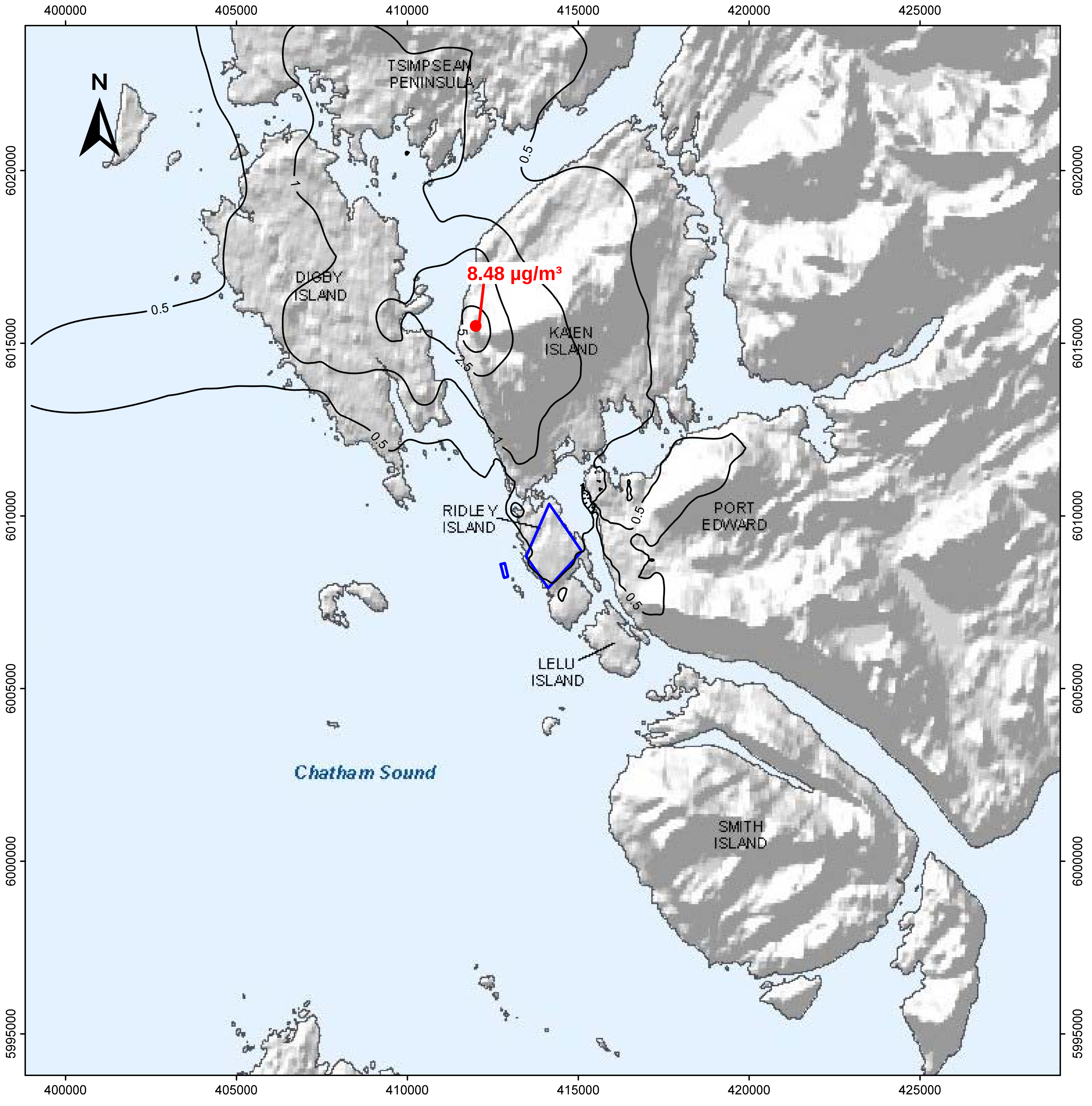
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted 24-hour Average Ground-level SO_2 Concentrations (µg/m³) Associated with the CEA Case

