Technical Data Report—Air Quality

Ksi Lisims LNG – Natural Gas Liquefaction and Marine Terminal Project

June 2024

Prepared for:

KSI LISIMS LNG

Prepared by:

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Executive Summary

The Nisga'a Nation, Rockies LNG Limited Partnership (**Rockies LNG**) and Western LNG LLC (via its subsidiary, Western LNG) (each a Proponent and collectively referred to herein as the **Proponents**), are proposing to jointly develop an energy project, the Ksi Lisims LNG – Natural Gas Liquefaction and Marine Terminal Project (the **Project**), a floating liquefied natural gas (**FLNG**) production, storage and offloading facility, with supporting upland infrastructure and a marine terminal. The Project site (**Site**) is located at Wil Milit, on the northern end of Pearse Island, British Columbia (**BC**), approximately 15 kilometres (**km**) west of the Nisga'a community of Gingolx and 900 metres (**m**) southeast of the Canada-US border. The Project is located on Category A fee simple land as defined in the Nisga'a Final Agreement (**Nisga'a Treaty**) and is adjacent to a proposed water lot located on the east side of the Project site, in the Portland Canal.

This technical data report (**TDR**) presents detailed technical data and analysis to determine the effects of Project emissions from construction and operation on air quality. Project construction is to occur over four years and consists of construction activities involving off-road and on-road equipment, and marine vessels. The Project operation emissions sources are mainly natural gas-fired equipment on two FLNG facilities which each include a heater, thermal oxidizer, and a flare, plus associated marine vessels. The Project will be powered by the BC Hydro grid; however, power from the grid may not be immediately available after the initiation of operation. A temporary continuous natural gas-fired combined cycle power plant will be required, consisting of three barges with three natural gas-fired turbine-driven generators and one steam generator on each barge until BC Hydro grid power is available.

Effects on air quality as a result of Project construction and operation, and construction of the transmission line are determined through a comparison of the changes in the maximum predicted concentrations against the BC air quality objectives (**AQOs**) and other applicable standards, objectives and criteria, including the Alberta ambient air quality objectives (**AAQOs**) for volatile organic compounds (**VOCs**), the Ontario ambient air quality criteria (**AAQCs**) for VOCs, and the Texas Environmental Screening Levels (**ESLs**) for polycyclic aromatic hydrocarbons (**PAHs**). The pollutants considered in this assessment include, oxides of nitrogen (**NO_X**), sulphur dioxide (**SO_2**), respirable particulate matter (**$PM_{2.5}$**) (including that from diesel exhaust), inhalable particulate matter (**PM_{10}**), total suspended particulate (**TSP**), carbon monoxide (**CO**), VOCs, and PAHs.

The Project construction emissions are assessed by comparing to a similar project in a similar setting, the LNG Canada Project. Similarly, the construction emissions associated with the transmission line are compared to the Project construction emissions. Emissions from construction of the Project likely results in infrequent and short-term elevated concentrations in the vicinity of the Site, however will remain below the BC AQOs and other applicable standards and criteria. Dispersion modelling of the construction of the LNG Canada Project showed overprediction in the predicted ground-level concentrations (LNG Canada 2019) due to a number of conservative assumptions including:

- CALPUFF modelling is designed for stack emission sources and not mobile tailpipe emission sources
- assuming construction activities occur 100% of the time and simultaneously, PM2.5
- emission factors overestimate emission by 2 to 6 times
- modelling and $PM_{2.5}$ emission factors do not account for the local precipitation acting as natural dust mitigation

Construction emissions associated with the transmission line are less than construction of the Project, and are short-term, intermittent, and transient, therefore effects on air quality will be less than that of Project construction.

The Project effects, with power from the BC Hydro grid and with on-Site power generation, are assessed in isolation (the Project-alone Cases), in combination with measured baseline (the Application Cases), and in combination with other proposed industrial emissions (the Cumulative Cases). Baseline air quality conditions are based upon measured values. There are no existing large emission sources within the assessment areas that would interact with the Project emissions. Overall, the existing air quality in the assessment areas is pristine. The effects of flaring are assessed separately (the worst-case flaring events Cases). An assessment of the air emissions from shipping along the shipping route was completed.

The Project-alone air dispersion modelling results, both with on-Site power generation and with power from the BC Hydro grid, show that there are elevated levels of nitrogen dioxide (**NO_2**), SO_2, $PM_{2.5}$, and CO in the immediate vicinity of the Project (less than 3 kilometres); however, the BC AQOs are not exceeded. In comparison to a similar project in a similar setting, concentrations of VOCs and PAHs are expected to be below the other applicable objectives and criteria. These effects diminish rapidly with increasing distance from the Project.

The Application Case results, both with on-Site power generation and with power from the BC Hydro grid, are similar to those of the Project-alone Cases. The addition of baseline does not result in any localized exceedances of the BC AQOs.

The Cumulative Case results, both with on-Site power generation and with power from the BC Hydro grid, are similar to those of the Application Cases. The addition of emissions from the Westcoast Connector Gas Transmission Project, specifically the proposed K5 Nasoga compressor station, does not result in localized exceedances of the the BC AQOs or the other appliable objectives and criteria.

The worst-case flaring events case results show that in the unlikely event that flaring coincides with worst-case meteorology, a moderate increase in NO_2, SO_2, and $PM_{2.5}$ is predicted to occur in the vicinity of the Site boundary. As flaring occurs sporadically, the likelihood of these effects being manifest in the receiving environment is low. Flaring is not expected to result in localized exceedances of the BC AQOs.

The results associated with marine shipping for the Operation Shipping Route and Open Water Assessment Cases show that there are elevated levels of NO_2 and SO_2 in the immediate vicinity of the shipping routes (less than 200 metres); however, the BC AQOs are not predicted to be exceeded. These effects diminish rapidly with increasing distance from the Project.

Results from the air dispersion modelling indicated the potential for elevated ambient concentrations of pollutants greater than the existing conditions (baseline) in the vicinity of the Site to occur, however based on the dispersion modelling and comparison to a similar project in a similar setting, concentrations are expected to remain below the BC AQOs and other applicable objectives and criteria.

1 Abbreviations

°C	degrees Celsius
µg/m^3	microgram per cubic metre
AAQO	Ambient Air Quality Objective
AAQC	Ambient Air Quality Criteria
AEP	Alberta Environment and Parks
AQO	Air Quality Objective
BC EAA	British Columbia *Environmental Assessment Act*
BC ENV	British Columbia Ministry of Environment and Climate Change Strategy
CAAQS	Canadian Ambient Air Quality Standards
cm	centimetre
CO	Carbon Monoxide
EA	environmental assessment
ECCC	Environment and Climate Change Canada
FLNG	floating liquefied natural gas production, storage and offloading facility
ha	hectare
IA	impact assessment
km	kilometre
LNG	liquefied natural gas
m	metre
m^3	cubic metre
mm	millimetre
m/s	metres per second

NAAQS	United States National Ambient Air Quality Standards
N	nitrogen
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
Ontario MOE	Ontario Ministry of Environment
OWAA	Open Water Assessment Area
PAH	Polycyclic aromatic hydrocarbons
$PM_{2.5}$	respirable particulate matter
PM_{10}	inhalable particulate matter
Project	Ksi Lisims LNG – Natural Gas Liquefaction and Marine Terminal Project
Proponents	Nisga’a Nation, Rockies LNG Limited Partnership and Western LNG
S	sulphur
Site	the Project Site
SO_2	sulphur dioxide
TDR	Technical Data Report
TSP	Total suspended particulate
UTM	Universal Transverse Mercator
VC	valued component
VOC	volatile organic compounds
WRF	Weather Research and Forecasting Model

1

1 Glossary

Air pollutant	A substance released into the atmosphere which may be harmful to human health, the environment, and/or animal health.
Ambient air	Atmospheric air outside of an industrial (occupational) workplace.
Baseline air quality	The concentration of pollutants in ambient air that are attributable to all natural and human-caused sources except the sources being modelled.
Plant boundary	As defined in the British Columbia Air Quality Dispersion Modelling Guideline (the Guideline) (BC ENV 2022a) as the Project fence line where public access is restricted.
Project Area	The area to be utilized by the Project, located on Pearse Island and Portland Canal.
Floating liquefied natural gas facility	A water-borne liquefied natural gas production facility that is purpose-built to liquefy and store liquefied natural gas and transfer it to liquefied natural gas carriers for global export.
The Guideline	Refers the British Columbia Air Quality Dispersion Modelling Guideline (BC ENV 2022a).
Liquefied natural gas (LNG)	Natural gas that has been cooled to approximately -162°C where the methane and other components condense from gas to liquid form. In its liquid state, natural gas takes up 1/600 of the space that the gaseous phase occupies.
LNG carrier	A marine cargo ship with specialized cryogenic tanks designed for transporting liquefied natural gas.
Natural gas	A naturally occurring hydrocarbon gas mixture consisting primarily of methane plus varying amounts of ethane, propane, butanes, pentanes, higher molecular weight hydrocarbons, hydrogen sulfide, carbon dioxide, water vapor, and sometimes helium and nitrogen.
the Application	The Application for an Environmental Assessment Certificate under the British Columbia *Environmental Assessment Act* and approval under the federal *Impact Assessment Act* (IAA).
the Project	The Ksi Lisims LNG – Natural Gas Liquefaction and Marine Terminal Project.

2

1.0 INTRODUCTION

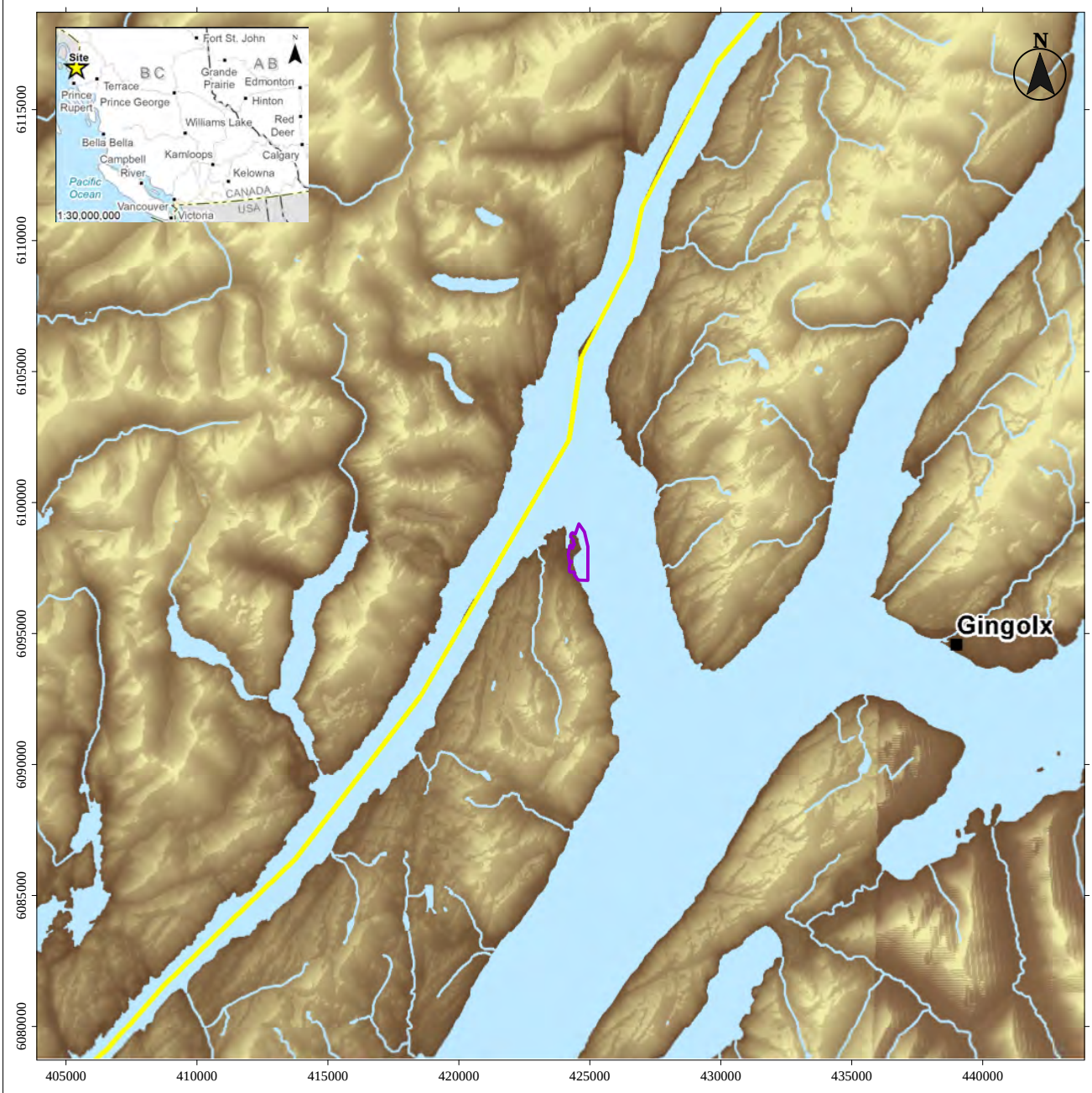
The Nisga'a Nation, Rockies LNG Limited Partnership (**Rockies LNG**) and Western LNG LLC (via its subsidiary, Western LNG) (each a Proponent and collectively referred to herein as the **Proponents**), are proposing to jointly develop an energy project, the Ksi Lisims LNG – Natural Gas Liquefaction and Marine Terminal Project (the **Project**), a floating liquefied natural gas (**FLNG**) production, storage and offloading facility, with supporting upland infrastructure and a marine terminal. The Project site (**Site**) is located at Wil Milit, on the northern end of Pearse Island, British Columbia (**BC**), approximately 15 kilometres (**km**) west of the Nisga'a community of Gingolx and 900 metres (**m**) southeast of the Canada-US border. The Project is located on Category A fee simple land as defined in the Nisga'a Final Agreement (**Nisga'a Treaty**) and is adjacent to a proposed water lot located on the east side of the Site, in the Portland Canal (Figure 1.0–1).

The Project is subject to an environmental assessment (**EA**) under the British Columbia *Environmental Assessment Act* (**BC EAA**) and an impact assessment (**IA**) under the federal *Impact Assessment Act* (**IAA**). The Government of BC requested substitution of the provincial review process for the federal impact assessment process from the federal Minister of Environment and Climate Change Canada. The federal Minister of Environment and Climate Change Canada approved the request for substitution. Given the location of the Project on Category A Lands owned by the Nisga'a Nation, the Application will also meet requirements of Chapter 10, paragraph 8 of the Nisga'a Treaty. Accordingly, an Application that focuses on a suite of valued components (**VCs**) has been prepared. VCs are components of the natural and human environment that are considered by the Proponent, public, Indigenous nations, scientists and other technical specialists, and government agencies involved in the assessment process to have scientific, ecological, economic, social, cultural, archaeological, historical, or other importance. This Technical Data Report (**TDR**) presents the existing conditions, predicted changes, and cumulative changes for ambient Air Quality to support the Application and permitting requirements.

The 'plant boundary' as defined in the BC Air Quality Dispersion Modelling Guideline (the **Guideline**) (BC Ministry of Environment and Climate Change Strategy (**ENV**) 2022a) is the Project fence line where public access is restricted. This 'plant boundary' is established for air quality dispersion modelling for the emissions from Project operation. The 'plant boundary' encompasses the FLNG facility, the marine terminal, and upland infrastructure and covers approximately 117 hectares (**ha**) of land and water on Pearse Canal and Portland Canal. The nearest permanently occupied dwellings are located approximately 15 km east of the Project in the remote community of Gingolx.

Stantec Consulting Ltd. (**Stantec**) was contracted by the Proponents to conduct the air quality assessment and prepare the TDR describing the effect of Project emissions on ambient Air Quality. The Project construction emissions sources include off-road and on-road vehicles and equipment, and marine vessels. The Project construction emissions are assessed by comparing emission levels to a similar project in a similar setting, the LNG Canada Project. The Project operation emission sources are mainly natural gas-fired equipment on two FLNG facilities which each include a heater, thermal oxidizer,

and a flare, plus associated marine vessels. The Project operation will be powered by the BC Hydro grid; however, power from the grid may not be immediately available after the initiation of operation. In that case, a temporary continuous natural gas-fired combined cycle power plant will be required, consisting of three barges with three natural gas-fired turbine-driven generators and one steam generator on each barge. The Project's operation emissions are assessed, using air dispersion modelling, in isolation, in combination with measured baseline, and with nearby proposed industrial emissions.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Site
Gingolx
International Boundary
Watercourse
Waterbody
Ground Elevation (m)
High : 1652
Low : 0

Ksi Lisims LNG Plant Boundary

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
1.0-1

Title
Project Location and Study Area

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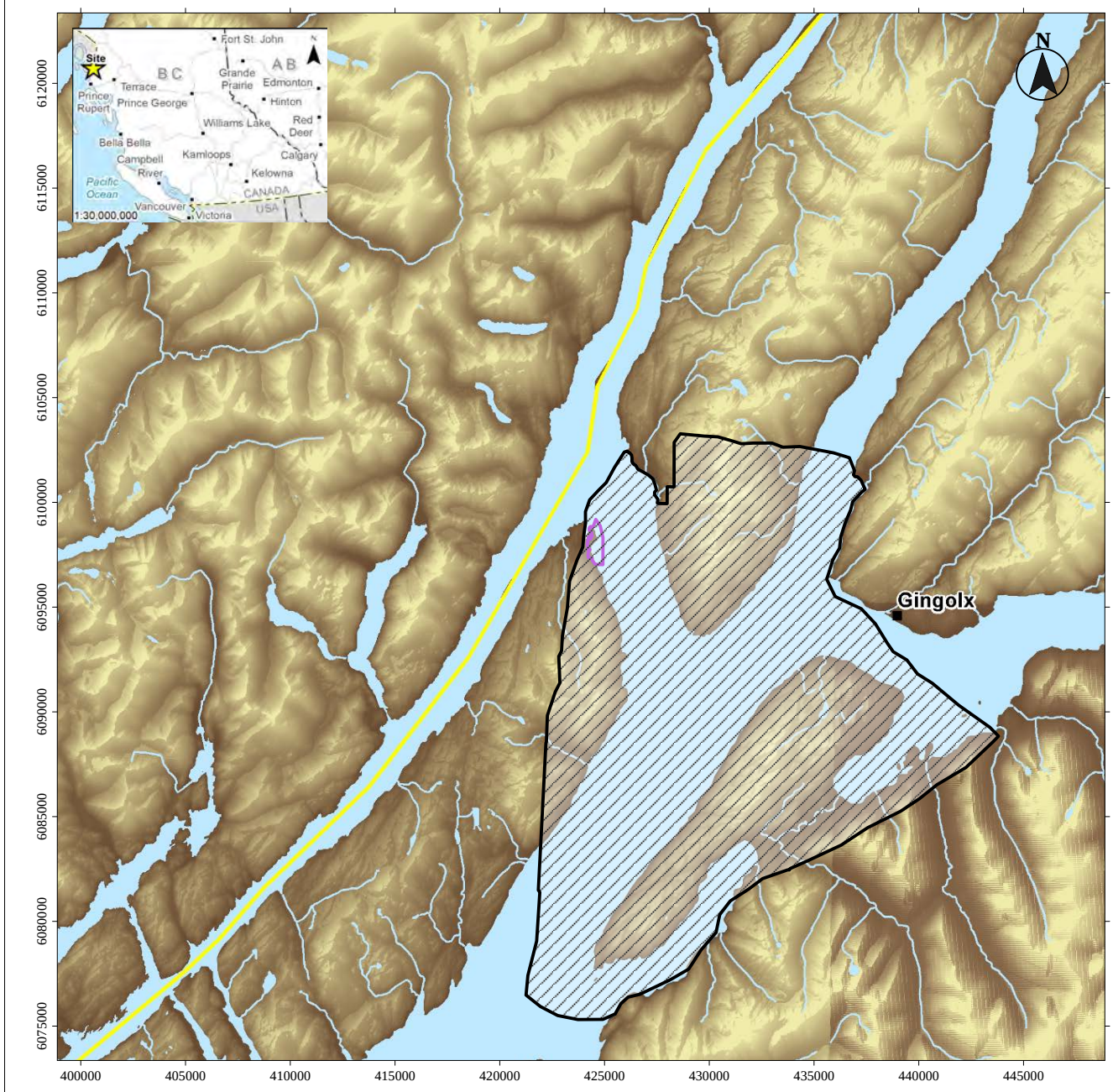
2.0 ASSESSMENT AREAS

The Project is located at Wil Milit on the northern end of Pearse Island, approximately 15 km west of the Nisga'a community of Gingolx. The Project centre in the Universal Transverse Mercator (**UTM**) coordinate system is 6,098,078 m north, 424,259 m east, Zone 9 (NAD 83) (or 55.0238°N Latitude, -130.1848°W Longitude). The marine terminal occupies approximately 117 ha of land and water on the Pearse Canal and Portland Canal with an elevation of approximately sea level to 20 m above mean sea level. Local relief surrounding the Project rises up to 1,000 m within 10 km.

The assessment areas presented in this TDR represent the areas included in the air quality assessment. This assessment allows for an understanding of the environment in support of the Project-specific effects assessment and the cumulative effects assessment. This includes assessment of both existing ambient air quality and the predicted effects of the emissions from the Project operation, and the nearby planned and approved projects. To assess the Projects activities, including construction, Project operation, operation shipping, and shipping in the OWAA there are four assessment areas included in the assessment for Air Quality. These include;

- Local Assessment Area (**LAA**) is used for the assessment of Project construction and operation and is defined as a 40 km by 40 km area. This assessment area is selected to assess the potential effects of emissions from the Project on the surrounding ambient air quality. The Regional Assessment Area (**RAA**) is the same as the LAA. Together they are referred as LAA/RAA (Figure 1.0–1)
- Transmission Line Assessment Area (**TLAA**) is a 36,400-ha area that encompasses the effects of the construction and operation of the third-party transmission line that will support the Project (Figure 2.0–1). Air quality effects are likely to be experienced within a smaller area, and for the assessment of air quality the assessment area is 5 km on either side of the transmission line
- Operation Shipping Route Assessment Area includes the Project-related operation marine shipping emissions for 5 km on either side of the marine shipping route from Triple Islands to the Site (Figure 2.0–2). The Operation Shipping Rout Assessment Area is expanded to the east side of the route to include Metlakatla Village and Lax Kw'alaams Village
- Open Water Assessment Area (**OWAA**) includes the Project-related operation open water marine shipping route from Triple Island to the 12 nautical mile (**nm**) limit in the Pacific Ocean, approximately 167 km. Project related emissions were assessed for 118 km west of Triple Islands including 5 km buffer on either side of the marine shipping route (Figure 2.0–3). This area represents where most interaction would occur between the LNG carrier and people using personal marine vessels.

The assessment areas consist of complex terrain including ocean channels and inlets, mountains, and river valleys.



Metres

0 5000 10000 15000

KSI LISIMS LNG

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Transmission Line Assessment Area

Notes

1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Stantec

Project Location
Pearse Island, BC

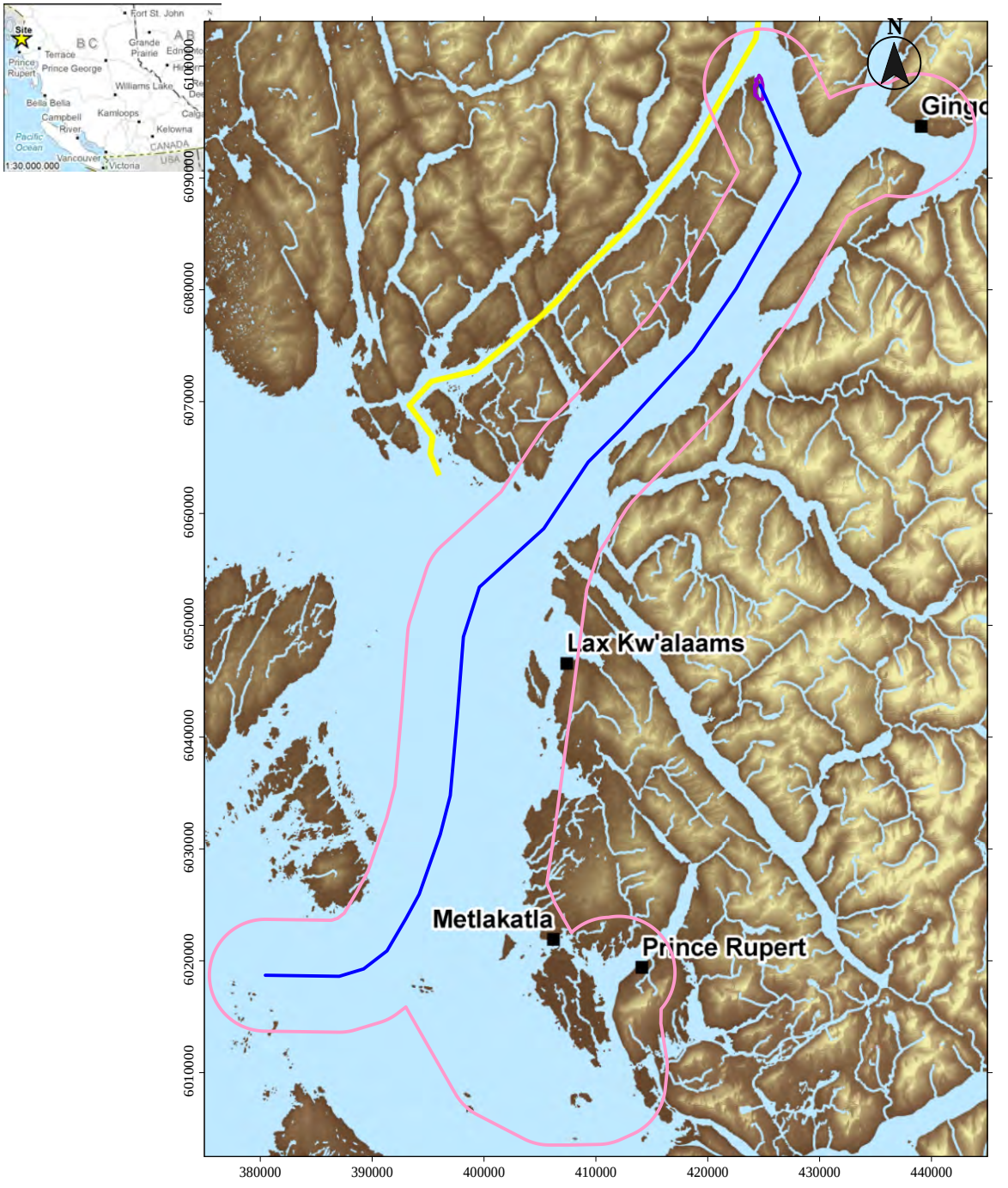
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Figure No.
2.0-1

Title
Transmission Line Assessment Area

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Shipping Boundary
Shipping Route

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

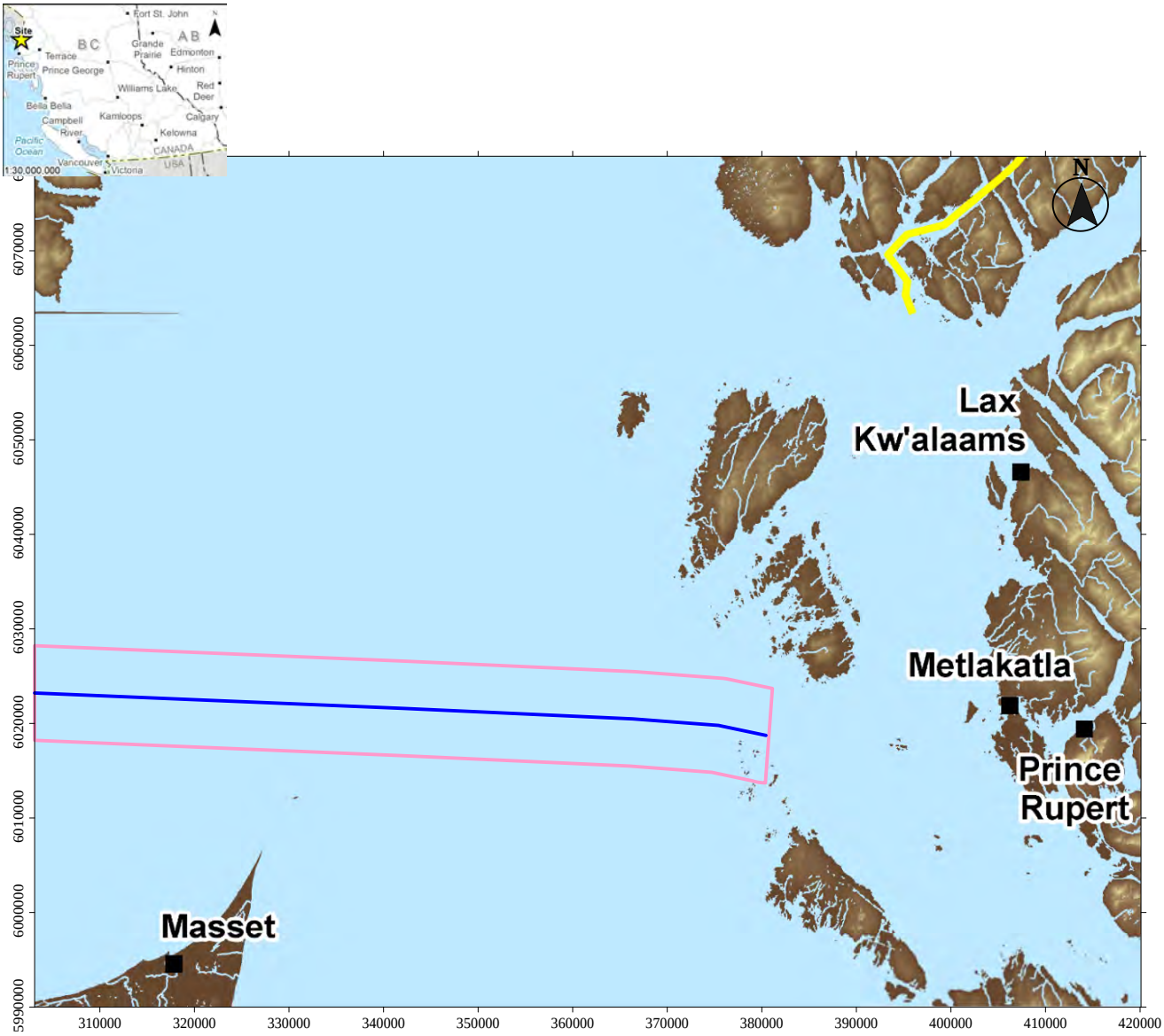
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Figure No.
2.0-2

Title
Operation Shipping Route Study Area

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

City/Town
International Boundary
Watercourse
Waterbody
Value
High : 1250
Low : 0

Open Water Assessment Area

Shipping Route

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
2.0-3

Title
Open Water Assessment Study Area

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3.0 METHODS

3.1 LEVEL OF ASSESSMENT

The Guideline (BC ENV, 2022a) defines three levels of air quality assessment that vary in the degree of detail and scope. Sections 1.5 and 2.2 of the Guideline (2022a) indicate that a Level 3 modelling assessment using the CALPUFF modelling system is appropriate for modelling air emissions associated with the Project due to the complex wind flow in the region and multiple emission sources. Dispersion modelling methods for this assessment followed the Guideline (BC ENV 2022a) and Dispersion Modelling Plan (Appendix A).