PROJECTION	DRAWN BY
UTM	LG
DATUM	CHECKED BY
NAD 83	JS
DATE	FIGURE NO.
2011-Oct-31	B-29

Job No: 1231-10264

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/cea/hd/Figure B-29 cea_SO2_d.srf



Legend

- Air Quality Modeling Fenceline
- SO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

British Columbia Level A Air Quality Objective
Annual Average SO_2 : 25 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

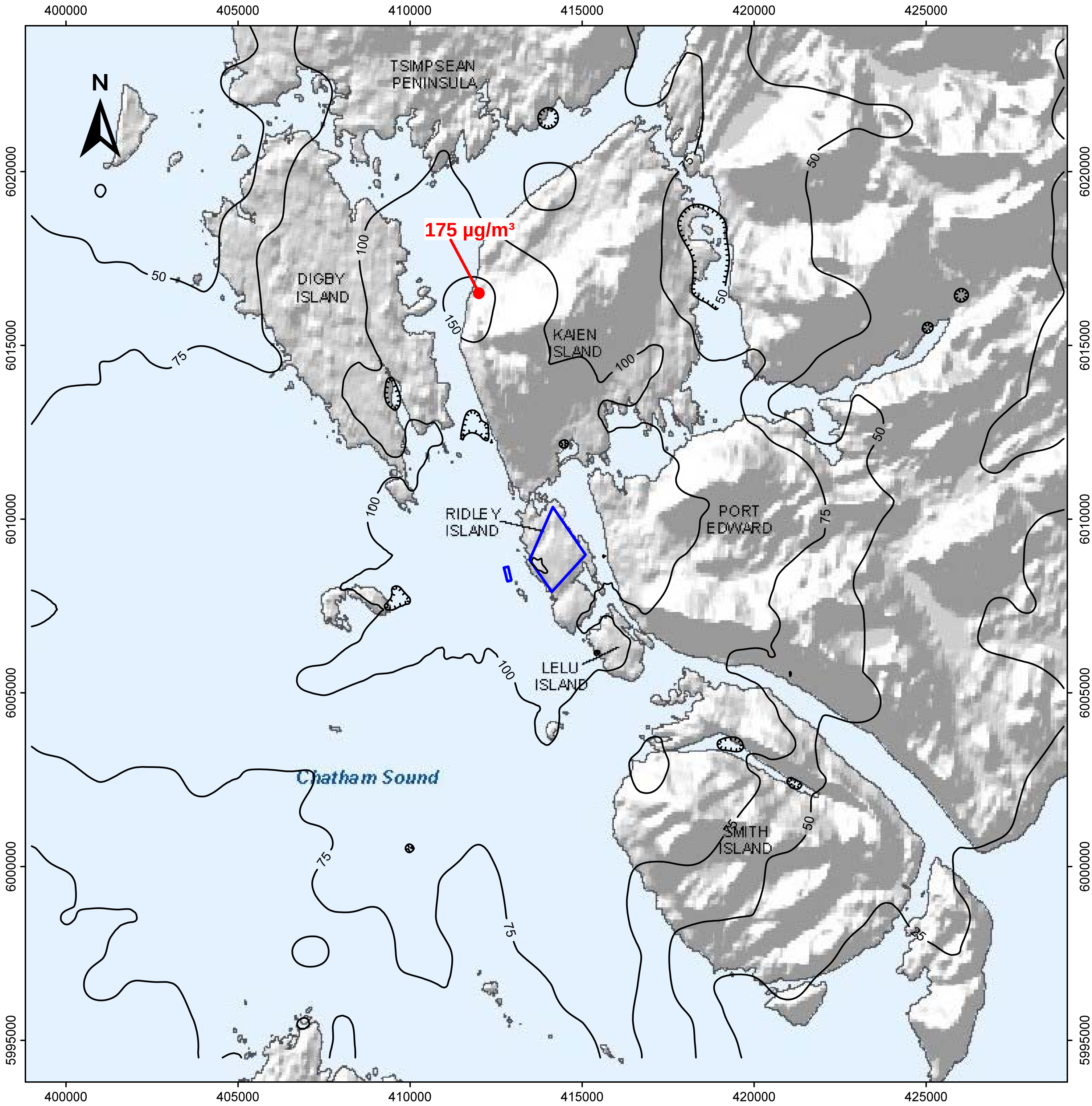
Canpotex
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted Annual Average Ground-level SO_2 Concentrations (µg/m³) Associated with the CEA Case