3.2 APPLICABLE OBJECTIVES FOR AIR QUALITY

Effects on air quality are determined, in part, by comparing the dispersion model predicted concentrations for air pollutants to the BC AQOs. The BC AQOs are a suite of ambient air quality criteria that have been developed provincially and nationally to inform decisions on the management of air contaminants (BC ENV 2021). The AQOs are used to gauge current and historical air quality and guide decisions on environmental impact assessments and authorizations. In BC, the BC ENV have stated that the BC AQOs are applicable beyond the facility fence line (BC ENV 2016; BC ENV 2020). Where exceedances of the BC AQOs are predicted through dispersion modelling, the BC ENV considers the context of magnitude, frequency, timing, and proximity to sensitive receptors. Should there be exceedances of the BC AQOs, the BC ENV would manage these in accordance with the federal Air Zone Management Framework (Canadian Council of Ministers of Environment [**CCME**] 2019) for improvements in air quality across the affected area and would include all important sources (BC ENV 2020).

The BC AQOs for NO_2 and sulphur dioxide are based on the Canadian Ambient Air Quality Standards (**CAAQS**), announced by the Government of Canada in 2017 (CEPA 2017) for the year 2020. The CCME (2019) have stated that achievement of the CAAQS is determined on an airshed and air zone basis, which cover broad geographical areas. They are regional ambient air quality standards. They are not intended to be applied to individual projects and facilities and are not intended to be used as fence line standards (CCME 2019). Rather, they are used by provinces and territories to guide air zone management actions intended to reduce ambient concentrations below the CAAQS, prevent CAAQS exceedances, and keep areas with ‘clean’ air quality clean (CCME 2019).

The BC AQOs and CAAQS are based on the potential for human health effects. The BC AQOs for nitrogen dioxide (**NO_2**), sulphur dioxide (**SO_2**), respirable particulate matter (**$PM_{2.5}$**), inhalable particulate matter (**PM_{10}**), and total suspended particulate (**TSP**) are shown in Table 3.2–1. BC currently does not have an AQO for carbon monoxide (**CO**), however, a rescinded pollution control objective is still used for reference purposes (ENV 2021). The CO pollution control objective is provided in Table 3.2–1.

Table 3.2–1 BC Air Quality Objectives

Air Pollutant	Averaging Interval	Air Quality Objective	
		(µg/m³)	**ppb**
NO_2	1-hour	113[a]	60
	Annual	32[b]	17
SO_2	1-hour	183[c]	70
	Annual	13[d]	5
$PM_{2.5}$	24-hour	25[e]	-
	Annual	8[f]	-
CO	1-hour	14,300	13,000
	8-hour	5,500	5,000

NOTES:

[a] Achievement for 1-hour NO_2 is based on 3-year average of the annual 98th percentile of daily 1-hour maximum. This requires the extraction of the highest predicted 1-hour value at each location for each day, followed by the calculation of the 98th percentile (the eighth highest) of those 365 values for each year, then average the three annual values.

[b] Achievement for annual NO_2 is based on the average of all 1-hour average concentrations over a single calendar year.

[c] Achievement for 1-hour SO_2 is based on 3-year average of the annual 99th percentile of daily 1-hour maximum. This requires the extraction of the highest predicted 1-hour value at each location for each day, followed by the calculation of the 99th percentile (the fourth highest) of those 365 values for each year, then average the three annual values.

[d] Achievement for SO_2 is based on the average of 1-hour concentrations averaged over one year.

[e] Achievement for $PM_{2.5}$ is based on annual 98th percentile of daily average, average over one year.

[f] Achievement for $PM_{2.5}$ is based on annual average, average over one year.

NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide

SOURCE: BC ENV 2021

Regulatory agencies have expressed an interest in referencing objectives other than the BC AQOs in this assessment. Specifically, they are interested in referencing the CAAQS for other years as shown in Table 3.2–2. Note, there are no CCME objectives for CO.

Table 3.2–2 Canadian Ambient Air Quality Standards for 2025

Air Pollutant	Averaging Interval	Other Regulatory Criteria	
		µg/m^3	ppb
NO_2	1-hour	79	42
	Annual	23	12
SO_2	1-hour	170	65
	Annual	11	4
$PM_{2.5}$	24-hour	27	-
	Annual	8.8	-
NOTE: The CAAQS listed are for the year 2025 for nitrogen dioxide (NO_2) and sulphur dioxide (SO_2), and 2020 for respirable particulate matter ($PM_{2.5}$). The statistical forms for each are the same as for the BC AQOs (Table 3.2–1).			
SOURCE: CCME 2021			

The assessment includes volatile organic compounds (**VOCs**) which consist of a mixture of volatile non-methane hydrocarbons. There are no criteria or objectives provincially or federally for VOCs; however, Alberta Environment and Parks (AEP) and Ontario Ministry of Environment (MOE) has Ambient Air Quality Objectives (**AAQO**) (AEP, 2012) and Ambient Air Quality Criteria (**AAQCs**) (Ontario MOE 2012) for speciated VOCs as shown in Table 3.2–3. The most stringent AAQO and AAQC is for benzene. The 1-hour average AAQO is 30 µg/m^3 (Alberta AAQO) and annual average is 0.45 µg/m^3 (Ontario AAQC) (AEPA 2019, Ontario MOE 2012).

Table 3.2–3 Objectives and Criteria for Volatile Organic Compounds

VOCs	Averaging Interval	Objectives and Criteria (µg/m^3)
Benzene	1-hour	30 [a]
	24-hour	2.3 [b]
	Annual	0.45 [b]
Toluene	1-hour	1,880 [a]
	24-hour	400 [a]
Ethylbenzene	1-hour	2,000 [a]
	24-hour	1,000 [b]
Xylenes	1-hour	2,300 [b]
	24-hour	700 [a]
Acetaldehyde	1-hour	90 [a]
	24-hour	500 [b]
Acrolein	1-hour	4.5 [a,b]
	24-hour	0.4 [a,b]
Benzaldehyde	1-hour	N/A
	24-hour	N/A
Formaldehyde	1-hour	65 [a]
	24-hour	65 [b]
Propylene	1-hour	N/A
	24-hour	4000 [b]
1,3-butadiene	1-hour	N/A
	24-hour	10 [b]
Propionaldehyde	1-hour	10 [b,c]
	24-hour	N/A
2,2,4-Trimethylpentane	1-hour	N/A
	24-hour	N/A

NOTES:

N/A indicates there is no objective or criteria for this VOC.

[a] Alberta Ambient Air Quality Objectives for various VOCs. Data source: Alberta Environment Protection (AEPA) (2019).

[b] Ontario Ambient Air Quality Criteria for various VOCs. Data source: Ontario Ministry of Environment (Ontario MOE) (2012).

[c] Criteria is for a 10-minute average (Ontario MOE 2012)

Similar to VOCs, there are no provincial or federal objectives or criteria for polycyclic aromatic hydrocarbon (**PAHs**), therefore, the Texas Environmental Screening Levels (**ESL**) shown in Table 3.2–4 are referred to. The most stringent ESL is the annual average for benzo[a]pyrene of 0.017 µg/m^3.

Table 3.2–4 Texas Environmental Screening Levels for Polyaromatic Hydrocarbons

PAH	Averaging Interval	ESL (µg/m^3) [a]
Acenaphthene	Annual Average	10
Acenaphthylene		10
Anthracene		0.1
Benzo[a]pyrene		0.017
Fluoranthene		0.05
Fluorene		1
2-Methylnaphthalene		20
Naphthalene		50
Perylene		0.05
Phenanthrene		0.8
Pyrene		0.05

NOTE:
[a] Environmental Screening Levels from Texas Air Monitoring Information System Database (2023)

The United States National Ambient Air Quality Standards (**NAAQS**) are referred to due to the Project's proximity (less than 1 km) to the Canada-US border, shown in Table 3.2–5 (US EPA 2021).

Table 3.2–5 United States National Air Quality Standards

Air Pollutant	Averaging Interval	Air Quality Standard ($\mu g/m^3$)
NO_2	1-hour	188
	Annual	100
SO_2	1-hour	196
	3-hour	1,300
$PM_{2.5}$	24-hour	35
	Annual	12
CO	1-hour	40,065
	8-hour	10,303

NOTES:

[a] Achievement for 1-hour NO_2 is based on 3-year average of the annual 98th percentile of daily 1-hour maximum. This requires the extraction of the highest predicted 1-hour value at each location for each day, followed by the calculation of the 98th percentile (the eighth highest) of those 365 values for each year, then average the three annual values.

[b] Achievement for annual NO_2 is based on the average of all 1-hour average concentrations over a single calendar year.

[c] Achievement for 1-hour SO_2 is based on 3-year average of the annual 99th percentile of daily 1-hour maximum. This requires the extraction of the highest predicted 1-hour value at each location for each day, followed by the calculation of the 99th percentile (the fourth highest) of those 365 values for each year, then average the three annual values.

[d] Achievement for 3-hour SO_2 is based on the rolling average of 1-hour concentrations one year. Not to be exceeded more than once per year.

[e] Achievement for $PM_{2.5}$ is based on annual 98th percentile of daily average, average over three years

[f] Achievement for $PM_{2.5}$ is based on annual average, average over three years

SOURCE: United States Environmental Protection Agency (US EPA) 2021

3.3 REGIONAL ATMOSPHERIC CONDITIONS

This section describes the existing regional conditions in the Assessment Areas. The baseline climate and meteorology, and air quality are described. Understanding both the existing climate and air quality, and its relationship with the landscape, helps establish the link between cause (emissions) and effect (resultant changes in air quality) and supports the Project Air Quality assessment.

3.3.1 Climate and Meteorology

3.3.1.1 Climate

Climate is defined as the weather conditions prevailing in an area over a long-time interval. The assessment areas are located in the temperate rainforest type of ecosystem. Temperate rainforests are rainforests with coniferous or broadleaf forests that occur in the temperate zone and receive heavy rainfall. The prevailing westerly storm track across the North Pacific, combined with orographic lift from the Coastal Mountains, produces high annual precipitation amounts throughout the region. The moderating influence of the ocean limits the seasonal temperature ranges, resulting in relatively mild winters and cool summers (Phillips 1990).

The climate of the assessment areas are characterized using the 30-year Environment and Climate Change Canada (**ECCC**) Canadian Climate Normals (1981–2010) for the Prince Rupert and Green Island stations (ECCC 2020). Canadian Climate Normals are calculated by the ECCC using the recommended methods for validity established by the World Metrological Organization (**WMO**) (ECCC 2020). The Prince Rupert station is located at the Prince Rupert airport, which is west of the city of Prince Rupert at an elevation of 35.4 m above sea level. The Green Island station is located 40 km northwest of Prince Rupert in Chatham Sound at an elevation of 11.9 m above sea level.

In addition to the climate normals stations, one year (September 1, 2021 to August 31, 2022) of on-Site meteorology data are summarized for the Project's remote solar powered meteorology station. The Project station is located on Pearse Island near the Site at an elevation of 31 m above sea level. Data from the Pearse Island station are continuously recorded and averaged hourly, and data quality is reviewed on a monthly basis. While these data are limited to one year, they are useful in characterizing local meteorological conditions at the Site. The temperature, precipitation, and relative humidity data are described below briefly for the climate normals stations and the Pearse Island station.

Air Temperature

Prince Rupert

The daily average air temperature in Prince Rupert is 7.5 degrees Celsius (**°C**). January is the coldest month, and August is the warmest (2.4°C and 13.8°C daily average temperature, respectively). The extreme air temperatures vary from -24.4°C (January 4, 1965) to 31.1°C (June 28, 2004).

Green Island

The daily average air temperature at Green Island is 8.5°C. January is the coldest month, and August is the warmest (3.2°C and 14.8°C daily average temperature, respectively). The extreme air temperatures vary from -18.5°C (November 26, 1985) to 29.0°C (June 19, 2004).

Pearse Island (On-Site)

The daily air average temperature, based on one year of collected data, at the on-Site meteorological station is 6.7°C. December is the coldest month, and August is the warmest (-3.7°C and 15.6°C daily average temperature, respectively). The extreme air temperatures vary from -13.7°C (December 28, 2021) to 26.0°C (August 25, 2022).

Precipitation

Prince Rupert

The annual precipitation in Prince Rupert is 2,619.1 millimetres (**mm**), of which 97% falls as rain. October is the wettest month (373.4 mm), and June is the driest (108.7 mm). The extreme daily precipitation (rainfall) is 118.2 mm (September 25, 1983). The extreme daily snowfall is 39.9 centimetres (**cm**) (January 20, 1973), and the extreme snow depth is 76 cm (January 9, 1965).

Green Island

The annual precipitation at Green Island is 2,474.3 mm, of which 98% falls as rain. October is the wettest month (353.9 mm), and June is the driest (105.3 mm). The extreme daily precipitation (rainfall) is 137.6 mm (September 22, 2001). The extreme daily snowfall is 22.2 cm (December 5, 1984), and the extreme snow depth is 28 cm (January 7, 1998).

Pearse Island (On-Site)

The annual rainfall, based on one year of data collected, at the on-Site meteorological station is 3,588.9 mm. January is the wettest month (628.8 mm), and July is the driest (53.7 mm). The extreme daily rainfall is 87.7 mm (September 25, 2021). The average snow depth is greatest in January (27.3 cm). The extreme daily snowfall is 33.4 cm (January 2, 2022), and the extreme snow depth is 149 cm (January 10, 2022).

Relative Humidity

Prince Rupert

The average relative humidity in Prince Rupert is 74.9% (as observed daily at 1500 local standard time). December has the highest average relative humidity, and April has the lowest (80.2% and 67.7%, respectively).

Green Island

Relative humidity is not observed at the Green Island station.

Pearse Island (On-Site)

The average relative humidity, based on one year of data collected, at the on-Site meteorological station is 89.3%. September has the highest average relative humidity, and April has the lowest (96.1% and 80.3%, respectively).

3.3.1.2 Meteorology

Meteorology is the study of the changes in wind speed and direction, temperature, air pressure, humidity, and other parameters in the atmosphere. Local meteorological conditions influence the transport and dispersion of air emissions. Wind speed, wind direction, and atmospheric turbulence are major meteorological elements that influence the transport and dispersion of particulate and gaseous emissions.

The Guideline (BC ENV 2022a) requires the application of at least three years of meteorological data as input for dispersion modelling and recommends use of a BC ENV-supplied Weather Research and Forecasting (**WRF**) meteorological dataset. The WRF model allows for the dynamical spatial and temporal downscaling of reanalysis datasets to predict Site-specific meteorological conditions more accurately. Hourly-averaged meteorological data from BC ENV were applied as input to CALMET and CALPUFF based on the WRF model output for the years 2011–2015, developed by Exponent (2021).These meteorological data were used in air dispersion modelling and are discussed in Section 3.7.2, and presented in detail in the CALMET Appendix B.

On-Site meteorological data collected at the Site was not used in the air dispersion modelling. The period of collection (2021-2022) does not align with the WRF data used for modelling (2011-2015). Additionally, due to the siting of the on-Site meteorological station, the wind speed and direction are strongly influenced by local topographical features.

The frequency distributions of hourly average wind speed based on one year of data measured at the Site station are shown in Figure 3.3–1. For 94.8% of the time, wind speeds were less than 4.0 metres per second (**m/s**). For 5.1% of the time, wind speeds were greater than or equal to 4.0 m/s. Figure 3.3–2 presents the annual wind rose. Winds from northwest, north, southeast, and southwest are the most dominant and prevailing winds. Winds are highly influenced by local topography. Pearse Island is sheltered by a range of high mountains to the south-southeast as well as to the west. The surrounding mountains influence the wind direction and speeds, with winds occurring more frequently in the direction of open canals and channels.

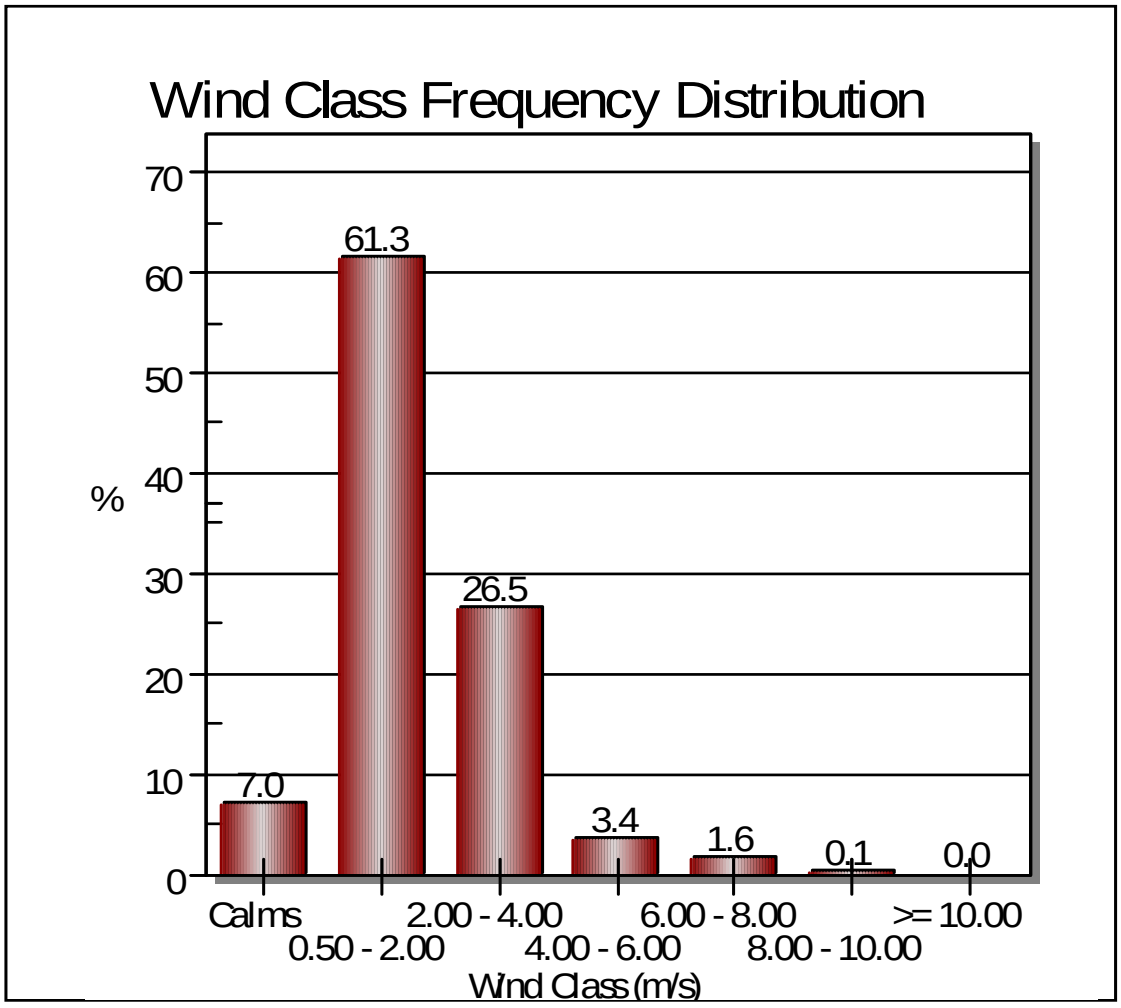


Figure 3.3–1 On-Site Station Wind Speed Frequency Distribution (September 1, 2021 to August 31, 2022)

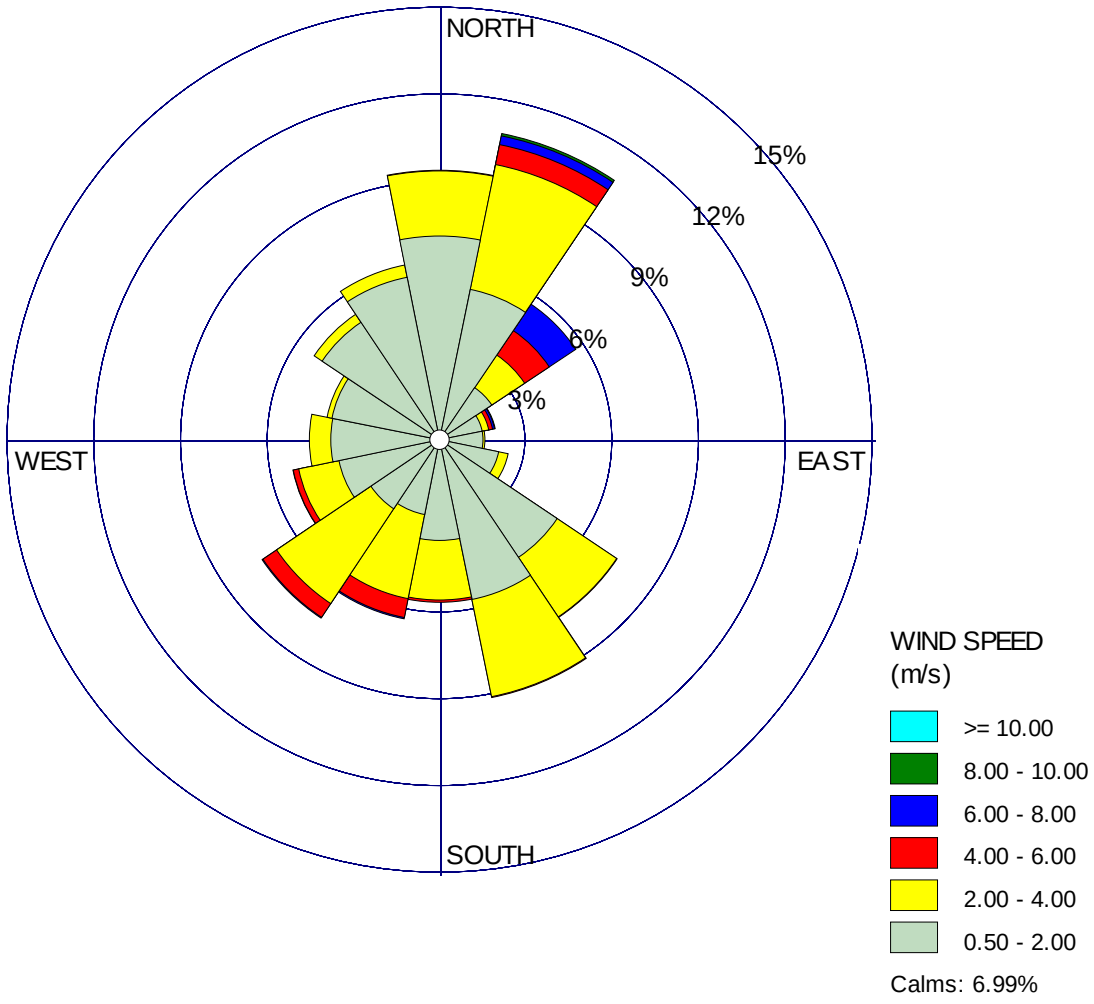


Figure 3.3–2 On-Site Station Windrose (September 1, 2021 to August 31, 2022)

3.3.2 Baseline Air Quality

It is useful in this type of study to know the model predicted incremental air quality contribution of the Project source or sources. It is also important to understand the cumulative effects on air quality. This is especially important when comparing model predictions to ambient objectives. The cumulative air quality is calculated by accounting for the contribution from all sources except the source or sources being modelled and adding that to the predicted increment from the Project. That contribution is termed "baseline" in BC.

The Guideline (BC ENV 2022a: Section 8.1) states that baseline may be determined from air quality monitoring data or may be estimated from modelling other contributing sources or a combination of both. Choosing the appropriate baseline concentration can be critical in assessing overall air quality effects. In order of priority, the information sources used to establish the baseline concentration level are:

- A network of long-term ambient monitoring stations near the source under study
- Long-term ambient monitoring at a different location that is adequately representative
- Modelled baseline

In this work, baseline air quality is determined by monitoring data at a different location that is adequately representative. A detailed description of how baseline air quality was determined is provided in Appendix A.

Within the assessment areas there are limited continuous emission sources. Influences on air quality may include occasional marine traffic and emissions that are transported into the assessment areas from other regions. Natural background sources are also considered, including wildfires and volcano activity. Steady wind flows from the Coastal mountains and from the Pacific Ocean predominantly bring clean air to the assessment areas. Overall, the existing air quality in the assessment areas is pristine.

Measured concentrations for NO_2, SO_2, $PM_{2.5}$, and CO were reviewed for several existing continuous monitoring stations in BC that were deemed representative of the assessment areas by considering similarities in emission sources (i.e., industrial, transportation, home heating), terrain influence, and meteorology. The monitoring stations reviewed included Prince Rupert Fairview, Kitamaat Village, Kitimat Whitesail, Kitimat Riverlodge, Smithers St. Josephs, and Quesnel Senior Secondary. The north coast passive monitoring results collected as part of the LNG Canada Project (LNGC Canada 2014a, 2014b) were also considered. A summary of monitoring station locations and pollutants reviewed are provided in Appendix A.

For NO_2 and SO_2, baseline was developed from the average of the LNG Canada passive monitoring using results from the remote coastal locations, as these are most representative of the Project area. These coastal locations have similar baseline air quality as the Project assessment areas as each location had limited influence from major emission sources (i.e., industry, community), and some influence from intermittent and mobile marine vessels emissions.

Section 8.1.4 of the Guideline (BC ENV 2022a) recommends developing baseline values using high percentile values which characterize baseline as a large increment of measured values (i.e., the 98th percentile for other air pollutants hourly and daily averages, and the mean values for annual averages). These values represent the greatest effects of all local industrial sources, natural background concentrations (globally and regionally), plus minor sources (local home heating, vehicle emissions, food preparation, and road dust).

Existing sources of $PM_{2.5}$ in the assessment areas are intermittent and include fugitive dust from mechanical disturbance or wind erosion, vehicles and marine traffic, and from wood burning (i.e., home heating, controlled outdoor burning, wildfires). These activities and sources of $PM_{2.5}$ are similar to that experienced in the similar sized Kitamaat Village. On this basis, the 98th percentile of the 24-hour average, and annual average, equivalent to the BC AQO statistic, measured $PM_{2.5}$ concentration at Kitamaat Village is used (Table 3.3–1). Further description of the determination of baseline concentration is provided in Appendix A.

The main emission source of CO is from fuel combustion (i.e., gasoline, natural gas, diesel, wood). Sources of CO in the Project assessment areas include intermittent marine vessels, on-road transportation, residential heating, and outdoor burning. Measurements at Smithers St. Joseph and Quesnel Senior Secondary School are influenced by higher occurrences of activities that produce CO as a result of the larger population in those towns (i.e., transportation, residential heating, industrial sources). The 98th percentile measured at St. Josephs is used for the Project's 1-hour and 8-hour baseline value (Table 3.3–1). Further description of the determination of baseline concentration is provided in Appendix A.

Baseline VOC and PAHs are considered negligible due to the limited influence from existing emission sources and the current pristine air quality conditions in the assessment areas. Biogenic VOCs are emitted from BC forests; however, these specific species of VOCs do not have an adverse effect on human health, some studies show forest biogenic VOCs have a positive effect on health (Antonelli, et al., 2020). The PAHs of concern are primarily released because of combustion of coal, gasoline, oil, wood, garbage, and tobacco (Centers for Disease Control and Prevention 2022), which is limited in the assessment areas.

Further description of the determination of baseline concentration is provided in Appendix A. Baseline concentrations for this air quality assessment are provided in Table 3.3–1.

Table 3.3–1 Summary of Baseline Concentrations

Air Pollutant	Averaging Period	Baseline Concentration ($\mu g/m^3$)
NO_2	1-hour	2.6
	Annual	
SO_2	1-hour	0.8
	Annual	
$PM_{2.5}$	24-hour	8.5
	Annual	3.5
CO	1-hour	882
	8-hour	750

NOTES:

For NO_2 and SO_2, baseline concentrations were determined from the north coast passive monitoring conducted for the LNG Canada Project (LNG Canada 2014b).

For $PM_{2.5}$ and CO, baseline air quality data were developed by Stantec from BC ENV 1998-2021 summary spreadsheets (BC ENV 2022b). Conversions from ppb to $\mu g/m^3$ assume Standard conditions of 20°C and 101.325 kPa.

NO_2:

The 1-hour and annual baseline NO_2 concentration was determined based on the average of the monthly average concentrations for remote coastal passive monitoring locations. Monitoring occurred for 2013 and 2014.

SO_2:

The 1-hour and annual baseline SO_2 concentration was determined based on the average of the monthly average concentrations for remote coastal passive monitoring locations. Monitoring occurred for 2013 and 2014.

$PM_{2.5}$:

The 24-hour $PM_{2.5}$ baseline was determined based on an average of the 98th percentile of the 24-hour averages for 2019, 2020, and 2021.

The annual $PM_{2.5}$ baseline was determined based on the average of the annual average for 2019, 2020, and 2021.

Baseline $PM_{2.5}$ was determined using the three most recent years of data from the most representative station: Kitamaat Village (BAM1020).

CO:

The 1-hour CO baseline was determined based on the average of the 98th percentile of 1-hour averages. The 8-hour baseline was determined based on the average of the 98th percentile of the daily averages. Baseline was determined using the two most recent years (2010-2011) of data from the nearest representative station: Smithers St. Joseph School.

3.4 INFORMATION SHARED BY THE NISGA'A NATION

Information and concerns relevant to Air Quality identified through engagement and consultation for the Project, and how concerns were considered in the assessment of Air Quality, are described in the VC Section of the Application (Section 7.02.2).

3.5 INDIGENOUS KNOWLEDGE AND INDIGENOUS USE

Metlakatla First Nation raised key issues and concerns regarding air quality effects, and Lax Kw'alaams raised key issues and concerns regarding air quality effects associated with marine shipping. The assessment area for the operation shipping route was expanded slightly on the east side of the route in order to include Metlakatla Village and Lax Kw'alaams Village.

3.6 EMISSION INVENTORY OVERVIEW

Project construction emissions are inventoried and compared to a similar project in a similar setting, the LNG Canada Project. Project emission sources include off-road and on-road vehicles and equipment, land clearing, and marine vessels. Similarly, construction of the transmission line are inventoried and compared to Project construction emissions.

Eight dispersion modelling scenarios are undertaken to examine the air quality implications of the Project operation. The modelling scenarios consider the Project operation both with the Project connected to the BC Hydro grid and with on-Site power generation. The modelling scenarios are called the Project-alone Case (BC Hydro Option), Project-alone Case (On-Site Power Generation), Application Case (BC Hydro Option), Application Case (On-Site Power Generation), Cumulative Case (On-Site Power), Cumulative Case (BC Hydro Option), and two non-routine flaring cases.

The continuous emission sources located on each FLNG include a 17 megawatt heat medium heater, thermal oxidizer, and a flare stack with continuous pilot and purge for each Warm Flare, Cold Flare, and Low Pressure Cold Flare. The power generation emission sources consist of natural gas-fired 54.6 megawatt (**MW**) natural gas turbine driven power generators. Detailed stack and emission parameters for the Project emission sources are provided in Appendix A.

A further five model scenarios are conducted to assess the effects on air quality as a result of operation shipping along the shipping route and in the OWAA. Emission sources include the LNG carrier and one escort tugboat. The evaluation of the operation shipping route includes three cases: Operation Shipping Route Case (Project-alone), Operation Shipping Route Case (Application), and Operation Shipping Route Case (Cumulative). The evaluation of the Open Water Assessment includes two cases: Open Water Assessment Case (Project-alone) and Open Water Assessment Case (Application). For all of these air dispersion model scenarios the Application Case involves the summation of the Project-alone and the baseline concentrations. The detailed stack and emission parameters for the Project shipping emission sources are provided in Appendix A.

The following list is a summary of the emission scenarios considered in the air quality assessment.

Project Construction: Includes emissions from construction of the Project.

Transmission Line Assessment Area: Includes emissions from construction of the transmission line. There are no emissions from the operation of the transmission line; therefore, it is not assessed further.

Project-alone Case (BC Hydro Option): Includes the Project emission sources, after connection to the BC Hydro grid, in isolation.

Project-alone Case (On-Site Power Generation): Includes the Project emission sources, including on-Site power generation sources, in isolation.

Application Case (BC Hydro Option): Includes the Project-alone Case (BC Hydro Option) with baseline added.

Application Case (On-Site Power Generation): Includes the Project-alone Case (On-Site Power Generation) with baseline added.

Cumulative Case (BC Hydro Option): Includes the Application Case (BC Hydro Option) and emissions from the Westcoast Connector Gas Transmission Project (2014), specifically the K5 Nasoga compressor station.

Cumulative Case (On-Site Power Generation): Includes the Application Case (On-Site Power Generation) and emissions from the Westcoast Connector Gas Transmission Project (2014), specifically the K5 Nasoga compressor station (located approximately 18 km southeast of the Site).

Worst Case Flaring Events Cases: Two scenarios considering credible worst-case flaring events are modelled in isolation.

Operation Shipping Route Case (Project-alone): Includes the Project emission sources for the operation shipping route, a worst-case scenario of two LNG carrier with one tug each, in isolation.

Operation Shipping Route Case (Application): Includes the Project emission sources for the operation shipping route, a worst-case scenario of two LNG carrier with one tug each, with baseline added.

Operation Shipping Route Case (Cumulative): Includes the Operation Shipping Route (Application Case) and emissions from the Westcoast Connector Gas Transmission Project (2014), specifically the K5 Nasoga compressor station.

Open Water Assessment Case (Project-alone): Includes the Project emission sources for the OWAA, a worst-case scenario of two LNG carrier, in isolation.

Open Water Assessment Case (Application): Includes the Project emission sources for the OWAA, a worst-case scenario of two LNG carrier, with baseline added.

3.6.1 Construction

Construction activities for the Project include Site preparation and infrastructure installation. Site preparation includes land clearing, handling of soil materials, grading, and possibly drilling and blasting. These activities will release emissions of air pollutants including NO_X, SO_2, $PM_{2.5}$ (including diesel $PM_{2.5}$), PM_{10}, TSP, CO, VOCs, and PAHs from equipment fuel combustion and fugitive dust. Land clearing emissions include emissions from burning of vegetation debris. This activity is one of the first to occur and is carried out during initial Site preparation, prior to many of the other construction activities . Debris burning will be carried out following the requirements of the BC Open Burning Smoke Control Regulation (Province of BC, 2023). The Site is located in a low smoke sensitivity area. Therefore, per the regulation requirements, burning will not exceed six consecutive days and will occur when the ventilation index is good or fair. Smoke will be monitored for potential impacts to nearby receptors. Emissions from land clearing are summarized in Table 3.6–1. As debris burning emissions will be short-term, intermittent, and occur separately from the other construction activities, they are not added to the total concentration emissions.

Once the Site is prepared the installation of terrestrial infrastructure occurs including the construction of offices, maintenance buildings, utilities including power supply, water supply, waste collection and treatment, fire protection, and workforce accommodation. Marine construction activities include preparation of the marine terminals for connection to the FLNGs and power barges. Marine vessels will deliver personnel, and construction equipment and materials to Site. These installation activities will release emissions of air pollutants including NO_X, SO_2, $PM_{2.5}$ (including diesel $PM_{2.5}$), PM_{10}, TSP, CO, VOCs, and PAHs from equipment fuel combustion. Fugitive dust emissions are expected to be limited during this stage.

Although the Proponents have not selected a floatel operator or type, it is expected that there will be two floatels on-Site during construction. For the purposes of estimating emissions, it is assumed that a 200-person floatel (small floatel) will be on-Site for the full duration of construction (i.e., 4-years). A second 600-person floatel (large floatel) will be on-Site during the peak construction timeframe (i.e., 2.5-years). Peak annual emissions from the floatel occur when both the small and large floatels are on-Site concurrently. The small and large floatels have an estimated power generation capacity of approximately 2 MW and 5 MW, respectively. The generators are expected to operate at about 50% of maximum generating capacity and operate on marine diesel oil. Emissions from these units are expected to include NO_X, SO_2, $PM_{2.5}$ (including diesel $PM_{2.5}$), CO, VOCs, and PAHs. Emissions associated with operation of the floatel diesel generators are summarized in the Table 3.6–1

The duration of construction is approximately four years, with the peak activity occurring in the second year. Construction will occur during daytime hours (i.e., 7am to 7pm). Mobile equipment emission calculations assumes equipment is in the Tier IV emissions category. Emissions for construction of the Project are presented in Table 3.6–1. Emissions are presented for the entire construction period and for the maximum construction year (i.e., year two).

Table 3.6–1 Project Construction Emissions

Construction	NO_X	SO_2	Fugitive PM_{10}	Fugitive $PM_{2.5}$	Diesel PM_{10}	Diesel $PM_{2.5}$	TSP	CO	VOC	PAH
	Tonnes									
Land Clearing Emissions	8.5	5.1	40	14	N/A	N/A	N/A	360	6.8	0.06
Total Construction Emissions										
Total Project Construction Emissions [b]	47	0.22	370	39	2.3	1.6	1,385	29.9	2.5	0.03
Marine Transportation Emissions for Construction	16	0.17	N/A	N/A	0.8	0.8	0.8	2.9	2.3	0.08
Maximum Annual Emissions										
Maximum Annual Project Construction Emissions [c]	25	0.2	166	18	1.6	0.9	622	28	1.2	0.01
Floatel Emissions										
Peak Annual Floatel Emissions During Constructions [d, e, f]	80	13	5.8	N/A	N/A	5.3	34	34	13	0.44

NOTES:

N/A denotes not applicable

[a] Land clearing emissions, including burning of debris, will occur prior to construction and will be carried out following the requirements of the BC Open Burning Smoke Control Regulation (Province of BC, 2023). Burning will occur for up to six consecutive days when the ventilation index is good or fair. Smoke will be monitored for potential impacts to nearby receptors. As debris burning emissions occur separately from the other construction activities, they are not added to the total concentration emissions.

[b] Total Project construction emissions over 4-year period. Land clearing and peak annual floatel emissions are not included in the maximum annual construction emissions.

[c] Maximum annual Project construction emissions is assumed to occur in the second year of construction when most equipment is on-Site. Land clearing and peak annual floatel emissions are not included in the maximum annual construction emissions.

[d] Assume small floatel is onSite for 4 years, large floatel is onSite during time of peak construction activities and number or workers

[e] For small floatel assumed power generators requirement is 2 MW (50%) load factor using marine diesel fuel.

[f] For large floatel assumed power generation requirement is 5 MW (50%) load factor using marine diesel fuel.

NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; PM_{10} = inhalable particulate matter; $PM_{2.5}$ = respirable particulate matter; TSP = total suspended particulate, CO = carbon monoxide; VOC = volatile organic compound (VOC); PAH = polycyclic aromatic hydrocarbons

3.6.2 Transmission Line Assessment Area

Emissions from construction of the 28.1 km transmission line are considered in the assessment of potential effects due to Project air emissions. Construction activities include site preparation and infrastructure installation. These activities will release emissions of air pollutants including NO_2, SO_2, $PM_{2.5}$ (including diesel $PM_{2.5}$), PM_{10}, TSP, CO, VOCs, and PAHs, from equipment fuel combustion and fugitive dust. An equipment inventory was used from Cedar LNG (2022b) which included the construction of an 8 km transmission line. The emissions from the construction of the Cedar LNG (2022b) transmission line were scaled to a length of 28.1 km, which represents the current longest potential transmission line option within the TLAA. Total construction emissions for the transmission line are provided in Table 3.6–2 and compared to construction of the Project. It is noted that VOC emissions are higher for construction of the transmission line compared to the Project. This is a result of the use of helicopters for the construction of the transmission line. There are no emissions from the operation of the transmission line; therefore, it is not assessed further.

Table 3.6–2 Total Construction Emissions for the Transmission Line

Construction	NO_X	SO_2	Fugitive PM_{10}	Fugitive $PM_{2.5}$	Diesel PM_{10}	Diesel $PM_{2.5}$	TSP	CO	VOC	PAH
	Tonnes									
Total Transmission Line Construction Emissions [a]	1.9	0.01	37	3.7	0.11	0.11	128	1.0	3.0	0.009
Percent Comparison to Total Project Construction [b]	4%	2%	10%	9%	5%	7%	10%	3%	118%	35%

NOTES:

[a] Transmission line construction emissions are scaled from construction equipment inventory for 8 km transmission line for the Cedar LNG Project (2022b)

[b] Total Project construction is presented in Table 3.6–1

NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; PM_{10} = inhalable particulate matter; $PM_{2.5}$ = respirable particulate matter; TSP = total suspended particulate, CO = carbon monoxide; VOC = volatile organic compound; PAH = polyaromatic hydrocarbons

3.6.3 Project-Alone Case (BC Hydro Option) Emissions

The sources making up the Project-alone Case (BC Hydro Option) include the Project equipment, after connection to the BC Hydro grid, operating at hourly, daily, and annual emission rates consistent with full equipment capacity. Table 3.6–3 summarizes the Project-alone Case (BC Hydro Option) annual emission rates.

PM_{10} from marine diesel exhaust is mostly (> 90%) of the $PM_{2.5}$ fraction which has the most potential for human health effects, therefore, only $PM_{2.5}$ is inventoried (US EPA 2022). Emissions of TSP include the particle sizes that are less than 30 microns, in the case of natural gas and diesel combustion most particulate matter is $PM_{2.5}$, therefore TSP is not inventoried (US EPA 2022).

Table 3.6–3 Project-alone Case (BC Hydro Option) Emissions Summary

Project [a]	Emissions (tonnes/year) [b]					
	NO_X	**SO_2**	**$PM_{2.5}$**	**CO**	**VOC**	**PAH**
Heat Medium Heater (2)	22	0.15	0.86	65	3.1	3.72E-04
Thermal Oxidizers (2)	68	150	0.21	27	0.79	8.99E-05
Flares (5)	0.30	0.0011	0.02	1.4	2.9	2.84E-06
Marine Sources (4)	23	1.3	0.55 [c]	26	0.84	0.003
Project-alone Case (BC Hydro Option)	**113**	**151**	**1.6**	**119**	**7.6**	**0.004**

NOTES:

[a] Number presented in brackets indicate the number of operating units for each emissions source type.

[b] For annual emissions a plant availability factor of 0.94 was applied for all sources except for marine sources, which are intermittent sources.

[c] $PM_{2.5}$ emissions from diesel exhaust from harbour tugboats assisting the LNG carrier into the berth. This activity occurs for 3-hours every 3 to 4 days when a LNG carrier arrives at Site. During maneuvering and while at berth the LNG carrier will operate on boil-off gas (LNG gas vapours).

NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter (including diesel $PM_{2.5}$); CO = carbon monoxide; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbons

Units designated as backup, emergency, or on standby will be depicted in the modelling exercise as not operating for all scenarios. These include diesel firewater pumps, and backup diesel-fired electrical generators which are for backup emergency purposes. The use of these equipment is infrequent and short-term and are not carried forward in the air dispersion modelling.

3.6.4 Project-Alone Case (On-Site Power Generation) Emissions

The sources making up the Project-alone Case (On-Site Power Generation) include the Project equipment, including on-Site power generation sources, operating at hourly, daily, and annual emission rates consistent with full equipment capacity. Table 3.6–4 summarizes the Project-alone Case (On-Site Power Generation) annual emission rates.

Table 3.6–4 Project-alone Case (On-Site Power Generation) Emissions Summary

Project [a]	Emissions (tonnes/year) [b]					
	NO_X	SO_2	$PM_{2.5}$	CO	VOC	PAH
Heat Medium Heater (2)	22	0.15	0.86	65	3.1	3.72E-04
Thermal Oxidizers (2)	68	150	0.21	27	0.79	8.99E-05
Power Generators (8)	1,032	16	84	175	40	0.03
Flares (5)	0.30	0.0011	0.02	1.4	2.9	2.84E-06
Marine Sources (4)	23	1.3	0.55 [c]	26	0.84	0.003
Project-alone Case (On-Site Power Generation)	**1,145**	**167**	**86**	**294**	**48**	**0.04**

NOTES:

[a] Number presented in brackets indicate the number of operating units for each emissions source type.

[b] For annual emissions a plant availability factor of 0.94 was applied for all sources except for marine sources which are intermittent sources.

[c] $PM_{2.5}$ emissions from diesel exhaust from harbour tugboats assisting the LNG carrier into the berth. This activity occurs for 3-hours every 3 to 4 days when a LNG carrier arrives at Site. During maneuvering and while at berth the LNG carrier will operate on boil-off gas (LNG gas vapours).

NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbons

Units designated as backup, emergency, or on standby will be depicted in the modelling exercise as not operating for all scenarios. These include diesel firewater pumps, and backup diesel-fired electrical generators which are for backup emergency purposes. The use of these equipment is infrequent and short-term and are not carried forward in the air dispersion modelling.

3.6.5 Application Case (BC Hydro Option) Emissions

The sources that make up the Application Case (BC Hydro Option) include the Project equipment, after connection to the BC Hydro grid (Table 3.6–3), plus added baseline concentrations (Table 3.3–1) (Project-alone Case [BC Hydro Option] + baseline).

3.6.6 Application Case (On-Site Power Generation) Emissions

The sources that make up the Application Case (On-Site Power Generation) include the Project equipment, including on-Site power generation sources (Table 3.6–4), plus added baseline concentrations (Table 3.3–1) (Project-alone Case [On-Site Power Generation] + baseline).

3.6.7 Cumulative Case (BC Hydro Option) Emissions

The sources that make up the Cumulative Case (BC Hydro Option) include the Project equipment, after connection to the BC Hydro grid (Table 3.6–3), plus added baseline concentrations (Table 3.3–1) and emissions from the Westcoast Connector Gas Transmission Project (2014), specifically the K5 Nasoga

compressor station. Table 3.6–5 summarizes the Cumulative Case (BC Hydro Option) annual emission rates. Besides the K5 Nasoga compressor station, there are no other past or present projects within the air quality assessment area that will interact with emissions from the Project.

Table 3.6–5 Cumulative Case (BC Hydro Option) Emissions Summary

Project	Emissions (tonnes/year)					
	NO_x	SO_2	$PM_{2.5}$	CO	VOC	PAH
Project-alone Case (BC Hydro Option)	113	151	1.6	119	8.2	0.004
K5 Nasoga Compressor Station [a]	756	27	62	685	851	0.064
Total	**872**	**179**	**64**	**807**	**859**	**0.068**

NOTES:

[a] Source: Westcoast Connector Gas Transmission Ltd. (2014)

NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbons

3.6.8 Cumulative Case (On-Site Power Generation) Emissions

The sources that make up the Cumulative Case (On-Site Power Generation) include the Project equipment, including on-Site power generation sources (Table 3.6–4), plus added baseline concentrations (Table 3.3–1) and emissions from the Westcoast Connector Gas Transmission Project (2014), specifically the K5 Nasoga compressor station. Table 3.6–6 summarizes the Cumulative Case (On-Site Power Generation) annual emission rates. Besides the K5 Nasoga compressor station, there are no other past or present projects within the air quality LAA/RAA that will interact with emissions from the Project.

Table 3.6–6 Cumulative Case (On-Site Power Generation) Emissions Summary

Project	Emissions (tonnes/year)					
	NO_x	SO_2	$PM_{2.5}$	CO	VOC	PAH
Project-alone Case (On-Site Power Generation)	1,148	168	86	297	48	0.04
K5 Nasoga Compressor Station[a]	756	27	62	685	851	0.064
Total	**1,904**	**195**	**148**	**982**	**899**	**0.103**

NOTES:

[a] Source: Westcoast Connector Gas Transmission Ltd. (2014)

NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbons

3.6.9 Worst-Case Flaring Events Case

The worst-case flaring events include two cases. Case 1 evaluates an emergency blowdown of both FLNGs through the warm and cold flares simultaneously; this represents the event with the largest volume of sweet natural gas to evaluate the NO_X and $PM_{2.5}$ emissions. During an emergency blowdown, only the flares are in operation. Emissions for this emergency blowdown event are provided in Table 3.6–7. Case 2 evaluates a high sulphur (**S**) flare event which could occur if one of the thermal oxidizer shuts down unintentionally. Emissions for the thermal oxidizer trip flare event are provided in Table 3.6–8. Gas compositions for the flaring events are provided in Table 3.6–9 and Table 3.6–10.

Flaring of natural gas and acid gas produces particles mostly of the $PM_{2.5}$ size fraction, therefore PM_{10} and TSP are not inventoried (US EPA 1998).

Table 3.6–7 Emergency Blowdown Flare Event Emissions

Project	Emissions (g/s)					
	NO_X	**SO_2 [b]**	**$PM_{2.5}$**	**CO**	**VOC**	**PAH**
Warm Flare [a]	19	0.19	0.8	87	184	0.0002
Cold Flare [a]	86	0.000008	78	391	831	0.0008
Emergency Blowdown Flare Case	**105**	**0.2**	**79**	**477**	**1,015**	**0.001**

NOTES:
Emissions are based on 0.5 hour duration.
[a] Estimated frequency for both warm flare and cold flare is once per annum, duration 0.5 hour for each flare.
[b] SO_2 emission estimations were based on the gas flow rate and gas composition including S content (1.7 ppm_V) provided by the Project.
NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbons

Table 3.6–8 Thermal Oxidizer Trip Flare Event Emissions

Project	Emissions (g/s)					
	NO_X	**SO_2**	**$PM_{2.5}$**	**CO**	**VOC**	**PAH**
Warm Flare (Thermal Oxidizer trip)[a]	0.01	1.45 [b]	0.05	0.06	0.119	1.16E-07
One Thermal Oxidizer Normal Operation	1.15	2.52	0.003	0.45	0.013	1.52E-06
Heat Medium Heater (2)	0.7	0.005	0.03	2.2	0.0525	1.25E-05
Power Generators (8)	35	0.54	2.8	5.9	1.36	0.001
Flares (5)	0.01	0.00004	0.0005	0.05	0.1	9.57E-08
Marine Sources (4) [c]	0.7	0.04	0.017 [d]	0.81	0.03	0.0001

Table 3.6–8 Thermal Oxidizer Trip Flare Event Emissions

Project	Emissions (g/s)					
	NO_X	SO_2	$PM_{2.5}$	CO	VOC	PAH
Project-alone Case (On-Site Power Generation)	**38**	**4.6**	**2.9**	**9.6**	**1.8**	**0.001**

NOTES:

[a] Estimated frequency for Thermal Oxidizer trip is once per annum, duration 350 hours.

[b] SO_2 emission estimation is based on the gas flow rate and gas composition including S content provided by the Project.

[c] Annual average emission rates.

[d] $PM_{2.5}$ emissions from diesel exhaust from harbour tugboats assisting the LNG carrier into the berth. This activity occurs for 3-hours every 3 to 4 days when a LNG carrier arrives at Site. During maneuvering and while at berth the LNG carrier will operate on boil-off gas (LNG gas vapours).

NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbons

1

Table 3.6–9 Natural Gas Composition for Emergency Blowdown Flare Event

Gas Composition	Mole Fraction	
	Warm Flare	Cold Flare
Hydrogen (H_2)	0.0000	0.0000
Helium (He)	0.0000	0.0000
Nitrogen (N_2)	0.0050	0.0500
Carbon Dioxide (CO_2)	0.0000	0.0000
Oxygen (O_2)	0.0000	0.0000
Hydrogen Sulphide (H_2S)	0.0000	0.0000
Methane (CH_4)	0.9000	0.2500
Ethane (C_2H_6)	0.0750	0.0000
Propane (C_3H_8)	0.0200	0.2500
Isobutane (i-C_4H_{10})	0.0000	0.0000
Butane (n-C_4H_{10})	0.0000	0.0000
Isopentane (i-C_5H_{12})	0.0000	0.2000
Pentane (n-C_5H_{12})	0.0000	0.0000
C6+	0.0000	0.0000
C7+	0.0000	0.0000
Water (H_2O)	0.0000	0.0000
Carbon Monoxide (CO)	0.0000	0.0000
Ammonia (NH_3)	0.0000	0.0000
Ethylene (C_2H_4)	0.0000	0.2500
Benzene (C_6H_6)	0.0000	0.0000

Table 3.6–9 Natural Gas Composition for Emergency Blowdown Flare Event

Gas Composition	Mole Fraction	
	Warm Flare	Cold Flare
Total	1.0000	1.0000
Lower Heating Value (LHV) (MJ/m^3)	36.8	72.0
Higher Heating Value (HHV) (MJ/m^3)	40.8	78.0

1 **Table 3.6–10 Natural Gas Composition for Thermal Oxidizer Trip Flare Event**

Gas Composition	Mole Fraction
	Warm Flare
Hydrogen (H_2)	0.0000
Helium (He)	0.0000
Nitrogen (N_2)	0.0000
Carbon Dioxide (CO_2)	0.9563
Oxygen (O_2)	0.0000
Hydrogen Sulphide (H_2S)	0.0006
Methane (CH_4)	0.0083
Ethane (C_2H_6)	0.0014
Propane (C_3H_8)	0.0003
Isobutane (i-C_4H_{10})	0.0000
Butane (n-C_4H_{10})	0.0000
Isopentane (i-C_5H_{12})	0.0000
Pentane (n-C_5H_{12})	0.0000
C6+	0.0000
C7+	0.0000
Water (H_2O)	0.0329
Carbon Monoxide (CO)	0.0000
Ammonia (NH_3)	0.0000
Ethylene (C_2H_4)	0.0000
Benzene (C_6H_6)	0.0001
Total	1.0000
Lower Heating Value (LHV) (MJ/m^3)	0.42
Higher Heating Value (HHV) (MJ/m^3)	0.47

3.6.10 Operation Shipping Route Case (Project-alone)

The sources making up the Operation Shipping Route Case (Project-alone) include Project emission sources for the operation shipping route. Most of the time LNG carriers are not in the vicinity of each other (1 km or greater), but for a short period of time an LNG carrier may pass another along the route. A worst-case scenario representing two LNG carriers passing each other is considered for the Operation Shipping Route (Project-alone) case. This worst-case scenario emission sources include two LNG carriers with one tug each. Marine vessel engine information, load factors, stack parameters, emission rates, and assumptions are provided in Appendix A. Table 3.6–11 summarizes the Operation Shipping Route Case (Project-alone) annual emission rates.