PROJECTION	UTM	DRAWN BY	LG
DATUM	NAD 83	CHECKED BY	JS
DATE	2011-Oct-31	FIGURE NO.	B-30

N:\1_Projects\123110264_Canpotex\01 - Ridley Island\srf\updated work\cea\a\Figure B-30 cea_SO2_a.srf

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- NO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

National Level A Air Quality Objective
One-hour Average NO_2 : 400 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Stantec

Canpotex

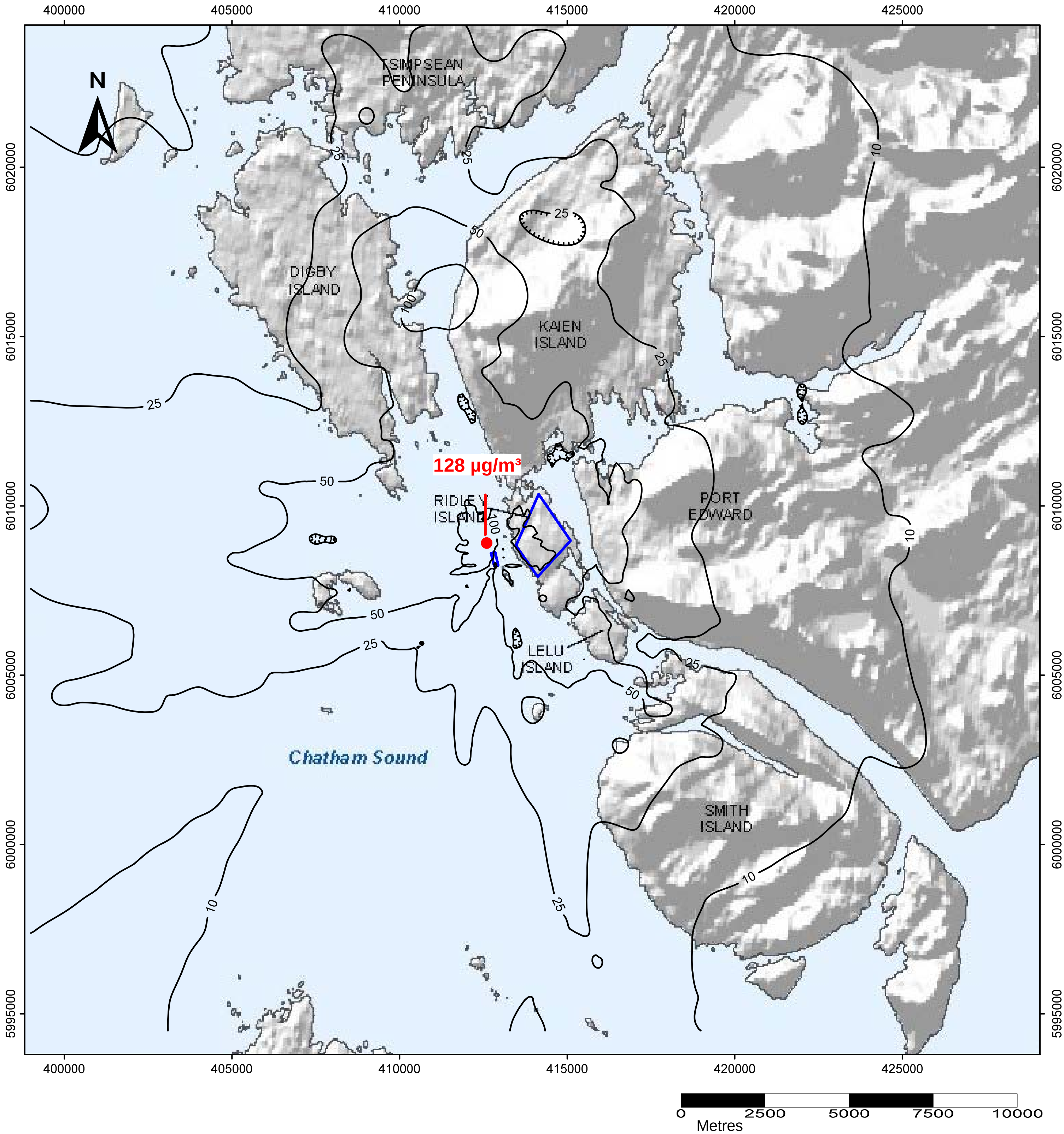
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted One-hour Average Ground-level NO_2 Concentrations (µg/m³) Associated with the CEA Case