Table 3.6–11 Operation Shipping Route Case (Project-alone) Emissions Summary

Project	Emissions (tonnes/year)					
	NO_X	SO_2	$PM_{2.5}$	CO	VOC	PAH
LNG Carrier (2)	76.0	6.9	2.3	17.8	9.0	0.30
Escort Tug (2)	8.4	1.3	0.6	3.5	1.7	0.06
Operation Shipping Route Case (Project-alone)	**84.3**	**8.2**	**2.8**	**21.3**	**10.7**	**0.36**

NOTES:
NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbons

3.6.11 Operation Shipping Route Case (Application)

The sources that make up the Operation Shipping Route Case (Application) include Project emission sources for the operation shipping route (Table 3.6–11), plus added baseline concentrations (Table 3.3–1) (Operation Shipping Route Case [Project-alone] + baseline).

3.6.12 Operation Shipping Route Case (Cumulative)

The sources that make up the Operation Shipping Route Case (Cumulative) include Project emission sources for the operation shipping route (Table 3.6–12), plus added baseline concentrations (Table 3.3–1) and emissions from the Westcoast Connector Gas Transmission Project (2014), specifically the K5 Nasoga compressor station. Table 3.6–12 summarizes the Operation Shipping Route Case (Cumulative) annual emission rates.

Table 3.6–12 Operation Shipping Route Case (Cumulative) Emissions Summary

Project	Emissions (tonnes/year)					
	NO_X	SO_2	$PM_{2.5}$	CO	VOC	PAH
Operation Shipping Route Case (Project-alone)	82	7.9	2.8	21	11	0.36
K5 Nasoga Compressor Station [a]	756	27	62	685	851	0.064
Operation Shipping Route Case (Cumulative)	**838**	**35**	**65**	**706**	**862**	**0.068**

NOTES:

[a] Source: Westcoast Connector Gas Transmission Ltd. (2014)

NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbons

3.6.13 Open Water Assessment Case (Project-alone)

The sources making up the Open Water Assessment Case (Project-alone) include Project emission sources for the operation shipping route, and a worst-case scenario of two LNG carriers passing each other. Marine vessel engine information, load factors, stack parameters, emission rates, and assumptions are provided in Appendix A. Table 3.6–13 summarizes the Open Water Assessment Case (Project-alone) annual emission rates.

Table 3.6–13 Open Water Assessment Case (Project-alone) Emissions Summary

Project	Emissions (tonnes/year)					
	NO_X	SO_2	$PM_{2.5}$	CO	VOC	PAH
LNG Carrier (2)	163	8.8	3.6	23	10	0.34
Open Water Assessment Case (Project-alone)	**163**	**8.8**	**3.6**	**23**	**10**	**0.34**

NOTES:

NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide; VOC = volatile organic compound; PAH = polycyclic aromatic hydrocarbons

3.6.14 Open Water Assessment Case (Application)

The sources that make up the Open Water Assessment Case (Application) include Project emission sources for the Open Water Assessment (Table 3.6–13), plus added baseline concentrations (Table 3.3–1) (Open Water Assessment Case [Project-alone] + baseline).

3.7 DISPERSION MODELLING METHODOLOGY

Effects of Project operation and associated shipping emissions on ambient air quality were assessed using air dispersion modelling. Air dispersion models provide a scientific link between the emission sources and downwind concentration profiles associated with the sources. Air dispersion models incorporate meteorological conditions to account for the transport and dilution of the plume in the atmosphere and incorporate terrain influences. The air dispersion modelling was conducted in accordance with the Guideline (BC ENV 2022a) and Dispersion Modelling Plan (Appendix A).

3.7.1 Dispersion Model Selection

Following the Guideline (BC ENV 2022a) a Level 3-type assessment was conducted. The CALPUFF modelling system (Scire et al. 2000) used included the following components:

- CALMET v6.5.0 for the meteorological model
- CALPUFF v7.2.1 for the dispersion model
- CALPOST v7.0.0 for the post processing

The CALPUFF modelling was conducted for a five-year interval dictated by the availability of prognostic meteorological data for the years 2011–2015.

3.7.2 Meteorology

For this assessment, the CALMET model was run using WRF (BC ENV 2014) data for the period of January 1,2011 to December 31, 2015. There are no upper air stations or surface stations within or nearby the CALMET domain within the WRF dataset; see Section C.5, Appendix B for details. On-Site meteorological data collected at the Site was not use in the assessment, due to siting terrain influences and limited data, as discussed in Section 3.3.1.2.

The Prince Rupert Airport station, located approximately 85 km to the southwest of the Project, was used to determine the representativeness of the WRF data prior to input to CALMET. Wind speed, wind direction, and temperature data at the lowest model level (10 m) were extracted from 2011–2015 WRF data and compared to the Prince Rupert Airport station meteorological station measurements. A detailed comparison is provided in Appendix B. The extracted data and the measurements are in reasonable agreement. Therefore, the WRF model predictions are reasonably representative of meteorological conditions.

Figure 3.7–1 is a wind rose for the Site derived from the 2011–2015 CALMET data set. It generally indicates surface patterns are dominated by winds from southwest, south, and northeast.

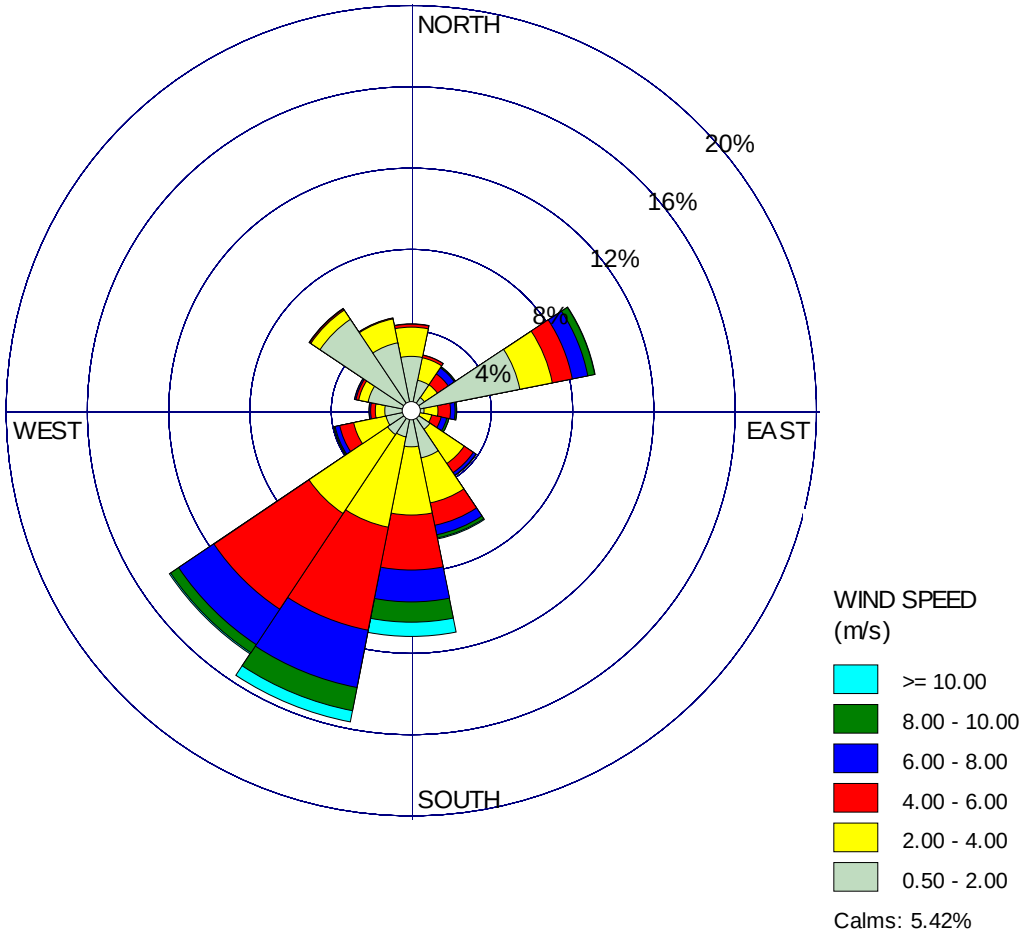


Figure 3.7–1 CALMET Predicted Windrose at the Project Site 2011-2015

3.7.3 Modelling Domain, Receptors, Land Use, and Terrain

Assessment area boundaries were established to focus the scope of the assessment and to enable a meaningful analysis of potential effects on air quality arising from the Project. The LAA/RAA for Project operation is discussed in this section. Please see Section 3.7.3.1 and Section 3.7.3.2, and Appendix A (Dispersion Model Plan) for a discussion of the assessment areas for the Operation Shipping Route and the Open Water Assessment, respectively.

It was determined that a 40 km by 40 km area centred on the Project is sufficient to determine the effect of Project emissions on ambient air quality. The assessment area boundaries enclose the concentration contours attributable to the Project that are greater than 10% of the BC AQOs in accordance with the Guideline (BC ENV 2022a).

The CALPUFF Appendix (Appendix C) details how the modelling was performed. Appendix A is the Dispersion Modelling Plan, consistent with the Guideline (BC ENV 2022a).

Predictions of ground-level air concentrations on and outside the plant boundary were produced according to the Guideline (BC ENV 2022a), using a series of nested Cartesian grids with increasing receptor density with proximity to the Site. The receptor grids and their corresponding spacing are as follows:

- 20 m receptor spacing along the plant boundary, as defined in the Guideline (BC ENV 2022a)
- 50 m spacing within 4.5 km by 3.5 km of the Project sources
- 250 m spacing within 7 km by 6 km of the Project sources
- 500 m spacing within 10 km by 10 km of the Project sources
- 1,000 m spacing within the 40 km by 40 km CALPUFF assessment area

The “plant boundary” is the term used in the Guideline (BC ENV 2022a: Section 7.3) to describe a line of receptors that demarcates public vs. worker exposures. Often the highest predicted concentrations are on or near to the Project boundary. The plant boundary for this assessment is defined as the outermost disturbed area at the Project (whether fenced or unfenced) and the marine portion. Access to these areas is expected to be restricted.

Within the plant boundary, meeting occupational health and safety criteria are of primary importance. The BC AQOs are applied to areas where there is public access on and beyond the plant boundary.

The receptor grid is comprised of 9,858 receptor locations. The extent of the receptor grid is considered sufficient to indicate the magnitude and spatial variation of the ground-level concentrations resulting from Project emissions. The maximum concentrations are resolved within a spatial resolution of 50 m since the maxima occur either on the plant boundary or within 3 km of the plant boundary.

A map of the CALPUFF domain (40 km by 40 km) and gridded receptors is provided in the Dispersion Modelling Plan (Appendix A).

For the CALPUFF model, the proposed sensitive receptors are provided in the Dispersion Modelling Plan (Appendix A: Table 4-1 and shown in Figure 4-4). These receptors were derived following Section 7.4 in the Guideline (BC ENV 2022a). The model predicted concentrations at sensitive receptors are reported in the Human Health VC Section and not in this report.

The sensitive receptors were broadly grouped as:

- 9 lakes, creeks, and rivers selected for the aquatics assessment
- 24 residential areas and Indigenous nation assumed areas used for harvesting selected for the Human Health Risk Assessment (HHRA)

Flagpole receptors are not required. There are no elevated receptors of interest nearby.

The land use in the CALPUFF modelling domain consists mostly of forest. The land use data for the geophysical model that characterizes the CALMET surface condition was taken from the North American Land Change Monitoring System (CEC 2020). Land use Classes in the CALMET Model Domain are depicted in Figure B.2 (Appendix B).

The Project occupies an area of complex terrain, with elevations ranging from 0 m to 1,652 m above sea level. The base elevation at the proposed Site is approximately 0 m above sea level (see Appendix B for details). The NASA 3-second Shuttle RADAR Topography Mission files (SRTM3) terrain data (~90 m resolution) (USGS 2022) was used to determine the terrain characteristics in the assessment area.

3.7.3.1 Operation Shipping Route

It was determined that a 5 km area centered on either side of the Operation Shipping Route, which is 101.4 km in length, is sufficient to determine the effect of Project-related operation marine shipping emissions on air quality. The assessment area is expanded to the east side of the route to include Metlakatla Village and Lax Kw'alaams Village. The assessment area boundaries enclose the concentration contours attributable to the Project that are greater than 10% of the BC AQOs in accordance with the Guideline (BC ENV 2022a).

Predictions of ground-level air concentrations on and outside the plant boundary were produced according to the Guideline (BC ENV 2022a), using a series of nested Cartesian grids with increasing receptor density with proximity to the Operation Shipping Route. The receptor grids and their corresponding spacing are as follows:

- 20 m receptor spacing along the Operation Shipping Route boundary
- 50 m spacing within 0.2 km of the Operation Shipping Route boundary
- 250 m spacing within 2.0 km of the Operation Shipping Route boundary
- 1,000 m spacing beyond 2.0 km of the Operation Shipping Route boundary
- 2,000 m spacing within the 70 km by 102 km CALPUFF study area

The plant boundary for the assessment of the Operation Shipping Route is defined as 70 m to each side along the route. This plant boundary area represents the region occupied by the LNG carriers and escort tugboats. The Operation Shipping Route grid is comprised of 35,244 receptor locations. The extent of the receptor grid is considered sufficient to indicate the magnitude and spatial variation of the ground-level concentrations resulting from Project-related operation marine shipping emissions. The maximum concentrations are resolved within a spatial resolution of 50 m since the maxima occur either on the Operation Shipping Route plant boundary or within 0.2 km of the Operation Shipping Route boundary.

3.7.3.2 Open Water Assessment

It was determined that a 5 km buffer area on either side of the OWAA, is sufficient to determine the effect of Project-related operation marine shipping emissions on ambient air quality. The assessment area boundaries enclose the concentration contours attributable to the Project that are greater than 10% of the BC AQOs in accordance with the Guideline (BC ENV 2022a).

Predictions of ground-level air concentrations on and outside the plant boundary were produced according to the Guideline (BC ENV 2022a), using a series of nested Cartesian grids with increasing receptor density with proximity to the OWAA. The receptor grids and their corresponding spacing are as follows:

- 20 m receptor spacing along the OWAA boundary
- 50 m spacing within 0.2 km of the OWAA boundary
- 250 m spacing within 2.0 km of the OWAA boundary
- 1,000 m spacing beyond 2.0 km of the OWAA boundary
- 2,000 m spacing within the 118 km by 90 km CALPUFF study area

The plant boundary for the assessment of the Open Water Assessment is defined as 50 m to each side along the route. This plant boundary area represents the region occupied by the LNG carriers. The Open Water Assessment grid is comprised of 27,713 receptor locations. The extent of the receptor grid is considered sufficient to indicate the magnitude and spatial variation of the ground-level concentrations resulting from Project-related operation marine shipping emissions in the OWAA. The maximum concentrations are resolved within a spatial resolution of 250 m since the maxima occur either on the Operation Shipping Route plant boundary or within 2.0 km of the OWAA boundary.

3.7.4 Oxides of Nitrogen to Nitrogen Dioxide Conversion

Oxides of nitrogen are comprised of nitric oxide (NO) and NO_2. Only NO_2 concentrations have a BC AQOs. Therefore, it is important to be able to estimate the portion of the predicted concentrations of oxides of nitrogen that are comprised of NO_2. For this assessment, the ambient ratio method 2 described in Section 3.2.1.2 of the Guideline (BC ENV 2022a) and Appendix A of the Guidance for NO_2 Dispersion Modelling in BC (BC ENV 2022c) was utilized. The baseline air quality in the assessment areas is considered pristine and there is no monitoring data available; on this basis, the Coastal Sites ambient ratio method 2 curve is used to convert NO to NO_2, as provided in the NO_2 Guidance (BC ENV 2022c).

3.7.5 Acidification Effects

The predicted deposition of pollutants containing S and nitrogen (**N**) will be developed by air dispersion modelling and then used by other disciplines (including human health, water quality, vegetation, and soils) to assess the potential for acidification and eutrophication.

3.7.6 Secondary Particulate Formation and Particle Deposition

The CALPUFF model was used to predict secondary $PM_{2.5}$ formation attributable to precursor SO_2 and oxides of nitrogen emissions. Particle deposition (primary particulate matter) was not modelled.

3.7.7 Stagnation

This assessment employs the CALPUFF dispersion modelling system since it can treat zero wind speeds and causality explicitly. This assessment used a numerical weather prediction model output (WRF) to better resolve complex coastal meteorology including periods with low wind speeds (calm).

3.7.8 Shore/Coastal Effects

The sub-grid-scale Thermal Internal Boundary Layer option (Shore/Coastal Effects) is not included since WRF combined with the 250 m grid CALMET model gives enough resolution of land/water meteorological conditions and the land/water boundary surrounding the Project location.

3.7.9 Plume Condensation (Fogging) and Icing

Plume condensation and freezing (fogging and icing) is not selected as an option because the combustion source plumes have buoyancy and momentum, and they are not particularly moisture laden. Condensing or freezing plumes near ground level are not expected.

3.7.10 Building Plume Downwash Effects

Buildings or other solid structures can affect the flow of air near a source and may induce building downwash effects caused by eddies on the downwind side. Downwash effects have the potential to reduce plume rise and affect dispersion.

It has been determined that there is potential for building downwash. Building downwash was modelled consistent with Section 7.6 in the Guideline (BC ENV 2022a). For sloped or peaked roofs, the building height is equivalent to halfway between the trough and the peak, consistent with Ministry direction. The emission sources, buildings, and structures that were considered in the downwash modelling are shown in the Dispersion Modelling Plan (Appendix A).

4.0 KEY RESULTS AND FINDINGS

Project construction emissions were calculated and compared to the construction emissions for the LNG Canada Project, a similar project in a similar setting. Below, the predicted concentrations from dispersion modelling for the construction of the LNG Canada Project are present in tabular form and discussed in the context of the Project.

Air dispersion modelling of the Project operation was used to predict the maximum NO_2, SO_2, $PM_{2.5}$, and CO concentrations for the Project-alone Cases, Application Cases, and Cumulative Cases. These predictions are presented in tabular form and discussed in the following sections. The predicted concentrations are presented without the addition of baseline for the Project-alone Cases, and with the addition of baseline for the Application Cases and Cumulative Cases. Isopleth figures showing predicted concentrations (by case) are presented in Appendix D. Project operation VOC and PAH emissions are not modelled but compared to Project construction and construction and operation of the LNG Canada Project.

4.1 CONSTRUCTION

A summary of Project construction emission is provided in Section 3.6 (Table 3.6–1).

Debris burning for land clearing will be one of the first construction activities undertaken on Site; land clearing emissions are summarized in Table 3.6–1. Debris burning will be carried out following the requirements of the BC Open Burning Smoke Control Regulations (Province of BC, 2023). The Project Site is located in a low smoke sensitivity area. Therefore, burning will not exceed six consecutive days and will occur when the ventilation index is good or fair, promoting good dispersion of smoke. Smoke will be monitored for potential impacts to nearby receptors. As debris burning emissions are short-term, intermittent, and occur separately from the other construction activities, they are not added to or assessed in conjunction with the total construction emissions. Effects to air quality as a result of debris burning are expected to be low.

Project construction emissions have not been assessed using dispersion modelling, however, are assessed qualitatively by comparing to emissions levels from a project with similar activities and in a similar setting. Project construction emissions are compared to construction emissions for LNG Canada Project (LNG Canada 2019) (Table 4.1–1). The LNG Canada Project construction consists of similar activities, including handling of soil materials, grading, installation of terrestrial infrastructure and a marine terminal. The LNG Canada Project is also located on the BC north coast, in Kitimat BC. Similar to the Project Site, Kitimat is located in the temperate rainforest type of ecosystem. The prevailing westerly storm track across the North Pacific, combined with orographic lift from the Coastal Mountains, produces high annual precipitation amounts throughout the region. The moderating influence of the ocean limits the seasonal temperature ranges, resulting in relatively mild winters and cool summers (Phillips 1990). Dispersion of air pollutants are influenced by local mountain-valley terrain similarly at the Project Site. The LNG Canada Project is larger as it has more than double the processing capacity (26 MTPA)

(LNG Canada 2014c) with the full build out (i.e., Phase 2) compared to the Project (12 MTPA). The LNG Canada Project footprint is also larger at 445 ha, compared to the Project footprint of 29.3 ha as the Project utilizes floating LNG facilities which reduces the on-land construction activities and construction emissions. As a result, the Project total construction emissions are 15% or less of the total construction emissions for the LNG Canada Project. The SO_2 emissions for the Project construction are the greatest at 15% of the total construction SO_2 emissions for the LNG Canada Project due to the potential need for drilling and blasting for the Project. Drilling and blasting were not required for the LNG Canada Project.

While Project construction emissions have not been assessed using dispersion modelling, they are assessed qualitatively by comparing to the LNG Canada Project. As part of the LNG Canada Project, a detailed CALPUFF dispersion modelling assessment for construction was conducted to support EAC #E15-01 Condition 19; requiring a Human Health Risk Assessment (**HHRA**) for off-duty workers staying at the Cedar Valley Lodge (**CVL**) (LNG Canada 2019). While the LNG Canada Project is larger than the Project, the types of construction activities are similar (i.e., material handling, grading, module installations), and occur in a similar setting, therefore, dispersion modelling results for Phase 1 and Phase 2 construction of the LNG Canada Project are used to evaluate potential for adverse effects from the construction phase of the Project.

Maximum predicted concentrations of construction alone (no baseline added) are provided in Table 4.1–2 (SO_2, NO_2 and $PM_{2.5}$), Table 4.1–3 (VOC), and Table 4.1–4 (PAH).

Table 4.1–1 Project Construction Emissions and Comparison to LNG Canada Project Construction Emissions

Construction	NO_X	SO_2	Fugitive PM_{10}	Fugitive $PM_{2.5}$	Diesel PM_{10}	Diesel $PM_{2.5}$	TSP	CO	VOC	PAH
	Tonnes									
Total Construction Emissions										
Total Project Construction Emissions [a]	47	0.38	370	39	2.3	1.6	1,385	33	2.5	0.03
Marine Transportation Emissions for Construction	16	0.17	N/A	N/A	0.8	0.8	0.8	2.9	2.3	0.08
Maximum Annual Emissions										
Maximum Annual Project Construction Emissions [b]	25	0.2	166	18	1.6	0.9	622	28	1.2	0.01
Comparison to LNG Canada Project Construction										
LNG Canada Phase 1 Annual Total Construction Emissions [c d]	648	2	2,310	236	39	38	8,689	488	46	0.35
LNG Canada Phase 2 Annual Total Construction Emissions [c d]	218	0.6	773	79	13	12	2,898	196	16	0.12
LNG Canada Total Construction Emissions [c d]	865	2.5	3,083	315	52	50	11,587	684	62	0.47
Percent Comparison to Total LNG Canada Construction [e]	5%	15%	12%	13%	4%	3%	12%	5%	4%	6%
Percent Comparison to Phase 2 LNG Canada Construction	21%	64%	48%	50%	18%	13%	48%	17%	16%	22%

Table 4.1–1 Project Construction Emissions and Comparison to LNG Canada Project Construction Emissions

Construction	NO_X	SO_2	Fugitive PM_{10}	Fugitive $PM_{2.5}$	Diesel PM_{10}	Diesel $PM_{2.5}$	TSP	CO	VOC	PAH
	Tonnes									

NOTES:

N/A denotes not applicable

Land clearing and peak annual floatel emissions are not included in the maximum annual construction emissions.

[a] Total Project construction emissions over 4 year period.

[b] Maximum annual Project construction emissions is assumed to occur in the second year of construction when most equipment is on-Site.

[c] Tonne per year annual construction emissions (LNG Canada 2019)

[d] PAHs in gaseous and particulate phases for the LNG Canada Project were calculated herein using total VOCs (46, 16, and 62 tonnes), diesel PM_{10} (39, 13, and 52 tonnes) and emission factors described in LNG Canada (2019;).; .

[e] Percent Comparison to Total LNG Canada Construction is determined using Total Project Construction Emissions divided by LNG Canada Total Construction emissions (e.g. for NO_X = 47 / 865 = 5%)

NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; PM_{10} = inhalable particulate matter; $PM_{2.5}$ = respirable particulate matter; TSP = total suspended particulate, CO = carbon monoxide; VOC = volatile organic compound (VOC); PAH = polycyclic aromatic hydrocarbons

1

Table 4.1–2 LNG Canada Project Construction Dispersion Modelling Results

Air Pollutant	Averaging Period [a]	Phase 1 Construction Predicted Concentration (µg/m³)		Phase 2 Construction Predicted Concentration (µg/m³)		BC AQOs (µg/m³)
		Maximum in CVL [b]	Maximum in Domain	Maximum in CVL [b]	Maximum in Domain	
SO_2	1-hour	1.13	66.2	0.34	13.7	173
	Annual	0.05	2.84	0.02	0.87	32
NO_2	1-hour	89.0	**885**	78.9	**356**	113
	Annual	10.3	**74.2**	6.42	**45.1**	23
$PM_{2.5}$	1-hour	**51.9**	**917**	**29.0**	**237**	25
	Annual	12.2	**376**	6.21	**94.9**	8

NOTES:
Bold values indicate an exceedance of the BC AQOs.
Predicted concentrations are from LNG Canada (2019a) Table 3.2–1 and Table 3.2–2.
Land clearing and peak annual floatel emissions are not included in the maximum annual construction emissions.
[a] Averaging period and achievement for each parameter are as stated in Table 3.2.1.
[b] The maximum in CVL references 100 receptors employed in the modelling to support the HHRA (LNG Canada 2019).
Baseline is not included as there are differences between in existing conditions at the LNG Canada Project location and the Project site.

The maximum predicted 99th percentile of the daily 1-hour maximum SO_2 concentration and annual average for construction of both Phase 1 and Phase 2 of the LNG Canada Project alone without baseline added are less than the BC AQOs and the 2025 CAAQS.

The maximum predicted 98th percentile of the daily 1-hour maximum NO_2 concentration and annual average for construction of Phase 1 of the LNG Canada Project alone without baseline at CVL are less than the BC AQOs; however, the 98th percentile of the daily 1-hour maximum NO_2 concentration is greater than the 2025 CAAQS. Phase 2 predicted 98th percentile of the daily 1-hour maximum NO_2 concentration and annual average are less than the BC AQO and 2025 CAAQS. Domain wide the 1-hour maximum and annual average are greater than the BC AQOs and 2025 CAAQS. Air dispersion modelling for construction of both Phase 1 and Phase 2 of the LNG Canada Project indicates that the maximum predicted NO_2 concentrations in the domain occur within the dredge area and marine terminal; away from locations where people live and gather.

The maximum predicted 98th percentile 24-hour maximum $PM_{2.5}$ concentration and annual average for construction of both Phase 1 and Phase 2 of the LNG Canada Project alone without baseline at CVL and domain wide are greater than the BC AQOs and the 2020 CAAQS. Road and fugitive dust comprise of 88% of the total $PM_{2.5}$ predicted concentration, with remaining 12% attributed to diesel $PM_{2.5}$. Dispersion modelling for construction of Phase 1 of the LNG Canada Project indicates that the maximum predicted $PM_{2.5}$ concentrations in the domain occur due to activities in the Beaver Creek realignment area and along the haul road. For Phase 2, maximum $PM_{2.5}$ concentration are attributable to the construction of Trains 3 and 4, and the marine terminal.

Table 4.1–3 LNG Canada Project Construction Predicted VOC Concentrations (Unadjusted)

VOC	Phase 1		Phase 2		Ambient Air Quality Objective and Criteria	
	1-hour Maximum Predicted Concentration (µg/m^3)	24-hour Maximum Predicted Concentration (µg/m=)	1-hour Maximum Predicted Concentration (µg/m^3)	24-hour Maximum Predicted Concentration (µg/m^3)	1-hour	24-hour
Benzene	6.23	**2.35**	6.08	**2.34**	30 [a]	2.3 [b]
Toluene	4.81	1.81	4.70	1.81	1,880 [a]	400 [a]
Ethylbenzene	1.10	0.415	1.07	0.414	2,000 [a]	1,000 [b]
Xylenes	3.35	1.26	3.27	1.26	2,300 [b]	700 [a]
Acetaldehyde	16.2	6.11	15.8	6.10	90 [a]	500 [b]
Acrolein	3.90	1.47	3.81	1.47	4.5 [a,b]	0.4 [a,b]
Benzaldehyde	0.00087	0.0000985	0.00172	0.000212	N/A	N/A
Formaldehyde	45.9	17.3	44.7	17.3	65 [a]	65 [b]
Propylene	0.0878	0.0142	2.15	0.111	N/A	4,000 [b]
1,3-butadiene	0.334	0.126	0.326	0.126	N/A	10 [b]
Propionaldehyde	4.18	1.58	4.08	1.57	10 [b,c]	N/A
2,2,4-Trimethylpentane	1.45	0.545	1.41	0.545	N/A	N/A

NOTES:

N/A indicates an objective or criteria does not exist.

Predicted concentrations are unadjusted (i.e., likely overpredicted due to a number of conservative assumptions in the dispersion modelling) from LNG Canada (2019a, 2019b). Adjusted concentrations (i.e., divided by 4 to account for potential overprediction bias) are provided in LNG Canada (2019a) however are not presented here.

[a] Alberta Ambient Air Quality Objectives for various VOCs. Data source: AEPA 2019.

[b] Ontario Ambient Air Quality Criteria for various VOCs. Data source: Ontario MOE 2012.

[c] Criteria is for a 10-minute average (Ontario MOE 2012)

For the Project these results infer that SO_2 will be less than the BC AQO, while NO_2 and $PM_{2.5}$ (mostly from fugitive dust, however, also include from diesel combustion) are predicted to be elevated at times in the vicinity of the Project construction sources.

The VOCs calculated for the construction of the Project are 4% of total construction of the LNG Canada Project and 16% of Phase 2 construction of the LNG Canada Project (Table 4.1–1). The model predicted concentrations of VOCs for construction of the LNG Canada Project are less than the Alberta Ambient Air Quality Objectives (AAQO) (AEPA 2019) and Ontario Ambient Air Quality Criteria (AAQC) (Ontario MOE 2012) (Table 4.1–3). On this basis, concentrations of VOCs for the construction of the Project are expected to also be less the Alberta AAQO and Ontario AAQC.

Table 4.1–4 LNG Canada Project PAH Dispersion Modelling Results

PAH	Phase 1 Maximum Annual Average (µg/m³)	Phase 2 Maximum Annual Average (µg/m³)	Environmental Screening Level [a] Annual (µg/m³)
Acenaphthene	0.0121	0.0119	10
Acenaphthylene	0.00758	0.00739	10
Anthracene	0.00144	0.00142	0.1
Benzo[a]pyrene	0.000130	0.000130	0.017
Fluoranthene	0.00264	0.00261	0.05
Fluorene	0.0120	0.0118	1
2-Methylnaphthalene	0.00000826	0.00000829	20
Naphthalene	0.0460	0.0449	50
Perylene	0.0000494	0.0000494	0.05
Phenanthrene	0.0233	0.0229	0.8
Pyrene	0.00226	0.00223	0.05

NOTES:

Bold values indicate and exceedance of the

Predicted concentrations are unadjusted (i.e., likely overpredicted due to a number of conservative assumptions in the dispersion modelling) from LNG Canada (2019). Adjusted concentrations (i.e., divided by 4 to account for potential overprediction bias) are provided in LNG Canada (2019) however are not presented here.

[a] Environmental Screen Level from Texas Air Monitoring Information System database (TAMIS) (2023)

Total PAHs calculated for the construction of the Project are 6% of total LNG Canada construction emissions and 22% of Phase 2 construction of the LNG Canada Project (Table 4.1–1). Dispersion modelling of PAHs for the LNG Canada HHRA that supported Condition 19 (LNG Canada 2019) are less than the Texas Environmental Screening Levels for the listed PAHs (TAMIS 2023) (Table 4.1–4). On this basis, concentrations of PAHs for the construction of the Project are expected to also be less the Texas Environmental Screening Levels.

The predicted concentrations presented above and in the LNG Canada Project Condition 19 HHRA (2019a, 2019b) are expected to be overpredicted based on the following conservative assumptions used in the modelling:

- Equipment and dust emissions occurring simultaneously for 12 hours each day (i.e., daily construction shift) from a number of distinct work areas. During construction, many activities will only take place for a fraction of the time and not all at the same time (LNG Canada 2019)
- Emission factors used for estimating PM emission rates are known to overestimate by a factor of two to six (Pouliot et al. 2010, Countess 2007, Pace 2005 as referenced in LNG Canada 2019). LNG Canada (2019b) forensically modelled 3-months of construction activity that occurred from April 1 to June 30, 2019 and found that dispersion modelling was over predicting $PM_{2.5}$ concentrations at the CVL monitoring location by more than a factor of two. It was recommended that the Condition 19 HHRA account for the overprediction bias seen for $PM_{2.5}$ for all contaminants of potential concern by dividing results by four (adjusted versus unadjusted predictions) (LNG Canada, 2019a, 2019b)
- CALPUFF and $PM_{2.5}$ emission factors do not consider the effect of local precipitation as natural dust mitigation leading to further overprediction of $PM_{2.5}$

LNG Canada was also required to conduct ambient monitoring at CVL. This monitoring station is approximately 100 m south of the of the dorm buildings and monitors for SO_2, NO_2, and $PM_{2.5}$ according to the Workforce Air Quality Health Plan (LNG Canada, 2023). Semi-annual monitoring reports are submitted to the BC EAO during Phase 1 of construction (LNG Canada, 2020, 2021a, 2021b, 2022). For all reporting periods, measured NO_2 at CVL monitoring station has been less than 41 ppb (77.2 µg/m^3) which is less than the BC AQOs. Similarly, for $PM_{2.5}$, all measurements at CVL monitoring station have been less than 73 µg/m^3 (Level 1 alert level as defined in the Workforce Air Quality Health Plan (LNG Canada, 2023)).

The Project construction activities (i.e., material handling, grading, and installation process modules) are similar to the construction activities of the LNG Canada Project, however, the Project level of activities and emissions are at a smaller scale. On the basis that the Project total construction emissions are less than that of the construction of the LNG Canada Project and the demonstrated conservative nature of the LNG Canada construction phase dispersion modelling, ambient levels of pollutants associated with construction of the Project are expected to be less than that predicted for construction of the LNG Canada Project, will be localized and intermittent, and Project residual effects will be low.

Although the Proponents have not selected a floatel operator or type, it is expected that there will be two floatels on Site during construction. Emissions associated with operation of the floatel diesel generators are summarized in the Table 4.1–5 and are compared to emissions from the Project (BC Hydro Case and On Site Power Generation Case) to evaluate potential for impacts on air quality. Peak annual emissions from the floatels are less than emissions from operation of the Project (considering the maximum of the two Project Cases), except for PAHs.

The Project SO_2, NO_X. CO and $PM_{2.5}$ emissions were assessed using dispersion modelling and maximum predicted concentrations were found to be less than the BC AQO. Maximum predicted concentrations occur on or near the Project fence line and decrease rapidly with distance from the emission sources. With the operation of the floatels it is expected that ambient concentrations of these pollutants will be elevated above existing conditions (i.e. pristine conditions); however ambient concentrations are expected to be less than the BC AQO, maximums will be on or near the fence line (e.g., less than 3 km from the facility based on operations dispersion modelling (Section 4.3 and 4.4)), and concentrations will decrease rapidly with distance from the floatel emission sources.

VOC emissions were not carried forward in the dispersion modelling for the Project as the emission levels for operation are low. The Project-alone Case (BC Hydro Option) total VOCs (7.6 tonnes/year) are 5% of that for the LNG Canada Project operation (138 tonnes VOCs/year) (LNG Canada, 2014a). The Project-Alone Case (On site Power Generation Case) total VOCs (48 tonnes/year) are 35% of that for the LNG Canada Project (LNG Canada, 2014a). Peak annual floatel total VOCs (13 tonnes/year) are 171% of Project-alone Case (BC Hydro Option), 30% of Project-Alone Case (On site Power Generation Case), and 9% of that for the LNG Canada Project operation (138 tonnes VOCs/year) (LNG Canada, 2014a). Dispersion modelling conducted for LNG Canada Project (LNG Canada, 2014a) indicate maximum predicted concentrations of VOC (assuming 0.5% of total VOCs was Benzene) are below the Alberta Ambient Air Quality Objective and the Ontario Ambient Air Quality Criteria for Benzene. As the peak annual floatel operations VOC emissions are a small fraction of the LNG Canada Project operation VOC emissions, ambient concentrations in the vicinity of the Project during construction are expected to be well below the Alberta AAQO and Ontario AAQC.

PAH emissions were not carried forward in the dispersion modelling for the Project as the emission levels for operations are low. The Project-alone Case (BC Hydro Option) total PAHs (0.004 tonnes/year) are 0.5% of that for the construction of the LNG Canada Project (0.35 tonnes PAHs/year Phase 1) (LNG Canada, 2014a). The Project-Alone Case (On site Power Generation Case) total PAHs (0.04 tonnes/year) are 5% of that for construction of the LNG Canada Project (LNG Canada, 2014a). Peak annual floatel total PAHs (0.44 tonnes/year) are small, however are 100 times higher than the Project-alone Case (BC Hydro Option) due to the characteristics of diesel fuel combustion compared to natural gas. Similarly, the Peak annual floatel total PAHs are small however are 10 times that of Project-Alone Case (On site Power Generation Case). Compared to the large-scale construction (in footprint and number of diesel equipment required) of the LNG Canada Project (0.35 tonnes PAHs/year Phase 1) (LNG Canada, 2014a), the peak annual PAHs are 126% of that for construction of the LNG Canada Project due the amount of diesel fuel consumption for these sizes (i.e., 2 MW, 5 MW) of floatel generators. Dispersion modelling conducted for the construction of the LNG Canada Project (LNG Canada, 2019) indicate maximum predicted concentrations of PAHs from diesel fired mobile construction equipment are well below the Texas Environmental Screening Levels (<6%). As the peak annual floatel operations PAHs emissions are similar to those for the construction of the LNG Canada, ambient concentrations of PAHs as a result of the floatel in the vicinity of Project during construction are expected to similarly be well below the Texas Screening Levels.

Emissions associated with operation of the Project floatels are compared to emissions from the Project (BC Hydro Case and On Site Power Generation Case) to evaluate potential for impacts on air quality and human health. Peak annual emissions from the floatels are less than emissions from operation of the Project (considering the maximum of the two Project Cases), except for PAHs.

On this basis the operation of the floatels during the Project construction is not anticipated to result in concentrations that exceed air quality standards.

Table 4.1–5 Floatel Emissions Comparison to Project Operation Emissions

Construction	NO_X	SO_2	PM_{10}	$PM_{2.5}$	CO	VOC	PAH
	Tonnes/year						
Peak Annual Floatel Emissions During Constructions [a, b, c]	80	13	5.8	5.3	34	13	0.44
Total Annual Emissions for Operations (BC Hydro Case) d	113	151	1.6		119	7.6	0.004
Total Annual Emissions for Operations (On Site Power Generation Case [d]	1,145	167	86		294	48	0.04

NOTES:

a. Small floatel is onSite for 4 years, large floatel is onSite during time of peak construction activities (2.5 years) and number or workers

b. For small floatel assumed power generators requirement is 2 MW (50%) load factor.

c. For large floatel assumed power generation requirement is 5 MW (50%) load factor.

d. Emissions from operations includes emissions from natural gas emission sources (heaters, thermal oxidizer, power generators, flares) and diesel sources (i.e., harbour tug boats)

4.2 TRANSMISSION LINE ASSESSMENT AREA

Total transmission line construction emissions are 35% or less than the total Project construction emissions (see Table 3.6–2, Section 3.3.2), except for VOCs. Total VOCs for the transmission line are higher than construction of the Project due to the potential use of two helicopters. Construction emissions associated with the transmission line are less than construction of the Project, and are short-term, intermittent, and transient.

4.3 PROJECT-ALONE CASE (BC HYDRO OPTION)

The predicted concentrations for the Project-alone Case (BC Hydro Option) (not including baseline) are shown in Table 4.3–1. The Project-alone Case (BC Hydro Option) includes emissions from heat medium heaters, thermal oxidizers, flares, and marine sources (Table 3.6–3)

Table 4.3–1 Project-alone Case (BC Hydro Option) Dispersion Modelling Results

Air Pollutant	Averaging Period	Maximum Predicted Concentrations (µg/m³)	AQO (µg/m³)
NO_2	1-hour	84.1	113 (79, 188)
	Annual	8.5	32 (23, 100)
SO_2	1-hour	156	183 (170, 196)
	Annual	4.9	13 (11)
$PM_{2.5}$	24-hour	1.5	25 (27, 35)
	Annual	0.2	8 (8.8, 12)
CO	1-hour	876	14,300 (40,065)
	8-hour	339	5,500 (10,303)

NOTES:
Achievement for each parameter and time averaging interval is as described in the notes section of Table 3.2–1.
The Project-alone Case (BC Hydro Option) includes emissions from heat medium heaters, thermal oxidizers, flares, and marine sources (Table 3.6–3)
Other regulatory criteria appear in brackets beside the AQOs (2020 or 2025 CAAQS, U.S. NAAQS).
NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide

The maximum 98th percentile of the predicted daily one-hour maximum ground-level NO_2 concentration for the Project-alone Case (BC Hydro Option) is 84.1 µg/m^3, which is less than the BC AQOs and U.S. NAAQS; however, are greater than the 2025 CAAQS. Concentrations are predicted to be greater than the 2025 CAAQS for less than 1.5% of hours in a year (i.e., 131 hours). Figure D.1 (Appendix D) shows that this maximum occurs approximately 270 m southwest of the Project on forested land. The area where concentrations are greater than the 2025 CAAQS occurs in a remote and unpopulated area near to the Project boundary.

The maximum predicted annual average ground-level NO_2 concentration is 8.5 µg/m^3, which is less than the BC AQOs, 2025 CAAQS, and U.S. NAAQS. Figure D.2 (Appendix D) shows that this maximum occurs on the Project plant boundary.

The BC Hydro Option provides a total reduction of NO_X by 1,032 tonnes per year compared to the on-Site Power Generation Case. See Section 4.4 for a discussion on the changes to predicted concentrations as a result of switching from on-Site power generation to BC Hydro.

The maximum 99th percentile of predicted daily one-hour maximum ground-level SO_2 concentration for the Project-alone Case (BC Hydro Option) is 156 µg/m^3, which is less than the BC AQOs 2025 CAAQS, and U.S. NAAQS. Figure D.3 (Appendix D) shows that this maximum occurs approximately 231 m southwest of the Project on forested land.

The predicted maximum annual average ground-level SO_2 concentration for Project-alone Case (BC Hydro Option) is 4.9 µg/m^3, which is less than the BC AQOs 2025 CAAQS, and U.S. NAAQS. Figure D.4 (Appendix D) shows that this maximum occurs approximately 47 m southwest of the Project on forested land.

The maximum 98th percentile of the predicted 24-hour average $PM_{2.5}$ concentration associated with the Project-alone Case (BC Hydro Option) is 1.5 µg/m^3, which is less than the BC AQOs, 2020 CAAQS, and U.S. NAAQS. Figure D.5 (Appendix D) shows that this maximum occurs on the Project plant boundary. The predicted annual average respirable $PM_{2.5}$ concentration for the Project-alone Case (BC Hydro Option) is 0.2 µg/m^3, which is less than the BC AQOs, 2020 CAAQS, and U.S. NAAQS. Figure D.6 (Appendix D) shows that this maximum occurs on the Project plant boundary.

The maximum predicted one-hour and eight-hour average CO concentrations associated with the Project-alone Case (BC Hydro Option) are 571 and 233 µg/m^3, respectively. The one-hour and eight-hour values are less than the BC AQOs and the U.S. NAAQS.

The Project-alone Case (BC Hydro Option) VOC emissions are not carried forward in the dispersion modelling as the emission levels (Table 3.6–3) are low. Based on past project experience, ambient concentrations are expected to be below the Alberta AAQOs and Ontario AAQCs. The Project-alone Case (BC Hydro Option) total VOCs (7.6 tonnes/year) are 5% of that for the LNG Canada Project operation (138 tonnes VOCs/year) (LNG Canada, 2014a). The LNG Canada Project determined for the Project-alone the maximum 1-hour and annual average predicted VOC concentrations were 36.3 µg/m^3 and 4.2 µg/m^3, respectively (LNG Canada 2014a). The LNG Canada Project estimated that approximately 0.5% of total VOC emissions were from benzene, which has the most stringent AAQO and AAQC, and modelling indicates concentrations would be well below the AAQO for benzene. As the Project operation VOC emissions are a small fraction of the LNG Canada Project operation VOC emissions, ambient concentrations in the vicinity of Project are expected to be well below the Alberta AAQO and Ontario AAQC.

Emissions of PAHs for the Project operation are not carried forward in the dispersion modelling as the emission levels (Table 3.6–3) are low and based on past project experience ambient concentrations are expected to be below the Texas ESL. The Project total PAHs are 13% of the Project construction PAH emissions and 0.5% of LNG Canada construction PAH emissions. Dispersion modelling of the LNG Canada Project construction PAHs show that predicted concentrations are below the ESLs (Table 4.1–4). As the Project PAH emissions are a fraction of the Project and the LNG Canada Project construction emissions, ambient concentrations in the vicinity of the Project are expected to be well below the PAH ESL.

4.4 PROJECT-ALONE CASE (ON-SITE POWER GENERATION)

The predicted concentrations for the Project-alone Case (On-Site Power Generation) (not including baseline) are shown in Table 4.4–1. The Project-alone Case (On-Site Power Generation) includes

emissions from turbine power generators, heat medium heaters, thermal oxidizers, flares, and marine sources (Table 3.6–4).

Table 4.4–1 Project-alone Case (On-Site Power Generation) Dispersion Modelling Results

Air Pollutant	Averaging Period	Maximum Predicted Concentrations (µg/m^3)	AQO (µg/m^3)
NO_2	1-hour	84.2	113 (79, 188)
	Annual	9.9	32 (23, 100)
SO_2	1-hour	156	183 (170, 196)
	Annual	5.0	13 (11)
$PM_{2.5}$	24-hour	4.0	25 (27, 35)
	Annual	0.4	8 (8.8, 12)
CO	1-hour	876	14,300 (40,065)
	8-hour	339	5,500 (10,303)

NOTES:
Achievement for each parameter and time averaging interval is as described in the notes section of Table 3.2–1.
The Project-alone Case (On-Site Power Generation) includes emissions from turbine power generators, heat medium heaters, thermal oxidizers, flares, and marine sources (Table 3.6–4).
Other regulatory criteria appear in brackets beside the AQO (2020 or 2025 CAAQS, U.S. NAAQS).
NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide

The maximum 98th percentile of the predicted daily one-hour maximum ground-level NO_2 concentration for the Project-alone Case (On-Site Power Generation) is 84.2 µg/m^3, which is less than the BC AQOs and U.S NAAQS; however, are greater than the 2025 CAAQS. Concentrations are predicted to be greater than the 2025 CAAQS for less than 2.1% of hours in a year (i.e., 184 hours). Figure D.7 (Appendix D) shows that this maximum occurs approximately 88 m southwest of the Project on forested land. The area where concentrations are greater than the 2025 CAAQS occurs in a remote and unpopulated area near to the Project boundary and on the land north of the Project.

The maximum predicted annual average ground-level NO_2 concentration is 9.9 µg/m^3, which is less than the BC AQOs, 2025 CAAQS, and U.S. NAAQS. Figure D.8 (Appendix D) shows that this maximum occurs on the Project plant boundary.

The Project proposes to use on-Site power generation for up to 5 years while the connection to the BC Hydro grid is developed. The on-Site power generation consists of eight natural gas-fired turbines which collectively emit 1,032 tonnes of NO_X per year. The one-hour maximum NO_2 concentration for the Project-alone Case (On-Site Power Generation) increases from the Project-alone Case (BC Hydro Option) by 0.1%. The annual average for the Project-alone Case (On-Site Power Generation) increases from the Project-alone Case (BC Hydro Option) by 16%. The maximum 1-hour concentration is mostly contributed to by the two thermal oxidizers (68 tonnes NO_X per year), one located on each of the FLNGs. The plume from the turbine power generators has greater buoyancy and plume rise than the thermal oxidizers which results in only a small increase in the maximum NO_2 concentration compared to the BC Hydro Option.

The improvement to air quality with the removal of the power generators when BC Hydro power is available is seen in the reduced area of predicted higher concentrations (Figure D.1 and Figure D.7) and lower annual average concentration (decrease by 16%) for the BC Hydro Case.

The maximum 99th percentile of predicted daily one-hour maximum ground-level SO_2 concentration for the Project-alone Case (On-Site Power Generation) is 156 µg/m^3, which is less than the BC AQOs, 2025 CAAQS, and U.S. NAAQS. Figure D.9 (Appendix D) shows that this maximum occurs approximately 231 m southwest of the Project on forested land.

The predicted maximum annual average ground-level SO_2 concentration for Project-alone Case (On-Site Power Generation) is 5.0 µg/m^3, which is less than the BC AQOs, 2025 CAAQS, and U.S. NAAQS. Figure D.10 (Appendix D) shows that this maximum occurs approximately 47 m southwest of the Project on forested land.

The maximum 98th percentile of the predicted 24-hour average $PM_{2.5}$ concentration associated with the Project-alone Case (On-Site Power Generation) is 4.0 µg/m^3, which is less than the BC AQOs, 2020 CAAQS, and U.S. NAAQS. Figure D.11 (Appendix D) shows that this maximum occurs approximately 2.5 km south of the Project on forested land. The predicted annual average $PM_{2.5}$ concentration for the Project-alone Case (On-Site Power Generation) is 0.4 µg/m^3, which is less than the BC AQOs, 2020 CAAQS, and U.S. NAAQS. Figure D.12 (Appendix D) shows that this maximum occurs approximately 680 m west of the Project on forested land.

The maximum predicted one-hour and eight-hour average CO concentrations associated with the Project-alone Case (On-Site Power Generation) are 876 and 339 µg/m^3, respectively. The one-hour and eight-hour values are less than the BC AQOs and U.S. NAAQS.

Emissions of VOCs for the Project operation are not carried forward in the dispersion modelling as the emission levels (Table 3.6–4) are low and based on past project experience ambient concentrations are expected to be below the Alberta AAQOs and Ontario AAQCs. The Project-alone (On-Site Power Generation) total VOCs (51 tonnes/year) are 37% of that for the LNG Canada Project operation (138 tonnes VOCs/year) (LNG Canada, 2014). The LNG Canada Project determined for the Project-alone the maximum 1-hour and annual average predicted VOC concentrations were 36.3 µg/m^3 and 4.2 µg/m^3, respectively (LNG Canada 2014). The LNG Canada Project estimated that approximately 0.5% of total VOC emissions were from benzene which has the most stringent AAQO and AAQC, and modelling indicates concentrations would be well below the AAQO for benzene. As the Project VOC emissions are a fraction of the LNG Canada Project VOC emissions, ambient concentrations in the vicinity of Project are expected to be well below the Alberta AAQO and Ontario AAQC.

Emissions of PAHs for the Project operation are not carried forward in the dispersion modelling as the emission levels (Table 3.6–4) are low and based on past project experience ambient concentrations are expected to be below the Texas ESL. The Project total PAHs are 133% of the Project construction PAH emissions and 5% of LNG Canada construction PAH emissions. Dispersion modelling of the LNG Canada Project construction PAHs show that predicted concentrations are below the ESLs

(Table 4.1–4). As the Project PAH emissions are a fraction the LNG Canada Project construction, ambient concentrations in the vicinity of the Project are expected to be well below the PAH ESL.

4.5 APPLICATION CASE (BC HYDRO OPTION)

The predicted concentrations for the Application Case (BC Hydro Option) are shown in Table 4.5–1. The Application Case (BC Hydro Option) include emissions from the Project-alone Case (BC Hydro Option) (Table 3.6–3) plus baseline (Table 3.3–1).

Table 4.5–1 Application Case (BC Hydro Option) Dispersion Modelling Results (including Baseline)

Air Pollutant	Averaging Period	Maximum Predicted Concentrations (including Baseline) (µg/m^3)	AQO (µg/m^3)
NO_2	1-hour	86.7	113 (79, 188)
	Annual	11.1	32 (23, 100)
SO_2	1-hour	157	183 (170, 196)
	Annual	5.7	13 (11)
$PM_{2.5}$	24-hour	10.0	25 (27, 35)
	Annual	3.7	8 (8.8, 12)
CO	1-hour	1,758	14,300 (40,065)
	8-hour	1,089	5,500 (10,303)

NOTES:
Achievement for each parameter and time averaging interval is as described in the notes section of Table 3.2–1.
Application Case (BC Hydro Option) include emissions from the Project-alone Case (BC Hydro Option) (Table 3.6–3) plus baseline (Table 3.3–1)
Other regulatory criteria appear in brackets beside the BC AQOs (2020 or 2025 CAAQS, U.S. NAAQS).
NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide

The maximum 98th percentile of the predicted daily one-hour maximum ground-level NO_2 concentration for the Application Case (BC Hydro Option) (with baseline added) is 86.7 µg/m^3, which is less than the BC AQOs and U.S. NAAQS; however, is greater than the 2025 CAAQS. Concentrations are predicted to be greater than the 2025 CAAQS for less than 1.9% of hours in a year (i.e., 167 hours). This increases by 0.4% with the addition of baseline. Figure D.13 (Appendix D) shows that this maximum occurs approximately 270 m southwest of the Project on forested land. The area where concentrations are greater than the 2025 CAAQS occurs in a remote and unpopulated area near to the Project boundary.

The maximum predicted annual average ground-level NO_2 concentration (with baseline added) is 11.1 µg/m^3, which is less than the BC AQOs, 2025 CAAQS, and the U.S. NAAQS. Figure D.14 (Appendix D) shows that this maximum occurs on the Project plant boundary.

As discussed in Section 4.3, the Project proposes to use on-Site power generation for up to 5 years of operation while the BC Hydro option is developed. The on-Site power generation consists of eight natural gas-fired turbines which emit a total of 1,032 tonnes of NO_X per year. The maximum 1-hour concentration is mostly contributed to by the two thermal oxidizers (68 tonnes NO_X per year), one located on each of the FLNG. The turbine power generators plumes achieve greater plume rise which results in only a small increase in maximum NO_2 concentration compared to the BC Hydro Option maxima. The improvement to air quality with the removal of the power generators when BC Hydro power is available is seen in the reduced area of higher concentrations (Figure D.13 and Figure D.19) and in lower annual average concentration for the BC Hydro Option.