PROJECTION UTM	DRAWN BY LG
DATUM NAD 83	CHECKED BY JS
DATE 2011-Oct-31	FIGURE NO. B-31

Job No: 1231-10264

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/cea/hd/Figure B-31 Base_NO2_h.srf



Legend

- Air Quality Modeling Fenceline
- NO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

National Level A Air Quality Objective
24-hour Average NO_2 : 200 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

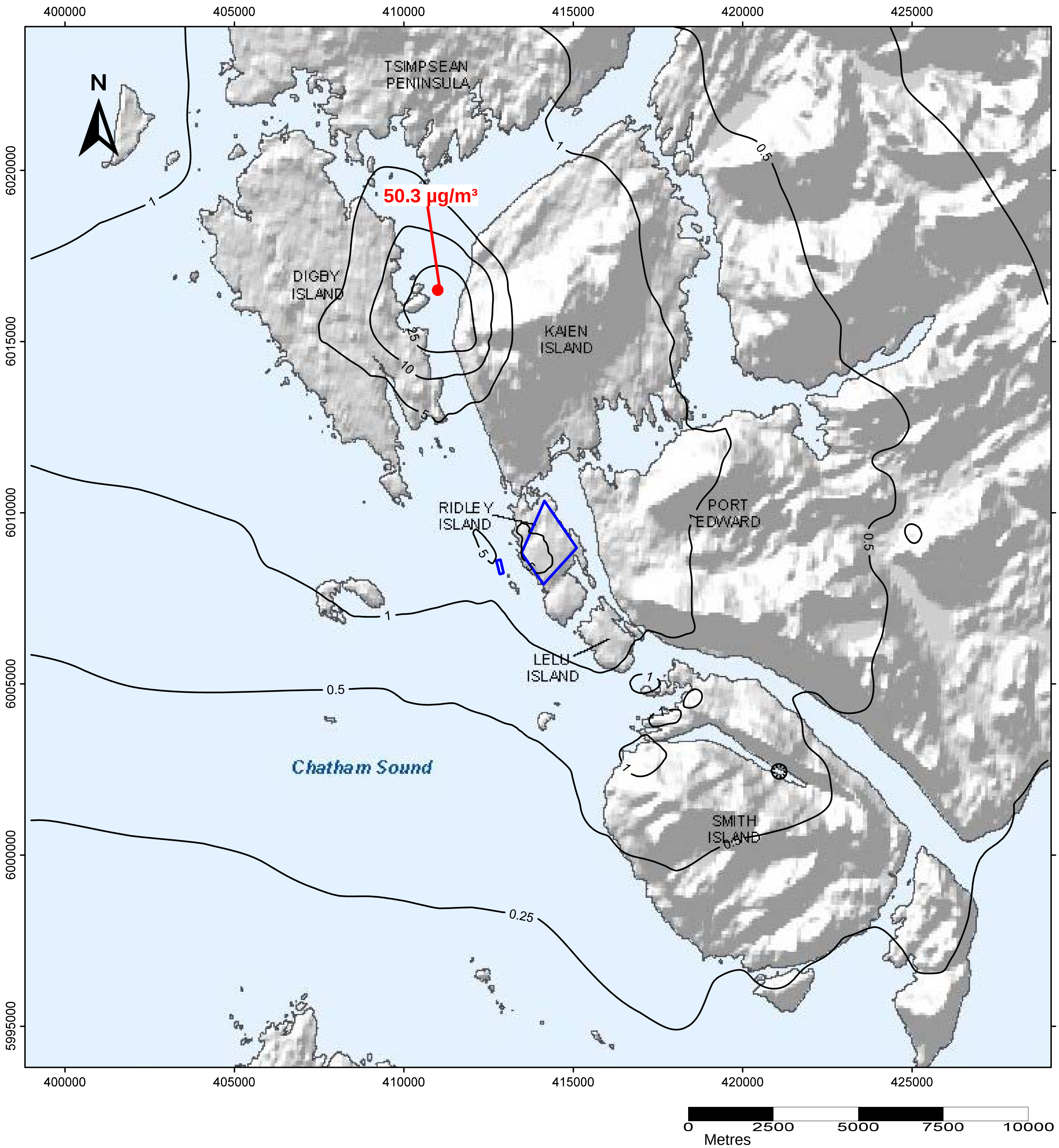
Canpotex
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted 24-hour Average Ground-level NO_2 Concentrations (µg/m³) Associated with the CEA Case

PROJECTION	UTM	DRAWN BY	LG
DATUM	NAD 83	CHECKED BY	JS
DATE	2011-Oct-31	FIGURE NO.	B-32

Job No: 1231-10264

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/cea/hd/Figure B-32 Cea_NO2_d.srf



Legend

- Air Quality Modeling Fenceline
- NO_2 Ground Level Concentrations: µg/m^3
- Maximum Concentration

National Level D Air Quality Objective
Annual Average NO_2 : 60 µg/m^3

N:/1_Projects/12310264_Canpotex/01 - Ridley Island/srf/updated work/cea/a/Figure B-33 cea_NO2_a.srf

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Stantec

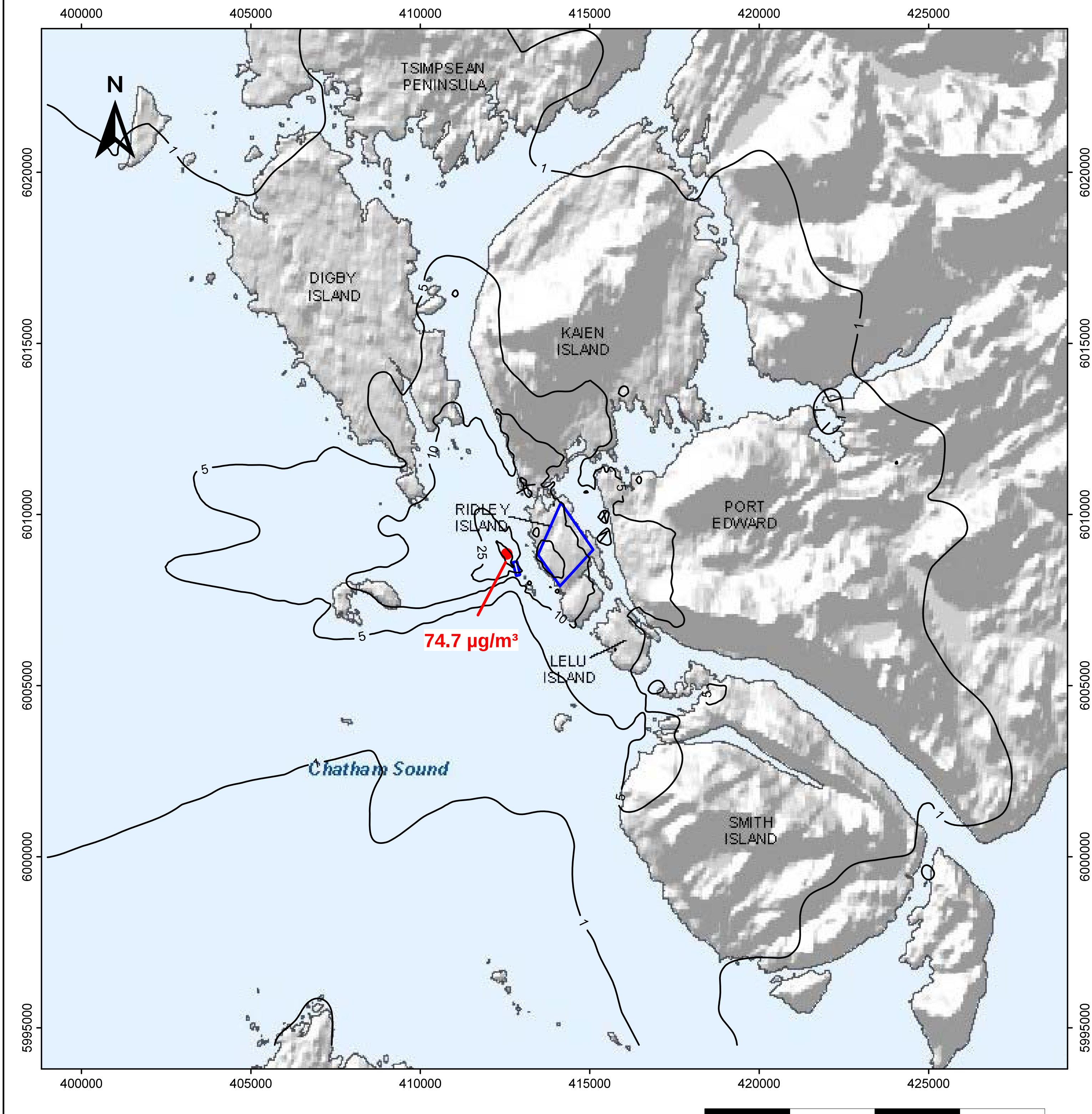
Canpotex

PRINCE RUPERT PORT AUTHORITY

Maximum Predicted Annual Average Ground-level NO_2 Concentrations (µg/m³) Associated with the CEA Case

PROJECTION UTM	DRAWN BY LG
DATUM NAD 83	CHECKED BY JS
DATE 2011-Oct-31	FIGURE NO. B-33

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- PM_{10} Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Level B Air Quality Objective
24-hour Average PM_{10} : 50 $\mu g/m^3$

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/cea/hd/Figure B-34 cea_PM10_d.srf