The maximum 99th percentile of predicted daily one-hour maximum ground-level SO_2 concentration (with baseline added) for the Application Case (BC Hydro Option) is 157 µg/m^3, which is less than the BC AQOs, 2025 CAAQS, and the U.S. NAAQS. Figure D.15 (Appendix D) shows that this maximum occurs approximately 231 m southwest of the Project on forested land.

The predicted maximum annual average ground-level SO_2 concentration (with baseline added) for Application Case (BC Hydro Option) is 5.7 µg/m^3, which is less than the BC AQOs, 2025 CAAQS, and the U.S. NAAQS. Figure D.16 (Appendix D) shows that this maximum occurs approximately 47 m southwest of the Project on forested land.

The maximum 98th percentile of the predicted 24-hour average $PM_{2.5}$ concentration (with baseline added) associated with the Application Case (BC Hydro Option) is 10.0 µg/m^3 which is less than the BC AQOs, 2020 CAAQS, and the U.S. NAAQS. Similarly, the maximum annual average $PM_{2.5}$ concentration (with baseline added) is 3.7 µg/m^3, which is less than the BC AQOs, 2020 CAAQS, and the U.S. NAAQS. Figure D.17 and Figure D.18 (Appendix D) shows that these maxima occur on the Project plant boundary.

The maximum predicted one-hour and eight-hour average CO concentrations (with baseline added) associated with the Application Case (BC Hydro Option) are 1,758 and 1,089 µg/m^3, respectively. The one-hour and eight-hour values are less than the BC AQOs and U.S. NAAQS.

For the Application Case (BC Hydro Option) the VOC and PAH emissions are low, therefore, ambient concentrations in the vicinity of Project are expected to be well below the Alberta AAQO, Ontario AAQC, and Texas ESLs.

4.6 APPLICATION CASE (ON-SITE POWER GENERATION)

The predicted concentrations for the Application Case (On-Site Power Generation) are shown in Table 4.6–1. The Application Case (On-Site Power Generation) includes emissions from the Project-alone Case (On-Site Power Generation) (Table 3.6–4) with baseline added (Table 3.3–1)

Table 4.6–1 Application Case (On-Site Power Generation) Dispersion Modelling Results (including baseline)

Air Pollutant	Averaging Period	Maximum Predicted Concentrations (including baseline) (µg/m^3)	AQO (µg/m^3)
NO_2	1-hour	86.8	113 (79, 188)
	Annual	12.5	32 (23, 100)
SO_2	1-hour	157	183 (170, 196)
	Annual	5.8	13 (11)
$PM_{2.5}$	24-hour	12.5	25 (27, 35)
	Annual	3.9	8 (8.8, 12)
CO	1-hour	1,758	14,300 (40,065)
	8-hour	1,089	5,500 (10,303)

NOTES:
Achievement for each parameter and time averaging interval is as described in the notes section of Table 3.2–1.
The Application Case (On-Site Power Generation) includes emissions from the Project-alone Case (On-Site Power Generation) (Table 3.6–4) with baseline added (Table 3.3–1)
Other regulatory criteria appear in brackets beside the BC AQOs (2020 or 2025 CAAQS, U.S. NAAQS).
NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide

The maximum 98th percentile of the predicted daily one-hour maximum ground-level NO_2 concentration (with baseline added) for the Application Case (On-Site Power Generation) is 86.8 µg/m^3, which is less than the BC AQOs and U.S. NAAQS; however, are greater than the 2025 CAAQS. Concentrations are predicted to be greater than the 2025 CAAQS for less than 2.6% of hours in a year (i.e., 288 hours). This is a 0.5% increase from the Project-alone case (On-Site Power Generation). Figure D.19 (Appendix D) shows that this maximum occurs approximately 88 m southwest of the Project on forested land. The area where concentrations are greater than the 2025 CAAQS occurs in a remote and unpopulated area near to the Project boundary and on the land north of the Project.

The maximum predicted annual average ground-level NO_2 concentration (with baseline added) is 12.5 µg/m^3, which is less than the BC AQOs, 2025 CAAQS, and U.S. NAAQS. Figure D.20 (Appendix D) shows that this maximum occurs on the Project plant boundary.

As discussed in Section 4.3, the Project proposes to use on-Site power generation for up to 5 years of operation while the BC Hydro option is developed. The on-Site power generation consists of eight natural gas-fired turbines which collectively emit 1,032 tonnes of NO_X per year. The maximum 1-hour concentration is mostly contributed to by the two thermal oxidizers (68 tonnes NO_X per year), one located on each of the FLNG. The turbine power generators plumes achieve greater plume rise which results in only a small increase in maximum NO_2 concentration compared to the BC Hydro Option maxima. The improvement to air quality with the removal of the power generators when BC Hydro power is available is seen in the reduced area of higher concentrations (Figure D.13 and Figure D.19) and in lower annual average concentration for the BC Hydro Option.

The maximum 99th percentile of predicted daily one-hour maximum ground-level SO_2 concentration (with baseline added) for the Application Case (On-Site Power Generation) is 157 µg/m^3, which is less than the BC AQOs, 2025 CAAQS, and U.S. NAAQS. Figure D.21 (Appendix D) shows that this maximum occurs approximately 231 m southwest of the Project on forested land.

The predicted maximum annual average ground-level SO_2 concentration for Application Case (On-Site Power Generation) (with baseline added) is 5.8 µg/m^3, which is less than the BC AQOs, 2025 CAAQS, and U.S. NAAQS. Figure D.22 (Appendix D) shows that this maximum occurs approximately 47 m southwest of the Project on forested land.

The maximum 98th percentile of the predicted 24-hour average $PM_{2.5}$ concentration (with baseline added) associated with the Application Case (On-site Power Generation) is 12.5 µg/m^3 which is less than the BC AQOs, 2020 CAAQS, and U.S. NAAQS. Similarly, the maximum annual average $PM_{2.5}$ concentration (with baseline added) is 3.9 µg/m^3, which is less than the BC AQOs. Figure D.23 and Figure D.24 (Appendix D) shows that these maxima occur on the Project plant boundary.

The maximum predicted one-hour and eight-hour average CO concentrations (with baseline added) associated with the Application Case (On-Site Power Generation) are 1,758 and 1,089 µg/m^3, respectively. The one-hour and eight-hour values are less than the BC AQOs and U.S. NAAQS.

For the Application Case (On-site Power Generation) the VOC and PAH emissions are low, therefore, ambient concentrations in the vicinity of Project are expected to be well below the Alberta AAQO, Ontario AAQC, and Texas ESLs.

4.7 CUMULATIVE CASE (BC HYDRO OPTION)

The predicted concentrations for the Cumulative Case (BC Hydro Option) are shown in Table 4.7–1. The Cumulative Case (BC Hydro Option) includes emissions from the Project-alone Case (BC Hydro Option) plus baseline (Application Case (BC Hydro Option)) plus emissions from the Westcoast Connector Gas Transmission K5 Nasoga compressor station (Table 3.6–5).

Table 4.7–1 Cumulative Case (BC Hydro Option) Dispersion Modelling Results (including Baseline)

Air Pollutant	Averaging Period	Maximum Predicted Concentrations (including baseline) (µg/m^3)	AQO (µg/m^3)
NO_2	1-hour	86.7	113 (79, 188)
	Annual	11.2	32 (23, 100)
SO_2	1-hour	157	183 (170, 196)
	Annual	5.7	13 (11)
$PM_{2.5}$	24-hour	10.3	25 (27, 35)
	Annual	3.7	8 (8.8, 12)
CO	1-hour	1,758	14,300 (40,065)
	8-hour	1,089	5,500 (10,303)

NOTES:
Achievement for each parameter and time averaging interval is as described in the notes section of Table 3.2–1.
The Cumulative Case (BC Hydro Option) includes emissions from the Project-alone Case (BC Hydro Option [Table 4.3–1]) plus baseline (Table 3.3–1) plus emissions from the Westcoast Connector Gas Transmission K5 Nasoga compressor station (Table 3.6–5).
Other regulatory criteria appear in brackets beside the BC AQOs (2020 or 2025 CAAQS, U.S. NAAQS.
NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide

The maximum 98th percentile of the predicted daily one-hour maximum ground-level NO_2 concentration (with baseline added) for the Cumulative Case (BC Hydro Option) is 86.7 µg/m^3, which is less than the BC AQOs and U.S. NAAQs; however, are greater than the 2025 CAAQS. Concentrations are predicted to be greater than the 2025 CAAQS for less than 1.9% of hours in a year (i.e., 167 hours) which is the same as the Application Case (BC Hydro Option). Figure D.25 (Appendix D) shows that this maximum occurs approximately 270 m southwest of the Project on forested land. The area where concentrations are greater than the 2025 CAAQS occurs in a remote and unpopulated area near to the Project boundary and in small areas northwest of the K5 Nasoga compressor station.

The maximum predicted annual average ground-level NO_2 concentration (with baseline added) is 11.2 µg/m^3, which is less than the BC AQOs, 2025 CAAQS, and U.S. NAAQS. Figure D.26 (Appendix D) shows that this maximum occurs on the Project plant boundary.

The maximum 99th percentile of predicted daily one-hour maximum ground-level SO_2 concentration (with baseline added) for the Cumulative Case (BC Hydro Option) is 157 µg/m^3, which is less than the BC AQOs, 2025 CAAQS, and U.S. NAAQS. Figure D.27 (Appendix D) shows that this maximum occurs approximately 231 m southwest of the Project on forested land.

The predicted maximum annual average ground-level SO_2 concentration (with baseline added) for Cumulative Case (BC Hydro Option) is 5.7 µg/m^3, which is less than the BC AQOs, 2025 CAAQS, and U.S. NAAQS. Figure D.28 (Appendix D) shows that this maximum occurs approximately 47 m southwest of the Project on forested land.

The maximum 98th percentile of the predicted 24-hour average $PM_{2.5}$ concentration (with baseline added) associated with the Cumulative Case (BC Hydro Option) is 10.3 µg/m^3 which is less than the BC AQOs, 2020 CAAQS, and U.S. NAAQS. Similarly, the maximum annual average $PM_{2.5}$ concentration (with baseline added) is 3.7 µg/m^3, which is less than the BC AQOs. Figure D.29 and Figure D.30 (Appendix D) shows that these maxima occur within 2 km of the K5 Nasoga compressor station plant boundary.

The maximum predicted one-hour and eight-hour average CO concentrations (with baseline added) associated with the Cumulative Case (BC Hydro Option) are 1,758 and 1,089 µg/m^3, respectively. The one-hour and eight-hour values are less than the BC AQOs and U.S. NAAQS.

For the Cumulative Case (BC Hydro Option) the VOC and PAH emissions are low, therefore, ambient concentrations in the Project LAA/RAA are expected to be well below the Alberta AAQO, Ontario AAQC, and Texas ESLs.

4.8 CUMULATIVE CASE (ON-SITE POWER GENERATION)

The predicted concentrations for the Cumulative Case (On-Site Power Generation) are shown in Table 4.8–1. The Cumulative Case (BC Hydro Option) includes emissions from the Project-alone Case (On-Site Power Generation) plus baseline (Application Case (On-Site Power Generation)) plus emissions from the Westcoast Connector Gas Transmission K5 Nasoga compressor station (Table 3.6–6).

Table 4.8–1 Cumulative Case (On-Site Power Generation) Dispersion Modelling Results (including Baseline)

Air Pollutant	Averaging Period	Maximum Predicted Concentrations (including baseline) (µg/m^3)	AQO (µg/m^3)
NO_2	1-hour	86.8	113 (79, 188)
	Annual	12.5	32 (23, 100)
SO_2	1-hour	157	183 (170, 196)
	Annual	5.8	13 (11)
$PM_{2.5}$	24-hour	12.5	25 (27, 35)
	Annual	3.9	8 (8.8, 12)
CO	1-hour	1,758	14,300 (40,065)
	8-hour	1,089	5,500 (10,303)

NOTES:
Achievement for each parameter and time averaging interval is as described in the notes section of Table 3.2–1.
The Cumulative Case (BC Hydro Option) includes emissions from the Project-alone Case (On-Site Power Generation [Table 4.4–1]) plus baseline (Table 3.3–1) plus emissions from the Westcoast Connector Gas Transmission K5 Nasoga compressor station (Table 3.6–6).
Other regulatory criteria appear in brackets beside the BC AQOs (2020 or 2025 CAAQS, U.S. NAAQS).
NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide

The maximum 98th percentile of the predicted daily one-hour maximum ground-level NO_2 concentration (with baseline added) for the Cumulative Case (On-Site Power Generation) is 86.8 µg/m^3, which is less than the BC AQOs and U.S. NAAQS; however, are greater than the 2025 CAAQS. Concentrations are predicted to be greater than the 2025 CAAQS for less than 2.6% of hours in a year (i.e., 288 hours). This is the same as the Application Case (On-Site Power Generation). Figure D.31 (Appendix D) shows that this maximum occurs approximately 88 m southwest of the Project on forested land. The area where concentrations are greater than the 2025 CAAQS occurs in a remote and unpopulated area near to the Project boundary and on the land north of the Project. There are also small areas to the northwest of the K5 Nasoga compressor station.

The maximum predicted annual average ground-level NO_2 concentration (with baseline added) is 12.5 µg/m^3, which is less than the BC AQOs. Figure D.32 (Appendix D) shows that this maximum occurs on the Project plant boundary.

As discussed in Section 4.3, the Project proposes to use on-Site power generation for up to 5 years of operation while the BC Hydro option is developed. The on-Site power generation consists of eight natural gas-fired turbines which collectively emit 1,032 tonnes of NO_X per year. The maximum 1-hour concentration is mostly contributed to by the two thermal oxidizers (68 tonnes NO_X per year), one located on each of the FLNG. The turbine power generators plumes achieve greater plume rise which results in only a small increase in maximum NO_2 concentration compared to the BC Hydro Option maxima. The

improvement to air quality with the removal of the power generators when BC Hydro power is available is seen in the reduced area of higher concentrations (Figure D.25 and Figure D.31) and in lower annual average concentration for the BC Hydro Option.

The maximum 99th percentile of predicted daily one-hour maximum ground-level SO_2 concentration (with baseline added) for the Cumulative Case (On-Site Power Generation) is 157 µg/m^3, which is less than the BC AQOs. Figure D.33 (Appendix D) shows that this maximum occurs approximately 231 m southwest of the Project on forested land.

The predicted maximum annual average ground-level SO_2 concentration (with baseline added) for Cumulative Case (On-Site Power Generation) is 5.8 µg/m^3, which is less than the BC AQOs. Figure D.34 (Appendix D) shows that this maximum occurs approximately 47 m southwest of the Project on forested land.

The maximum 98th percentile of the predicted 24-hour average $PM_{2.5}$ concentration (with baseline added) associated with the Cumulative Case (On-Site Power Generation) is 12.5 µg/m^3 which is less than the BC AQOs. Similarly, the maximum annual average is 3.9 µg/m^3, which is less than the BC AQOs. Figure D.36 and Figure D.37 (Appendix D) shows that these maxima occur within 2.5 km of the Project plant boundary.

The maximum predicted one-hour and eight-hour average CO concentrations (with baseline added) associated with the Cumulative Case (On-Site Power Generation) are 1,758 and 1,089 µg/m^3, respectively. The one-hour and eight-hour values are less than the BC AQOs.

For the Cumulative Case (On-Site Power Generation) the VOC and PAH emissions are low, therefore, ambient concentrations in the Project LAA/RAA are expected to be well below the Alberta AAQO, Ontario AAQC, and Texas ESLs.

4.9 WORST-CASE FLARING EVENTS CASE

The two worst-case flaring events were modelled as continuous sources. The emissions are described in Section 3.6.9 and the daily emission rates listed in Table 3.6–7 and Table 3.6–8. The results in Table 4.9–1 represent the maximum predicted concentrations (without baseline) over five-years (2011–2015), or the worst hour or 24-hour interval in 43,824 hours or 1,826 days. An analysis of the five-year data set comparing the most observed meteorological conditions in the five-year period to the most common conditions associated with highest model predictions (values greater than the 1-hour 95th percentile maximum ground-level NO_2 concentrations for Case 1, and the 1-hour 95th percentile maximum ground-level SO_2 concentrations for Case 2) was completed and is shown in Table 4.9–1. Concentrations greater than 13.3 µg/m^3 (for NO_2) and 12.4 µg/m^3 (for SO_2) occur less than 5% of the time. Therefore, the likelihood of a rare flaring event coinciding with worst-case meteorology is low. The annual average results can be disregarded as they assume the flare operates continuously, and it operates rarely and for brief time intervals.

Table 4.9–1 Worst-Case Flaring Events Modelling Results

Air Pollutant	Averaging Period	Maximum Predicted Concentrations (µg/m³)		AQO (µg/m³)
		Case 1[a]	Case 2[b]	
NO_2	1-hour	17.4	0.3	113 (79, 188)
	Annual	-	0.002	32 (23, 100)
SO_2	1-hour	0.1	67.6	183 (170, 196)
	Annual	-	0.3	13 (11)
$PM_{2.5}$	24-hour	2.4	0.1	25 (27, 35)
	Annual	-	0.01	8 (8.8, 12)
CO	1-hour	508	7.5	14,300 (40,065)
	8-hour	102	1.0	5,500 (10,303)

NOTES:

[a] Emergency Blowdown

[b] Thermal oxidizer trip

Achievement for each parameter and time averaging interval is as described in the notes section of Table 3.2–1.

Other regulatory criteria appear in brackets beside the BC AQOs (2020 or 2025 CAAQS, U.S. NAAQS).

NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; $PM_{2.5}$ = respirable particulate matter; CO = carbon monoxide

Table 4.9–2 Frequency of Observed Meteorological Conditions

Parameter	Five-year Meteorological Dataset [a]		Hours with 1-hour NO_2 Concentrations Above the 95th Percentile Value (Case 1) [b]		Hours with 1-hour SO_2 Concentrations Above the 95th Percentile Value (Case 2) [c]	
	Most Observed	Frequency (%)	Most Observed	Frequency (%)	Most Observed	Frequency (%)
Pasquill-Gifford Stability Class	D	66	F	2	D	1.8
Wind Speed (m/s)	1.0 to 2.0	28	1.0 to 2.0	1.4	1.0 to 2.0	1.8
Wind Direction	SSW	16	ENE	0.7	NNW	1.1

NOTES:

[a] Represents incidence within 43,824 hours.

[b] Represents incidence above or equal to 95th percentile threshold of 13.3 µg/m³ within 43,824 hours (equal to 2,192 hours or approximately 5%).

[c] Represents incidence above or equal to 95th percentile threshold of 12.4 µg/m³ within 43,824 hours (equal to 2,192 hours or approximately 5%).

Case 1 represents the largest volume of sweet natural gas directed to the warm flare to evaluate a high oxides of nitrogen and $PM_{2.5}$ emission event. The results show a moderate increase in NO_2 and $PM_{2.5}$ attributable to this event in a worst-case scenario. The maximum 98th percentile of the predicted daily one-hour maximum ground-level NO_2 concentration is 17.4 µg/m^3 and the maximum 98th percentile of the predicted 24-hour average $PM_{2.5}$ concentration is 2.4 µg/m^3. Both are less that the BC AQOs. For Case 1 NO_2, 95% of the hourly predictions were less than 13.3 µg/m^3, or 11.8% of the BC AQO.

Case 2 represents a high S flare event which could occur if one thermal oxidizer tripped. The results show a moderate increase in SO_2 attributable to this event. The maximum 99th percentile of the predicted daily one-hour maximum ground-level SO_2 concentration is 67.6 µg/m^3, which is less than the BC AQOs. For Case 1 SO_2, 95% of the hourly predictions were less than 12.4 µg/m^3, or 6.8% of the BC AQO.

For the worst case flaring cases the PAH emissions are low and based on past project experience (LNG Canada Project), associated ambient concentrations in the Project LAA/RAA area are expected to be below the Texas ESLs. While VOC emission levels (Table 3.6–7) are elevated for the worst case flare event (Case 1), the LNG Canada Project (2014) estimated only a small portion of those emissions are benzene (0.5%), a specie of VOC with the most stringent AAQO (AEPA 2019). On this basis, and the short-term and infrequent nature of the flare events it is expected that ambient concentrations will be below the AAQO.

4.10 OPERATION SHIPPING ROUTE CASE (PROJECT-ALONE)

The predicted concentrations for the Operation Shipping Route Case (Project-alone) (not including baseline) are shown in Table 4.10–1. Predicted concentrations for NO_2 and SO_2 are only presented as these air pollutants the potential for the largest effect (i.e., human health) and are represented to show that maximum concentration of air pollutants occurs near to the marine vessel and does not persist due to the transient nature of the emission source.

Table 4.10–1 Operation Shipping Route Case (Project-alone) Dispersion Modelling Results

Air Pollutant	Averaging Period	Maximum Predicted Concentrations (µg/m^3)	AQO (µg/m^3)
NO_2	1-hour	84.1	113 (79, 188)
	Annual	7.1	32 (23, 100)
SO_2	1-hour	28.6	183 (170, 196)
	Annual	0.9	13 (11)

NOTES:
Achievement for each parameter and time averaging interval is as described in the notes section of Table 3.2–1.
Other regulatory criteria appear in brackets beside the BC AQOs (2020 or 2025 CAAQS, U.S. NAAQS).
NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide

The maximum 98th percentile of the predicted daily one-hour maximum ground-level NO_2 concentration for the Operation Shipping Route Case (Project-alone) is 84.1 µg/m^3, which is less than the BC AQOs. Figure D.37 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 30.4 km southwest of the Project over water.

The maximum predicted annual average ground-level NO_2 concentration is 7.1 µg/m^3, which is less than the BC AQOs. Figure D.38 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 23.1 km southwest of the Project over water.

The maximum 99th percentile of predicted daily one-hour maximum ground-level SO_2 concentration for the Operation Shipping Route Case (Project-alone) is 28.6 µg/m^3, which is less than the BC AQOs. Figure D.39 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 29.4 km southwest of the Project over water.

The predicted maximum annual average ground-level SO_2 concentration for Operation Shipping Route Case (Project-alone) is 0.9 µg/m^3, which is less than the BC AQOs. Figure D.40 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 23 km southwest of the Project over water.

For the Operation Shipping Route Case (Project-alone) the VOC and PAH emissions are similar to that of Project operation and construction. Based on past project experience (LNG Canada Project) and the transient nature of the marine vessels, ambient concentrations of VOCs and PAHs in the Operation Shipping Route assessment area are expected to be below the Alberta AAQO, Ontario AAQC, and Texas ESLs.

4.11 OPERATION SHIPPING ROUTE CASE (APPLICATION)

The predicted concentrations for the Operation Shipping Route Case (Application) are shown in Table 4.11–1. The Operation Shipping Route Case (Application) includes emissions from the Operations shipping sources (LNG carrier, tugboat) plus baseline (Table 3.3–1). Predicted concentrations for NO_2 and SO_2 are only presented as these air pollutants have the potential for the largest effects (i.e., human health)

and are represented to show that maximum concentration of air pollutants occurs near to the marine vessel and does not persist due to the transient nature of the emission source.

Table 4.11–1 Operation Shipping Route Case (Application) Dispersion Modelling Results (including Baseline)

Air Pollutant	Averaging Period	Maximum Predicted Concentrations (including baseline) (µg/m^3)	AQO (µg/m^3)
NO_2	1-hour	86.7	113 (79, 188)
	Annual	9.7	32 (23, 100)
SO_2	1-hour	29.4	183 (170, 196)
	Annual	1.7	13 (11)

NOTES:
Achievement for each parameter and time averaging interval is as described in the notes section of Table 3.2–1.
The Operation Shipping Route Case (Application) includes emissions from the Operations shipping sources (LNG carrier, tugboat) plus baseline (Table 3.3–1).
Other regulatory criteria appear in brackets beside the BC AQOs (2020 or 2025 CAAQS, U.S. NAAQS).
NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide

The maximum 98th percentile of the predicted daily one-hour maximum ground-level NO_2 concentration (with baseline added) for the Operation Shipping Route Case (Application) is 86.7 µg/m^3, which is less than the BC AQOs. Figure D.41 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 30.4 km southwest of the Project over water.

The maximum predicted annual average ground-level NO_2 concentration (with baseline added) is 9.7 µg/m^3, which is less than the BC AQOs. Figure D.42 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 23.1 km southwest of the Project over water.

The maximum 99th percentile of predicted daily one-hour maximum ground-level SO_2 concentration (with baseline added) for the Operation Shipping Route Case (Application) is 29.4 µg/m^3, which is less than the BC AQOs. Figure D.43 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 29.4 km southwest of the Project over water.

The predicted maximum annual average ground-level SO_2 concentration (with baseline added) for Operation Shipping Route Case (Application) is 1.7 µg/m^3, which is less than the BC AQOs. Figure D.44 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 23 km southwest of the Project over water.

For the Operation Shipping Route Case (Application Case) VOC and PAH emission levels are similar to that of Operation Shipping Route Case (Project-alone). Based on past project experience (LNG Canada Project) and the transient nature of the marine vessels, ambient concentrations of VOCs and PAHs in the

Operation Shipping Route assessment area are expected to be below the Alberta AAQO, Ontario AAQC, and Texas ESLs.

4.12 OPERATION SHIPPING ROUTE CASE (CUMULATIVE)

The predicted concentrations for the Operation Shipping Route Case (Cumulative) are shown in Table 4.12–1. The Operation Shipping Route Case (Cumulative) includes emissions from the Operations shipping sources (LNG carrier, tugboat) plus baseline (Table 3.3–1), and emissions from Westcoast Connector Gas Transmission K5 Nasoga compressor station. Predicted concentrations for NO_2 and SO_2 are only presented as these air pollutants have the potential for the largest effect (i.e., human health) and are represented to show that maximum concentration of air pollutants occurs near to the marine vessel and does not persist due to the transient nature of the emission source.

Table 4.12–1 Operation Shipping Route Case (Cumulative) Dispersion Modelling Results (including Baseline)

Air Pollutant	Averaging Period	Maximum Predicted Concentrations (including baseline) (µg/m³)	AAQO (µg/m³)
NO_2	1-hour	86.7	113 (79, 188)
	Annual	9.8	32 (23, 100)
SO_2	1-hour	29.4	183 (170, 196)
	Annual	1.7	13 (11)

NOTES:
Achievement for each parameter and time averaging interval is as described in the notes section of Table 3.2–1.
The Operation Shipping Route Case (Cumulative) includes emissions from the Operations shipping sources (LNG carrier, tugboat) plus baseline (Table 3.3–1), and emissions from Westcoast Connector Gas Transmission K5 Nasoga compressor station.
Other regulatory criteria appear in brackets beside the BC AQOs (2020 or 2025 CAAQS, U.S. NAAQS).
NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide

The maximum 98th percentile of the predicted daily one-hour maximum ground-level NO_2 concentration (with added baseline) for the Operation Shipping Route Case (Cumulative) is 86.7 µg/m^3, which is less than the BC AQOs. Figure D.45 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 30.4 km southwest of the Project, over water.

The maximum predicted annual average ground-level NO_2 concentration (with added baseline) is 9.8 µg/m^3, which is less than the BC AQOs. Figure D.46 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 23.1 km southwest of the Project, over water.

The maximum 99th percentile of predicted daily one-hour maximum ground-level SO_2 concentration (with added baseline) for the Operation Shipping Route Case (Cumulative) is 29.4 µg/m^3, which is less than the BC AQOs. Figure D.47 (Appendix D) shows that this maximum occurs, approximately 29.4 km southwest of the Project, over water.

The predicted maximum annual average ground-level SO_2 concentration (with added baseline) for Operation Shipping Route Case (Cumulative) is 1.7 µg/m^3, which is less than the BC AQOs. Figure D.48 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 23 km southwest of the Project, over water.

For the Operation Shipping Route Case (Cumulative Case) VOC and PAH emission levels are similar to that of Cumulative Case (BC Hydro Option). Based on past project experience (LNG Canada Project), and the transient nature of the marine vessels, and the limited interaction with emission from the K5 Nasoga compressor station, ambient concentrations of VOCs and PAHs in the Operation Shipping Route assessment area are expected to be below the Alberta AAQO, Ontario AAQC, and Texas ESLs

4.13 OPEN WATER ASSESSMENT CASE (PROJECT-ALONE)

The predicted concentrations for the Open Water Assessment Case (Project-alone) (not including baseline) are shown in Table 4.13–1. Predicted concentrations for NO_2 and SO_2 are only presented as these air pollutants have the potential for the largest effects (i.e., human health) and are represented to show that maximum concentration of air pollutants occurs near to the marine vessel and does not persist due to the transient nature of the emission source.

Table 4.13–1 Open Water Assessment Case (Project-alone) Dispersion Modelling Results

Air Pollutant	Averaging Period	Maximum Predicted Concentrations (µg/m^3)	AQO (µg/m^3)
NO_2	1-hour	80.6	113 (79, 188)
	Annual	1.3	32 (23, 100)
SO_2	1-hour	8.9	183 (170, 196)
	Annual	0.1	13 (11)

NOTES:
Achievement for each parameter and time averaging interval is as described in the notes section of Table 3.2–1.
Other regulatory criteria appear in brackets beside the BC AQOs (2020 or 2025 CAAQS, U.S. NAAQS).
NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide

The maximum 98th percentile of the predicted daily one-hour maximum ground-level NO_2 concentration for the Open Water Assessment Case (Project-alone) is 80.6 µg/m^3, which is less than the BC AQOs. Figure D.49 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 92 km southwest of the Project, over water.

The maximum predicted annual average ground-level NO_2 concentration is 1.3 µg/m^3, which is less than the BC AQOs. Figure D.50 (Appendix D) shows that this maximum occurs within 2.0 km of the shipping route, approximately 107 km southwest of the Project, over water.

The maximum 99th percentile of predicted daily one-hour maximum ground-level SO_2 concentration for the Open Water Assessment Case (Project-alone) is 8.9 µg/m^3, which is less than the BC AQOs. Figure D.51 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 93 km southwest of the Project, over water.

The predicted maximum annual average ground-level SO_2 concentration for Open Water Assessment Case (Project-alone) is 0.1 µg/m^3, which is less than the BC AQOs. Figure D.52 (Appendix D) shows that this maximum occurs within 2.0 km of the shipping route, approximately 108 km southwest of the Project, over water.

For the Open Water Assessment Area Case (Project-alone) the VOC and PAH emission levels are less than that of Operation Shipping Route Case (Project-alone) as there is no requirement for an escort tugboat in open water. Based on past project experience (LNG Canada Project), and the transient nature of the marine vessels, ambient concentrations of VOCs and PAHs in the Open Water Assessment Area are expected to be below the Alberta AAQO, Ontario AAQC, and Texas ESLs

4.14 OPEN WATER ASSESSMENT CASE (APPLICATION)

The predicted concentrations for the Open Water Assessment Case (Application) are shown in Table 4.14–1. This case includes emissions from the LNG carrier plus baseline (Table 3.3–1). Predicted concentrations for NO_2 and SO_2 are only presented as these air pollutants have the potential for the largest effects (i.e., human health) and are represented to show that maximum concentration of air pollutants occurs near to the marine vessel and does not persist due to the transient nature of the emission source.

Table 4.14–1 Open Water Assessment Case (Application) Dispersion Modelling Results (including Baseline)

Air Pollutant	Averaging Period	Maximum Predicted Concentrations (including baseline) (µg/m^3)	AQO (µg/m^3)
NO_2	1-hour	83.2	113 (79, 188)
	Annual	3.9	32 (23, 100)
SO_2	1-hour	9.7	183 (170, 196)
	Annual	0.9	13 (11)

NOTES:
Achievement for each parameter and time averaging interval is as described in the notes section of Table 3.2–1.
This case includes emissions from the LNG carrier plus baseline (Table 3.3–1).
Other regulatory criteria appear in brackets beside the BC AQOs (2020 or 2025 CAAQS, U.S. NAAQS).
NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide

The maximum 98th percentile of the predicted daily one-hour maximum ground-level NO_2 concentration (with baseline added) for the Open Water Assessment Case (Application) is 83.2 µg/m^3, which is less than the BC AQOs. Figure D.53 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 92 km southwest of the Project, over water.

The maximum predicted annual average ground-level NO_2 concentration (with baseline added) is 3.9 µg/m^3, which is less than the BC AQOs. Figure D.54 (Appendix D) shows that this maximum occurs within 2.0 km of the shipping route, approximately 107 km southwest of the Project, over water.

The maximum 99th percentile of predicted daily one-hour maximum ground-level SO_2 concentration (with baseline added) for the Open Water Assessment Case (Application) is 9.7 µg/m^3, which is less than the BC AQOs. Figure D.55 (Appendix D) shows that this maximum occurs within 200 m of the shipping route, approximately 93 km southwest of the Project, over water.

The predicted maximum annual average ground-level SO_2 concentration (with baseline added) for Open Water Assessment Case (Application) is 0.9 µg/m^3, which is less than the BC AQOs. Figure D.56 (Appendix D) shows that this maximum occurs within 2.0 km of the shipping route, approximately 108 km southwest of the Project, over water.

For the Open Water Assessment Area Case (Application) VOC and PAH emission levels are similar that of Open Water Assessment Area Case (Project-alone) as baseline VOC and PAH concentrations are negligible (Section 3.3.2). Based on past project experience (LNG Canada Project), and the transient nature of the marine vessels, ambient concentrations of VOCs and PAHs in the Open Water Assessment Area are expected to be below the Alberta AAQO, Ontario AAQC, and Texas ESLs

5.0 CONCLUSIONS

An air quality assessment of the Project construction and operation has been conducted to support the Application. An assessment of air quality effects for the construction of the transmission line, operation shipping activities along the shipping route (Operation Shipping Route), and in the Open Water Assessment Area have also been conducted.

Predictive air dispersion modelling (LNG Canada 2019) shows that emissions from construction of the Project will result in infrequent and short-term elevated concentrations in the vicinity of the Site. Air dispersion modelling completed for the construction of the LNG Canada Project showed overprediction of ground-level air quality concentrations (LNG Canada 2019) due to a number of conservative assumptions including, CALPUFF model is designed for stack emission sources and not mobile tailpipe emission sources, assuming construction activities occur 100% of the time and simultaneously, $PM_{2.5}$ emission factors over estimate emissions by 2 to 6 times, and the model and $PM_{2.5}$ emission factors do not account for the local precipitation acting as natural dust mitigation. Ambient air quality monitoring at CVL shows pollutant concentrations to be less than those predicted by the air dispersion model by a factor 2.

The construction emissions associated with the Project's transmission line are less than construction of the Project, and are short-term, intermittent, and transient.

The emissions associated with the operation of the Project are predicted to result in a localized, infrequent occurrence of elevated concentrations in the immediate vicinity of the Project, with maximum concentrations less than the BC AQOs and the U.S NAAQS. The 2025 CAAQS for NO_2 are exceeded up 2.6% of the hours in a year (i.e., 228). This effect is greatest on the plant boundary and diminishes with increasing distance from the Project emission sources. This predicted deterioration is attributable to the combustion sources on-Site (heaters, thermal oxidizers, flares, gas turbines, and marine vessels).

The model predicted concentrations for air pollutants associated with the Operation Shipping Route Cases and the Open Water Assessment Cases are less than the regulatory criteria. This assessment shows that the largest effect of the Project on ambient air quality will occur locally, within approximately 100 m to 3 km from the facility, and within 200 m to 2 km from the shipping routes. These effects are predicted to occur in remote, unoccupied lands and waters.

The conclusions of this assessment are based on a number of conservative assumptions which results in confidence that the potential air quality effects are not underpredicted. It is assumed that the Project-alone Case and Cumulative Case emission sources are operating simultaneously and continuously at their maximum emission rates. The assessment accounts for the concurrence of maximum, sustained emissions, and the poorest dispersion meteorology over a five-year period. It is unlikely that these conditions will occur simultaneously.

It is therefore concluded that effects on ambient air quality, as a result of construction and operation of the Project, result in the occasional elevated ambient concentrations of pollutants above existing conditions (baseline), however based on air dispersion modelling predictions, concentrations in the vicinity of the Site are expected to remain below the BC AQOs.

6.0 CLOSURE

This TDR was prepared for the sole benefit of the Nisga'a Nation and its partners Rockies LNG Limited Partnership and Western LNG to describe the existing conditions and the Project and cumulative changes within the Project assessment areas for the Air Quality VC.

Respectfully submitted,

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APPENDIX A

Dispersion Modelling Plan

1 Appendix A DISPERSION MODELLING PLAN

Dispersion Modelling Plan

Ksi Lisims LNG – Natural Gas Liquefaction Facility and Marine Terminal

June 2024

Prepared for:

KSI LISIMS LNG

Prepared by:

Stantec Consulting Ltd.

Project Number: 123221820

Revision: F

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Abbreviations

ARM 2	Ambient Ratio Method 2
AQO	Air Quality Objective
BC	British Columbia
ECCC	Environment and Climate Change Canada
ENV	British Columbia Ministry of Environment and Climate Change Strategy
°C	degrees Celsius
C2H5SH	ethyl mercaptan
C3H7SH	propyl mercaptan
CAAQS	Canadian Ambient Air Quality Standards
CCME	Canadian Council of Ministers of the Environment
CEC	Commission for Environmental Cooperation
CH3SH	methyl mercaptan
CO	carbon monoxide
COS	carbonyl sulphide
FLNG	Floating liquification of natural gas facility
g/s	grams per second
H_2S	hydrogen sulphide
ha	hectare
K	Kelvin
km	kilometre
kW	kilowatt
LNG	Liquified Natural Gas

LP	Low Pressure
m	metre
m/s	metres per second
MAQCHEM	Aqueous phase chemistry flag
m asl	metres above sea level
m E	Easting (metres)
m N	Northing (metres)
MLWC	Liquid Water Content flag
NAAQS	National Ambient Air Quality Standards (US)
NAD83	North American Datum of 1983
NASA	National Aeronautics and Space Administration
NO_2	nitrogen dioxide
NO_X	nitrous oxide
PM_{10}	particulate matter with an aerodynamic diameter less than equal to 10 micrometres
$PM_{2.5}$	fine particulate matter with an aerodynamic diameter less than equal to 2.5 micrometres
RAA	regional assessment area
SO_2	sulphur dioxide
SRTM3	3-second shuttle topography mission files
t/d	tonnes per day
$\mu g/m^3$	microgram per cubic metre
UTM	Universal Transverse Mercator
US EPA	United States Environmental Protection Agency
WRF	Weather Research and Forecast model

1.0 DISPERSION MODELLING PLAN

The format of this dispersion modelling plan follows the template provided by the British Columbia (BC) Ministry of Environment and Climate Change Strategy (BC ENV) (ENV 2022a). Text in *italics* is provided as part of the BC ENV template and details the required information for each section of the dispersion modelling plan. This assessment will be using the CALPUFF modelling system therefore any requirements in the BC ENV template related to other dispersion modelling systems (i.e., AERMOD) have been removed.

2.0 GENERAL

Date: 15-September-2023

Facility Name: Ksi Lisims LNG Project

Company: Nisga'a Nation and its partners Rockies LNG Limited Partnership and Western LNG LLC

Company Contact: Sandra Webster (swebster@ksilisimslng.com)

Location:
Latitude: 55.0238°N Northing: 6,098,078 m N Zone 9
Longitude: -130.1848°W Easting: 424,259 m E Zone 9

Air Quality Consultant and Contact Name:

Stantec Consulting Ltd.
April Hauk
250-261-3849
April.Hauk@stantec.com

Stantec Consulting Ltd.
Reid Person
403-781-4159
reid.person@stantec.com

Ministry Contact Name(s):
Gavin King
250-312-6798
Gavin.King@gov.bc.ca

Level of Assessment (1, 2 or 3) and provide rational for the proposed level of assessment:

A Level 3 Assessment will be conducted to assess the air quality consequences of emissions as a result of the Ksi Lisims LNG Project – Natural Gas Liquefaction and Marine Terminal Project (the Project), a floating liquefied natural gas (FLNG) export facility, with supporting upland infrastructure and a marine terminal. Section 2.2.2 of the British Columbia Air Quality Dispersion Modelling Guideline (Guideline) (BC ENV, 2022b) indicates that a Level 3 assessment is appropriate for modelling the Project emission sources. This is due to the complex topography and wind flows in the region and the multiple emission sources.

The Project is being evaluated for the British Columbia Environmental Assessment process. The air quality assessment will be conducted following the Guideline (BC ENV, 2022b), using the CALPUFF modeling system. CALMET module will use Weather Research Forecast (WRF) data as input.

Does this plan follow a modelling approach that is similar to the approach taken in a previous air quality assessment already reviewed and accepted by the Ministry? If so, provide the project name and Ministry contact:

Due to the remote location and uniqueness of the Project, the modelling methodology described here is specific to the Project.

3.0 PROJECT DESCRIPTION AND GEOGRAPHIC SETTING

Provide an overview of the project, including process description and the purpose of the dispersion modelling study:

The Nisga'a Nation and its partners Rockies LNG Limited Partnership (Rockies LNG) and Western LNG LLC (via its subsidiary, Western LNG) (collectively referred to as the Proponents), are proposing to jointly develop the Ksi Lisims LNG - Natural Gas Liquefaction and Marine Terminal Project (the Project).
The Project Site is located at Wil Milit, on the northern end of Pearse Island, approximately 15 kilometres (km) west of the Nisga'a community of Gingolx and 900 m southeast of the Canada-US border.
The Project is located on Category A fee simple land as defined in the Nisga'a Final Agreement and is adjacent to a proposed water lot located on the east side of the Project Site, in Portland Canal.

Since 2014 the Nisga'a Nation has been working to develop liquefied natural gas (LNG) and pipeline facilities in and around its treaty territory. This Project is the culmination of that work and is a key element of the Nisga'a Nation's economic and social development strategy. It will provide training, jobs and new business opportunities for the Nisga'a people and other Indigenous Nation communities. Economic development opportunities such as this Project will help ensure the continued growth and vitality of the Nisga'a Nation and other Indigenous Nations.

The Project will operate under a governance structure that provides each of the Proponents meaningful input into the management and operation of the Project, ensuring that it is operated in a manner that is consistent with the Nisga'a Nation's commitment to stewardship of the land and its people. The Project is consistent with the economic development aspirations of the Nisga'a Nation and provincial government-led economic recovery measures while still meeting the sustainable economic development objectives of the Nisga'a Nation, British Columbia (BC) and Canada.

At full build-out, the Project will receive between 1.7 and 2 Bcf/d (i.e., 48.1 and 56.6 million m^3 per day) of pipeline grade natural gas and produce up to 12 mtpa of LNG. The Project will consist of two floating LNG production, storage and off-loading barges (FLNGs). The main refrigerant compressor drives are electric motors. Each FLNG will include feed gas pre-treatment, multiple single mixed refrigerant liquefaction trains, LNG storage, mooring systems, LNG ship-to-ship off-loading equipment, boil off gas management, emergency flare system, and utilities. The Project design is in early stages and detailed design will be developed during FEED. Further detail on Project process description can be found in the Detailed Project Description (Ksi Lisims 2022).

The purpose of the assessment is to support the Project's application for Environmental Certification that is being evaluated under the British Columbia Environmental Assessment process. The local assessment area (LAA) for the facility will be set to 40 km by 40 km as recommended in the Guideline (BC ENV 2022b) to capture predicted concentrations that are 10% of the applicable air quality objective on a project alone basis.

The LAA for the Operations Shipping Route assessment will be set as a 5 km extending on either site of the Operations Shipping Route. The Operations Shipping Route extends 101.4 km from Triple Islands to the Site. The study area is expanded to the east side of the route to include Metlakatla Village and Lax Kw'alaams Village. The study area boundaries enclose the concentration contours attributable to the Project that are greater than 10% of the applicable regulatory criteria in accordance with the Guideline (BC ENV 2022b).

The LAA for the Open Water Assessment Area (OWAA) will be set as a 5 km extending on either site of the shipping route. The OWAA extents from Triple Island to the 12 nautical mile. The study area boundaries enclose the concentration contours attributable to the Project that are greater than 10% of the applicable regulatory criteria in accordance with the Guideline (BC ENV 2022b).

The regional assessment areas (RAA) for the Facility assessment, the Operations Shipping Route assessment, and the OWAA are set to be equivalent to the LAA as at distances beyond the LAA there is likely no measurable interaction of emissions from past, present or foreseeable future projects with the Project emissions.

Provide a description of the following:

- *Terrain characteristics within domain: flat terrain or complex terrain (i.e., will complex flow need to be considered?)*
- *Dominant land cover: urban, rural, industrial, agricultural, forested, rock, water, grassland*

The Project facility area occupies approximately 30 hectares (ha) of land as well as a water lot on the Pearse Canal and Portland Canal. Project Area elevation is approximately sea level to 30 metres above sea level (m asl). The region consists of complex terrain including ocean channels and inlets, mountains, and river valleys. The dominant land cover in the model domain is 57.6% evergreen forest and 19.6% water. The dispersion of emissions from the Project are dictated by local meteorology, which is influenced by the surrounding complex terrain. The nearest permanently occupied dwellings are located approximately 15 km east of the Project in the community of Gingolx.

The Operations Shipping Route extends 101.4 km from Triple Islands to the Site. The study area is at sea level and consist mostly of water. In some more narrow channel areas along the Operations Shipping Route some shoreline is captured within the LAA. The LAA is expanded to the east side of the route to include Metlakatla Village and Lax Kw'alaams Village.

4.0 DISPERSION MODEL

4.1 SELECTED DISPERSION MODEL

List model(s) and version to be used:

The following models will be used for the Level 3 Assessment for the Project with no modifications to the original computer code. They have been optimized to run in a LINUX computing environment.

- CALMET v6.5.0
- CALPUFF v7.2.1
- CALPOST v7.0.0

Specify any non-guideline models or versions (i.e., beta-test versions) planned for use. Provide rationale:

No non-guideline models or versions are planned for this assessment.

If modifications to any of the models are planned, provide a description and the rationale:

No modifications to the models are planned.

4.2 DEFAULT SWITCH SETTINGS

For CALMET/CALPUFF identify any key switch settings in CALMET and CALPUFF that will be different from the "black (do not touch)" defaults as per Tables 6.2 and 7.1 (BC ENV 2022b). Provide rationale.

- The key switch settings in CALPUFF will be the "black (do not touch)" defaults as per Table 6.2 and Table 7.1 in the Guideline (BC ENV 2022b). MAQCHEM=0 and MLWC =0, denoting no aqueous phase chemistry will be selected (discussed in Section 10.2.1).
- As CALMET is being run in no-obs mode values for R1 and RMAX1 are not used. More switch settings are provided in Appendix A (Table A.1).

For the CALMET model provide:

- *A CALMET domain map that also shows the locations of surface meteorological stations and upper air stations:* Domain maps are provided in Figure 4.1, Figure 4.2**,** and Figure 4.3 for the Facility assessment, Operations Shipping Route assessment, and the Open Water Assessment Area (OWAA). There are no surface meteorological stations and upper air stations in these domains.
- *Anticipated grid resolution*: 250 (m)
- *Number of grids in X and Y direction:* NX = 200, NY = 200
- *Vertical levels (m)*: 12 vertical layers are used at 10, 30, 60, 100, 200, 400, 700, 1100, 1570, 2100, 2690 and 3500 (13 ZFACE layers (m): 0, 20, 40, 80, 120, 280, 520, 880, 1320, 1820, 2380, 3000 and 4000)



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Site
Gingolx
International Boundary
Watercourse
Waterbody
Ground Elevation (m)
High : 1652
Low : 0

Ksi Lisims LNG Plant Boundary
K5 Nasoga Compressor Station

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

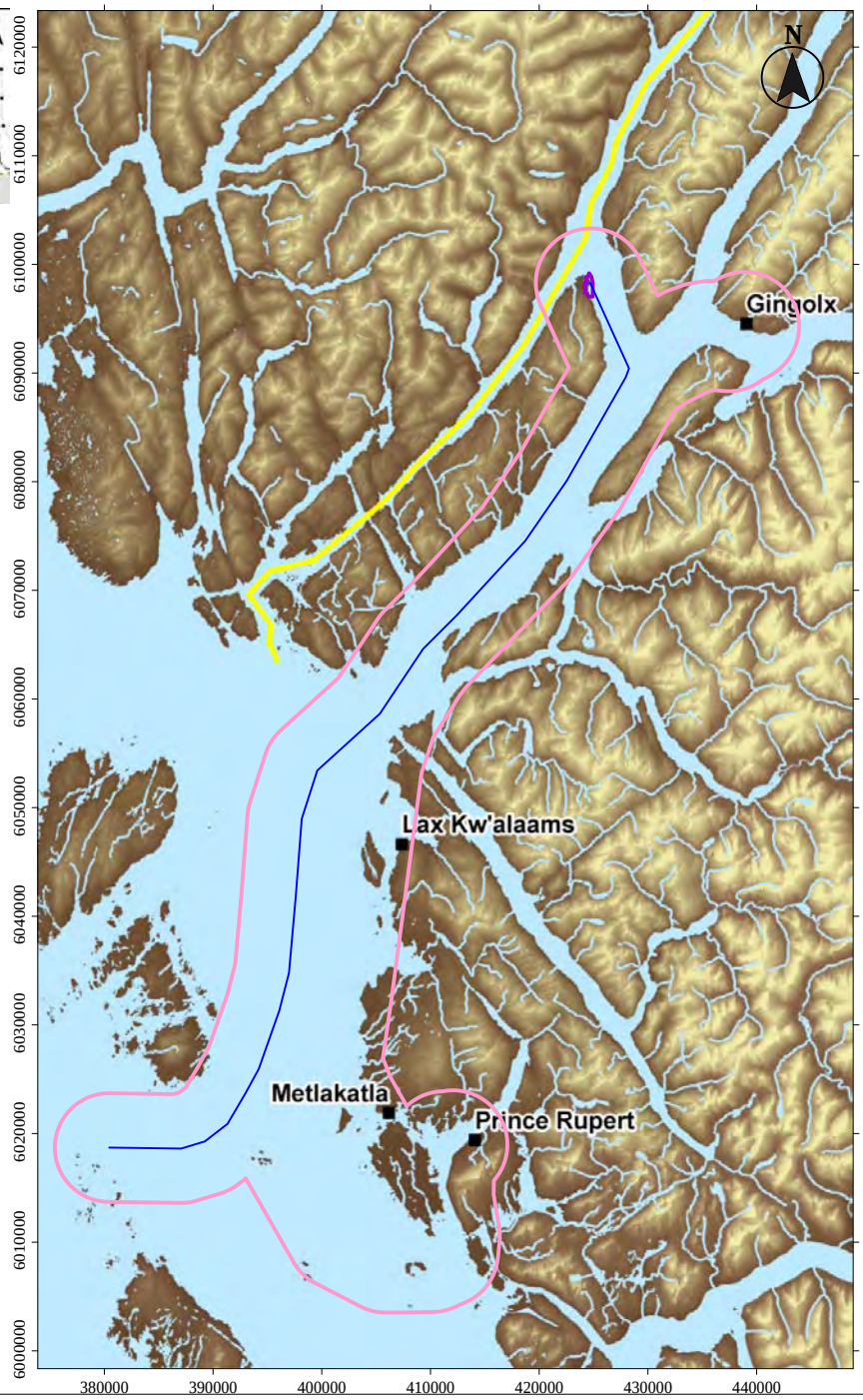
Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
4.1

Title
CALMET Model Domain and Terrain
for the Facility Assessment

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Shipping Boundary
Shipping Route

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
4.2

Title
CALMET Model Domain and Terrain
for the Operations Shipping Route

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

City/Town
International Boundary
Watercourse
Waterbody
Value
High : 1250
Low : 0

Shipping Route

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
4.3

Title
CALMET Model Domain and Terrain
for Open Water Assessment

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4.3 CALPUFF RECEPTORS

4.3.1 Gridded Receptors

For the CALPUFF model

Proposed receptor grid spacing for the Facility assessment (see Section 7.2 in the Guideline (BC ENV 2022b):

- 20 m receptor spacing along the plant boundary (as defined in Section 7.3 in the Guideline [BC ENV 2022b])
- 50 m spacing within 4.5 km x 3.5 km of the Project Sources
- 250 m spacing within 7 km x 6 km of the Project Sources
- 500 m spacing within the 10 km by 10 km of the Project Sources
- 1,000 m spacing within the 40 km by 40 km CALPUFF study area

The 50 m and 250 m spaced receptors are extended west to cover the land in the vicinity of the Project site. Where to the east, the land use is mostly water and expected to have less potential for long-term exposure to emission by marine users that are transient in nature. There are 10,038 receptors in total.

Proposed receptor grid spacing for the Operations Shipping Route assessment (see Section 7.2 in the Guideline (BC ENV 2022b):

- 20 m receptor spacing along the Operations Shipping Route
- 50 m spacing within 0.2 km of the Operations Shipping Route
- 250 m spacing within 2.0 km of the Operations Shipping Route
- 1,000 m spacing within the Operations Shipping Route
- 2,000 m spacing within the 70 km by 102 km CALPUFF study area

There are 35,244 receptors in total. Note that for reduction of computational load, the 500 m spacing receptors within 5 km and the 1,000 m spacing receptors beyond 5 km (per the Guideline) of the Operations Shipping Route are adjusted using 1,000 m spacing and 2,000 m spacing, respectively. Initial modelling results show that the maximum predicted concentrations resulting from shipping sources are predicted to occur on the shipping route. The maximum concentrations at distances within 0.2 km to 2.0 km of Operations Shipping Route are about 15% of the BC AQO for SO_2 and about 75% of the BC AQO for NO_2.The maximum concentrations at distances within 2.0 km to 5.0 km are about 10% of the BC AQO for SO_2 and about 70% of the BC AQO for NO_2. The maximum concentrations at distances beyond 5.0 km are about 10% of the BC AQO for SO_2 and about 50% of the BC AQO for NO_2.
The concentration gradient (change in concentration within distance) in the areas with reduced receptor density is small. The reduction of the receptor density does not affect the model's ability to predict spatial distribution of concentrations or identifying areas of maximum concentrations.

Proposed receptor grid spacing for the OWAA assessment (see Section 7.2 in the Guideline (BC ENV 2022b):

- 20 m receptor spacing along the Open Water Shipping Route
- 50 m spacing within 0.2 km of the Open Water Shipping Route
- 250 m spacing within 2.0 km of the Open Water Shipping Route
- 1,000 m spacing within 5.0 km of the Open Water Shipping Route
- 2,000 m spacing within the 118 km by 90 km CALPUFF study area

There are 27,713 receptors in total. Note that for reduction of computational load, the 500 m spacing receptors within 5 km and 1,000 m spacing receptors beyond 5 km (per the Guideline) of the Open Water Shipping Route are adjusted using 1,000 m spacing and 2,000 m spacing, respectively. Initial modelling results show that the maximum predicted concentrations resulted from shipping sources are predicted to occur on the shipping route. The maximum predicted SO_2 concentrations are less than 5% of the BC AQO within the study area. The maximum predicted NO_2 concentrations at distances within 0.2 km to 2.0 km are about 75% of the BC AQO. The maximum predicted NO_2 concentrations at distances within 2.0 km to 5.0 km and beyond 5.0 km are about 25% of the BC AQO. The NO_2 concentrations decrease quickly with distance (within 2 km) from the marine emission sources. The predicted concentrations of SO_2 and NO_2 at distances beyond 2.0 km are a small percentage of the BC AQO. The reduction of the receptor density does not affect the model's ability to predict spatial distribution of concentrations or identifying areas of maximum concentrations.