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Stantec

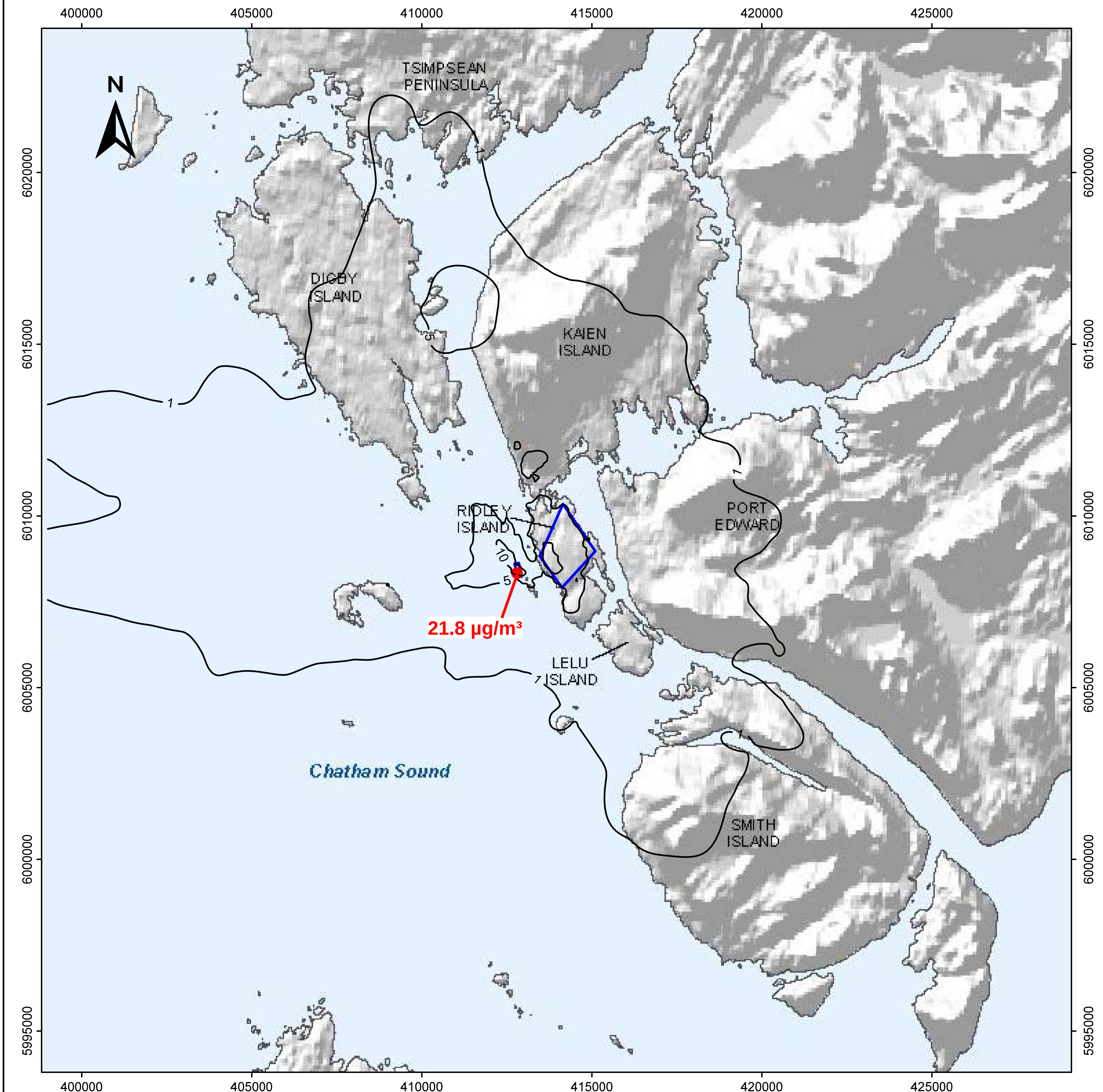
Canpotex

PRINCE RUPERT PORT AUTHORITY

Maximum Predicted 24-hour Average Ground-level PM_{10} Concentrations (µg/m³) Associated with the CEA Case

PROJECTION	DRAWN BY
UTM	LG
DATUM	CHECKED BY
NAD 83	JS
DATE	FIGURE NO.
2011-Oct-31	B-34

Job No: 1231-10264



Legend

- Air Quality Modeling Fenceline
- $PM_{2.5}$ Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Air Quality Objective
Annual 98th Percentile 24-Hour $PM_{2.5}$:25 $\mu g/m^3$

N:\1_Projects\123110264_Canpotex\01 - Ridley Island\srf\updated work\cea\hd\Figure B-35 cea_PM2.5_d.srf

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

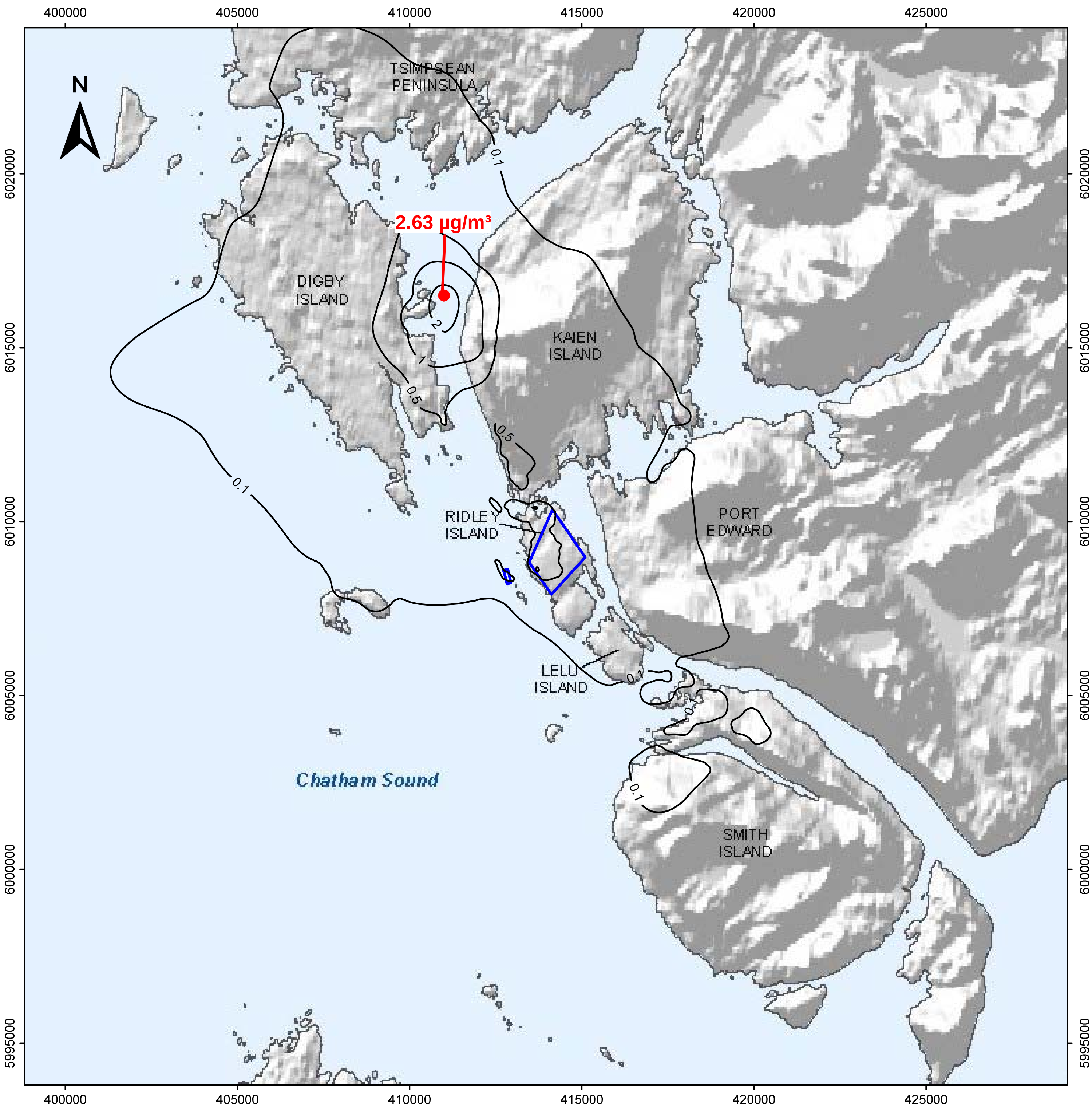
Canpotex

PRINCE RUPERT PORT AUTHORITY

Predicted 98th Percentile 24-hour Average Ground-level $PM_{2.5}$ Concentrations ($\mu g/m^3$) Associated with the CEA Case

PROJECTION	DRAWN BY
UTM	LG
DATUM NAD 83	CHECKED BY JS
DATE 2011-Oct-31	FIGURE NO. B-35

Job No: 1231-10264



0 2500 5000 7500 10000
Metres

Legend

- Air Quality Modeling Fenceline
- $PM_{2.5}$ Ground Level Concentrations: ug/m^3
- Maximum Concentration

British Columbia Air Quality Objective
Annual Average $PM_{2.5}$: 8 µg/m^3

Stantec Consulting Ltd.
4370 Dominion Street 5th Floor
Burnaby, British Columbia
V5G 4L7
Tel. (604) 436 3014
Fax. (604) 436 3752

Canpotex
PRINCE RUPERT PORT AUTHORITY

Maximum Predicted Annual Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) Associated with the CEA Case

PROJECTION	UTM	DRAWN BY	LG
DATUM	NAD 83	CHECKED BY	JS
DATE	2011-Oct-31	FIGURE NO.	B-36

Job No: 1231-10264

N:/1_Projects/123110264_Canpotex/01 - Ridley Island/srf/updated work/cea/a/Figure B-36 cea_PM2.5_a.srf