A map of the CALPUFF domain and receptor grid.

A map of the CALPUFF domain and gridded receptors for the Facility assessment, Operation Shipping Route assessment, and the OWAA are shown in Figure 4.3, Figure 4.4, and Figure 4.5.

Receptor (flagpole) height (m) (see Section 7.5 (BC ENV 2022b)).

Flagpole receptors are not required. There are no elevated receptors of interest nearby.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Site
Gingolx
International Boundary
Watercourse
Waterbody
Ground Elevation (m)
High : 1652
Low : 0

Ksi Lisims LNG Plant Boundary
K5 Nasoga Compressor Station
CALPUFF Gridded Receptor

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

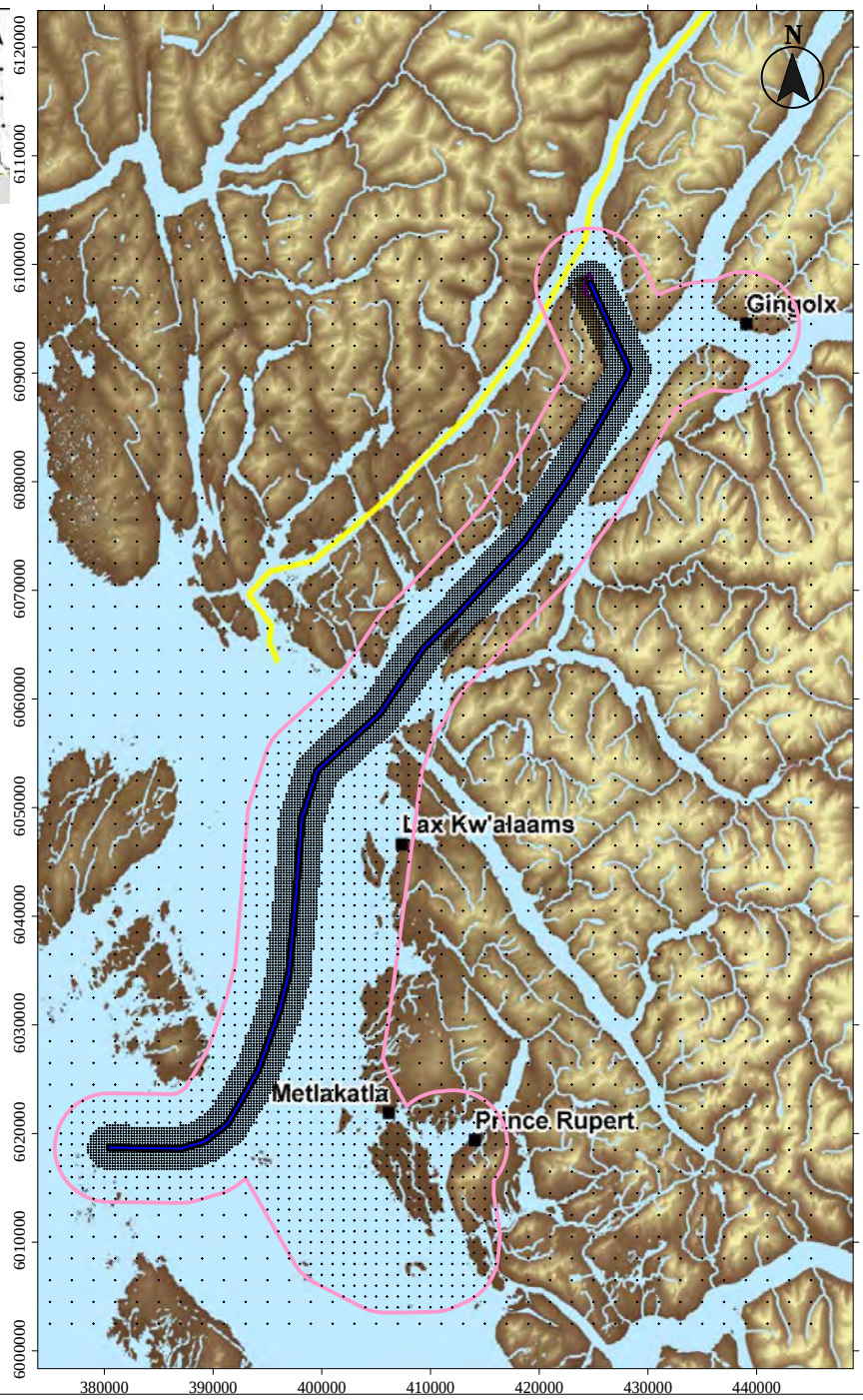
Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
4.4

Title
CALPUFF Gridded Receptors for Facility Assessment

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KSI LISIMS LNG

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

\+ CALPUFF Gridded Receptor

Shipping Boundary
Shipping Route

Metres
0 15000 30000

Stantec

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Project Location
Pearse Island, BC

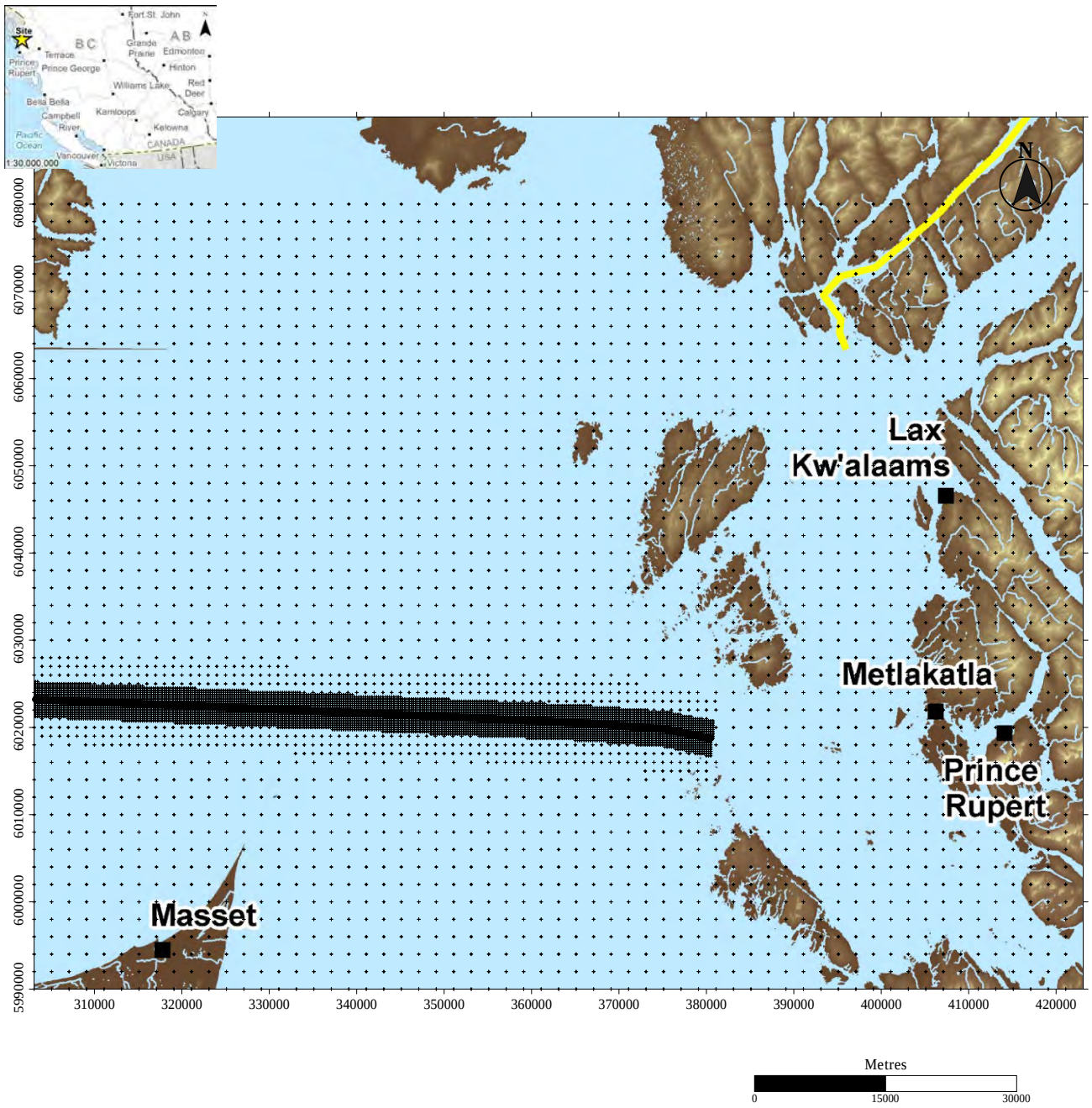
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
4.5

Title
CALPUFF Gridded Receptors for Operations Shipping Route

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

City/Town
International Boundary
Watercourse
Waterbody
Value
High : 1250
Low : 0

\+ CALPUFF Gridded Receptor

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
4.6

Title
CALPUFF Gridded Receptors for Open Water Assessment

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4.3.2 Sensitive Receptors

For the CALPUFF model the proposed sensitive receptors (see Section 7.4 in the Guideline [BC ENV 2022b]):

Sensitive receptors for the Facility assessment are listed in Table 4.1 and shown in Figure 4.4. These receptors were broadly grouped as follows:

- 11 sensitive receptors corresponding to selected lakes, creeks, and rivers for aquatics assessment.
- 24 human health sensitive receptors corresponding residential areas and Indigenous Group harvesting locations.
- 1 sensitive receptor for on-site operation accommodation

Table 4.1 Sensitive Receptors for Facility Assessment

Receptor ID	UTM Zone 9		Description
	m E	m N	
Aquatic Sensitive Receptors			
LK-01	430199	6100418	Unnamed Lake
LK-02	431403	6105518	Unnamed Lake in Dogfish Creek watershed
LK-03	429636	6105496	Unnamed Lake in Dogfish Creek watershed
LK-04	424269	6094695	Unnamed Lake
STR-01	426989	6101430	Dogfish Creek
BK-LK-01	431334	6103912	Unnamed Lake
BK-LK-02	431631	6103742	Unnamed Lake
BK-LK-03	431622	6103046	Unnamed Lake
BK-LK-04	422455	6094227	Unnamed Lake
STR-02	423984	6098260	Stream
STR-03	423005	6098167	Stream
Human Health Sensitive Receptors			
A01	439097	6094849	Gingolx Center
A02	439661	6095298	Gingolx Northeast
A03	438974	6094359	Gingolx SE shore
A04	438549	6094661	Gingolx W shore
A05	438040	6094916	Road to Marina West of Gingolx
A06	437483	6095031	Marina West of Gingolx
A07	424024	6098622	Harvesting West 200 m
A08	423291	6098529	Harvesting West 1 km
A09	422994	6098197	Harvesting West 1.2 km
A10	422548	6097873	Harvesting West 2.8 km

Table 4.1 Sensitive Receptors for Facility Assessment

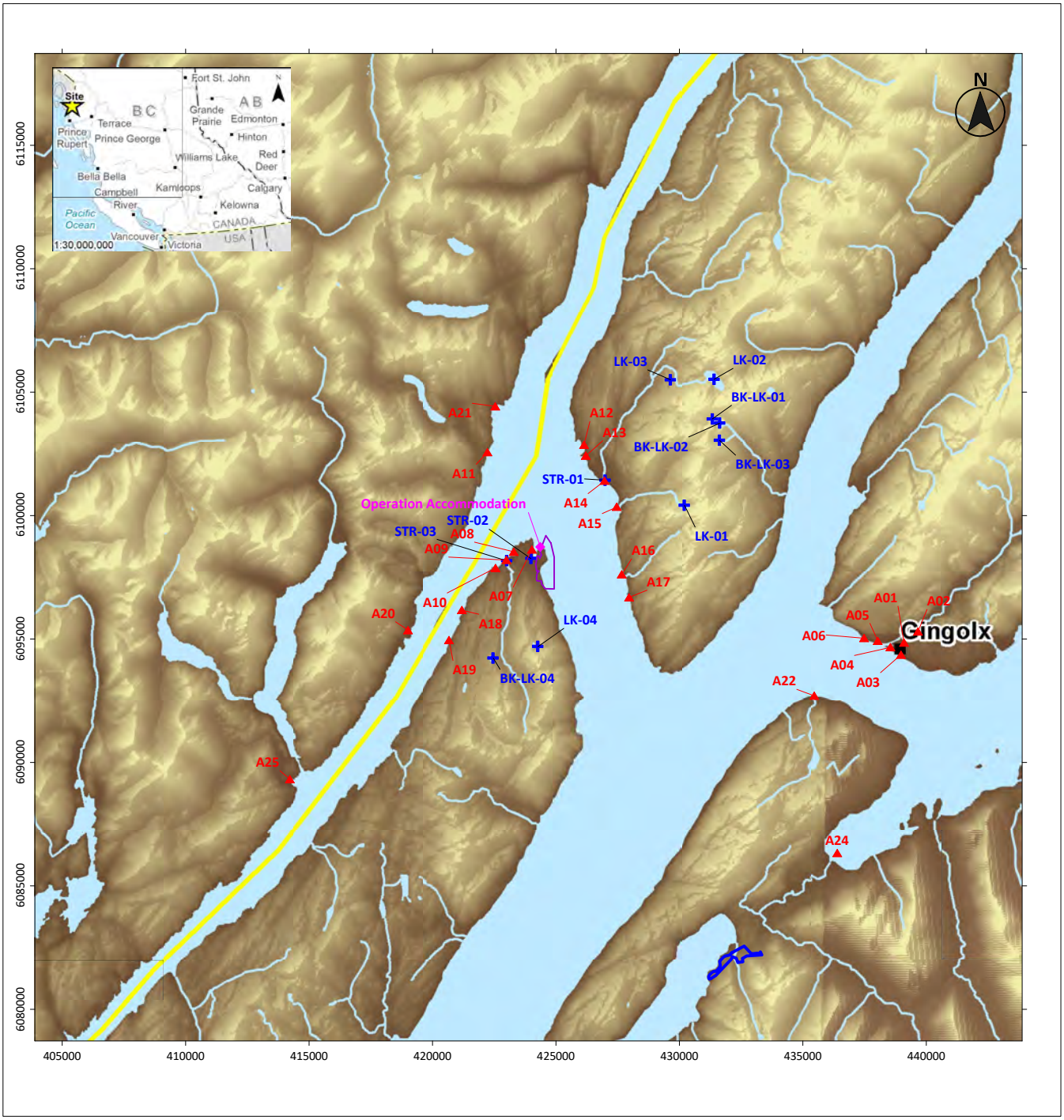
Receptor ID	UTM Zone 9		Description
	m E	m N	
A11	422225	6102566	Harvesting Northwest 5 km
A12	426135	6102864	Harvesting Northeast 5 km
A13	426209	6102420	Harvesting Northeast 4.7 km
A14	426969	6101403	Harvesting Northeast 4.2 km
A15	427463	6100351	Harvesting Northeast 4.0 km
A16	427667	6097617	Harvesting East 3.5 km
A17	427967	6096684	Harvesting Southeast 4.0 km
A18	421186	6096168	Harvesting Southwest 3.5 km
A19	420664	6094956	Harvesting Southwest 4.8 km
A20	419008	6095353	Harvesting Southwest 6.0 km
A21	422539	6104424	Harvesting Southwest 6.5 km
A22	435467	6092697	Harvesting South of Gingolx
A24	436392	6086322	Harvesting Southeast
A25	414218	6089320	Private Fishing Lodge (US) SW 13 km
Operation Accommodation	424371	6098721	On-site Worker Accommodation

Sensitive receptors corresponding to residential and Indigenous Group harvesting locations for the Operation Shipping Route assessment are listed in Table 4.2 and shown in Figure 4.7.

Table 4.2 Sensitive Receptors for Operation Shipping Route

Receptor ID	UTM Zone 9		Description
	m E	m N	
Port Simpson	407149	6046775	Community of Port Simpson
Metlakatla	405779	6021936	Community of Metlakatla

Due to the remoteness of the OWAA and the transient nature of the LNG carrier, there are no sensitive receptors identified within the OWAA.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Stantec; Rockies LNG; Maxar

Site
Gingolx
International Boundary
Watercourse
Waterbody
Ground Elevation (m)
High : 1652
Low : 0

Ksi Lisims LNG Plant Boundary
K5 Nasoga Compressor Station
Sensitive Receptors for Human Health Assessment
Sensitive Receptors for Aquatics Assessment
Sensitive Receptor for Noise Assessment

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

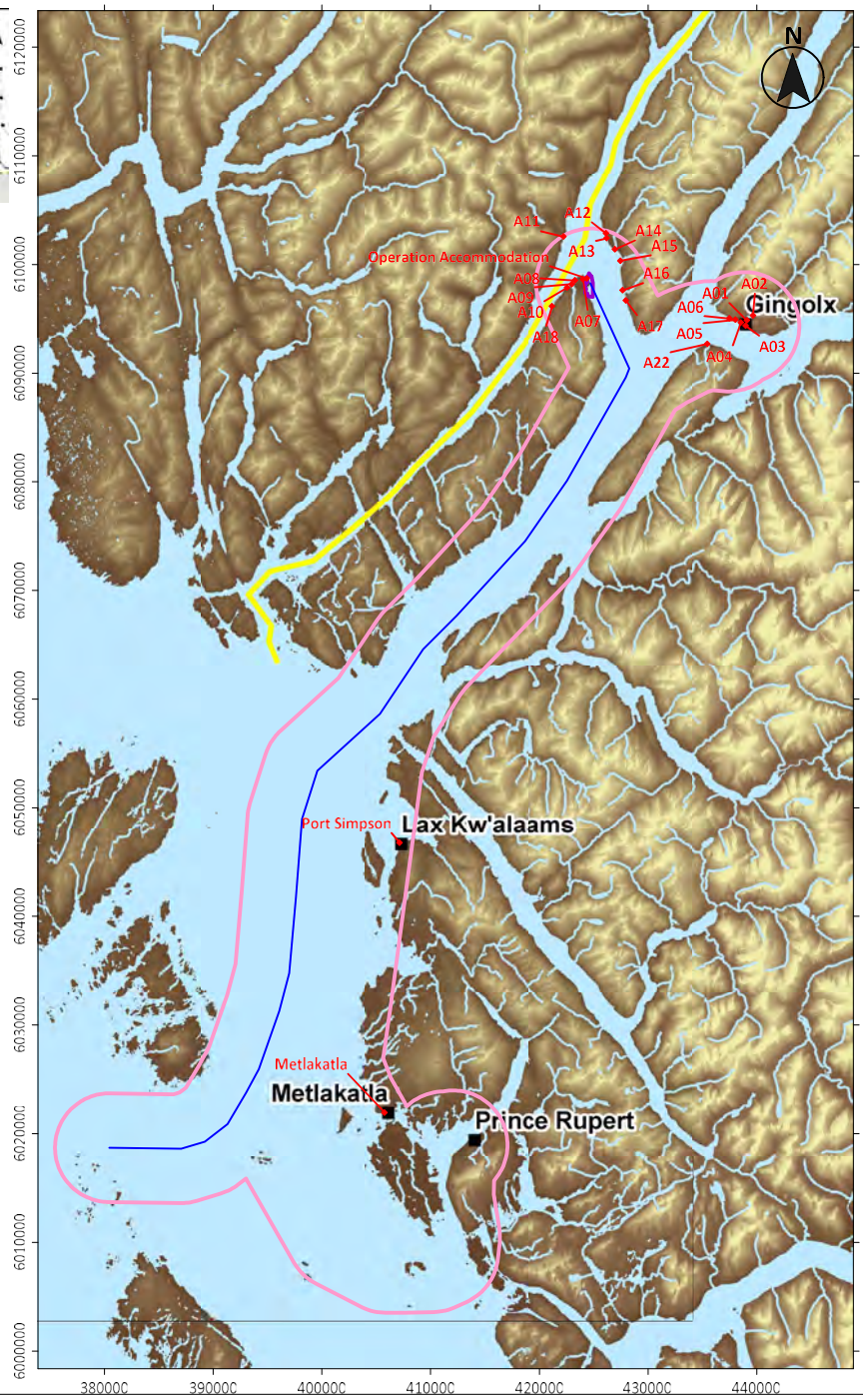
Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
4.7

Title
CALPUFF Sensitive Receptors for the Facility Assessment

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KSI LISIMS LNG

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Shipping Boundary
Shipping Route

Sensitive Receptors
for Operation Shipping Route Assessment

Metres
0 15000 30000

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Stantec; Rockies LNG; Maxar

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
4.8

Title
Sensitive Receptors
for Operation Shipping Route Assessment

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5.0 PLANNED MODEL OUTPUT: AIR QUALITY ASSESSMENT NEEDS

What model output is required for decision makers and stakeholders? (i.e., what is the purpose of the assessment?). Circle as appropriate. Air Quality: concentrations, depositions, visibility, fogging, icing, other (specify)

Model output for the Facility assessment will include predicted ground-level concentrations for NO_2, SO_2, $PM_{2.5}$, and CO and deposition rates for S, N and S+N. Project operation VOCs, and PAHs emission levels are less than Project construction. Based on past project experience (LNG Canada 2014, 2019), these pollutants are expected to be below the applicable regulatory criteria and therefore not carried forward to modelling. Further supporting information will be provided in the assessment.

Model output for the Operations Shipping Route Assessment will include predicted ground-level concentrations of NO_2 and SO_2 as these are the pollutant with the potential largest effect and will be used to show the spatial extent of predicted concentrations and the location of maximum concentrations.

$PM_{2.5}$, CO, VOCs, and PAHs emission levels from the LNG carrier and escort tugboat are similar to levels from Project construction and operation. Based on this, past project experience (Cedar 2022, LNG Canada 2014, 2019), and the transient nature of the LNG carriers it is expected that maximum concentrations of $PM_{2.5}$, CO, VOCs, and PAHs will be less than the AQO, occur close to the ship, will not persist, and will disperse quickly with increasing distance from the LNG carrier, therefore $PM_{2.5}$, CO, VOCs, and PAHs are not carried forward into the dispersion modelling for the Operations Shipping Route.

The 1-hour, 24-hour, 8-hour, and annual averages will be presented following the statistical form of the applicable regulatory criteria used for comparison.

Ambient concentrations will be assessed in the air quality valued component (VC) chapter. Ambient concentrations will also be assessed in human health and vegetation resources VC chapters. Deposition rates will be assessed in the vegetation resources and water resources VC chapters.

Tables and Figures for Level 2 and 3 Assessments (see detailed list in Section 8.3.2 (BC ENV 2022b):

Spatial distribution maps of air quality parameters (maximums, exceedance frequencies, annual averages)

Figures will include spatial distribution maps of maximum predicted concentrations for NO_2 and SO_2 for the Facility assessment, Operation Shipping Route, and OWAA. Maximum predicted concentration of $PM_{2.5}$ will be presented in spatial distribution maps for the Facility assessment only. Both hourly (i.e., 1-hour, 24-hour) and annual averages will be presented. Averages will be presented as the appropriate statistical form for comparison to the applicable air quality objective (AQO) (i.e., maximum predicted 3-year average of the 98th percentile of the daily 1-hour maximum nitrogen dioxide

concentration). Spatial distribution maps for CO will not be presented unless predicted concentrations are greater than 50% of the AQO.

If exceedances of the applicable regulatory criteria are predicted, figures showing the frequency (i.e., % of hours) of exceedance will be included.

Tables of maximum short and long term average air quality parameters (locations and associated meteorological conditions)

Tables of maximum predicted concentrations for NO_2, SO_2, $PM_{2.5}$, and CO equivalent to the statistical form of the applicable AQO (i.e., maximum predicted 3-year average of the 98th percentile of the daily 1-hour maximum nitrogen dioxide concentration) will be provided. If exceedances are predicted, the areal extent, frequency, and meteorological circumstances associated with those exceedances will be investigated.

Tables of air quality parameters at select receptors of interest (maximums, frequency distributions)

For sensitive receptors listed in Table 4.1 and Table 4.2 and shown in Figure 4.4 and Figure 4.8, tables of predicted concentrations of NO_2, SO_2, and $PM_{2.5}$ will be presented using the statistical form consistent with the World Health Organization air quality guidelines as requested by the health regulators. These results will be presented and discussed in the Human Health Assessment.

Tables of air quality parameters under abnormal emission situations (upsets, start-up)

For non-routine emission scenarios for Facility operation, tables of maximum predicted concentrations of NO_2, SO_2, $PM_{2.5}$, and CO equivalent to the statistical form of the applicable AQO (i.e., maximum predicted 3-year average of the 98th percentile of the daily 1-hour maximum nitrogen dioxide concentration) will be provided. If exceedances are predicted the areal extent, frequency, and meteorological circumstances associated with those exceedances will be investigated.

Output spatial scale: near-field (<10 km), local (<50 km), regional (>50 km)

Figures will be provided for LAA/RAA (Facility: 40 km by 40 km; Operations Shipping Route: 70 km by 102 km) if complex spatial distribution of concentrations is predicted in the vicinity of the Project or along the shipping route, additional figures for the near-field will be investigated.

Special output required for vegetation, health risk or visibility assessments

Figures of predicted deposition rates will be provided for the vegetation and water VCs. These will not be presented in the air quality assessment.

Figures for human health will be similar to those produced for the air quality assessment. Discussion of effects to human health will not be discussed in the air quality assessment.

Visibility is not assessed for the Project.

Other (specify): There are no other tables or figures proposed at this time.

6.0 EMISSION SOURCES AND CHARACTERISTICS

6.1 CONTAMINANTS EMITTED FOR EACH EMISSION SCENARIO

Provide the following details of the sources to be modelled, type, contaminants, basis of emissions

Characteristics of emissions from Project operation sources consist of those from the combustion of sweet natural gas, and intermittent sources of marine diesel combustion. Project emissions include oxides of nitrogen (NO_x), sulphur dioxide (SO_2), particulate matter with aerodynamic diameter less than 2.5 microns ($PM_{2.5}$) (including diesel $PM_{2.5}$), and carbon monoxide (CO). These substances will be carried forward in each model scenario discussed in Section 6.2. For each model scenario and for all substances the source type is Point (P).

Project operation VOCs, and PAHs emission levels are less than Project construction. Based on past project experience (LNG Canada 2014, 2019), these pollutants are expected to be below the applicable regulatory criteria and therefore not carried forward to modelling. Further supporting information will be provided in the assessment.

When considering particulate matter emissions from operation of the facility and the LNG carrier using LNG for fuel while at berth, natural gas is considered a clean burning fuel. In the combustion of natural gas all particulate matter created is considered to be $PM_{2.5}$ (U.S. EPA 1998, U.S. EPA 2022). Since $PM_{2.5}$ is a component of particulate matter with aerodynamic diameter less than 10 microns, in this case PM_{10} is comprised of only the $PM_{2.5}$ fraction. On this basis TSP and PM_{10} will not be modelled separately. Particulate matter emission from tugboats operating on diesel fuel are primarily (97%) of the $PM_{2.5}$ fraction (U.S. EPA 2022) and the remaining PM is PM_{10}. It is assumed during operation that tugboats will be operational for 3 hours every 3-4 days while an LNG carrier is at berth. Therefore, on this basis nearly all of the emitted particulate matter is in the $PM_{2.5}$ size range and that $PM_{2.5}$ is the size category with greatest potential for health effects and lowest air quality objectives, only $PM_{2.5}$ is carried forward to the modelling. PM_{10} and TSP will not be carried into the modelling for facility operations as the predicted concentrations would essentially be the same as those for $PM_{2.5}$.

The Project is not a direct emitter of ozone; however, the Project does emit precursor pollutants (i.e., NO_X, SO_2). LNG Canada demonstrated the incremental addition of precursor emissions as a result of that project is unlikely to alter the ozone production in the Kitimat airshed (LNG Canada 2014a). As the Project has similar emission sources and are of less magnitude compared to LNG Canada, the Project is not likely to substantively enhance the production of ozone in the vicinity of the Project. On this basis, modelling of ozone will not be conducted.

The Project consists of two floating LNG facilities (FLNG) with identical emission sources. The continuous emission sources located on each FLNG include a heat medium heater, thermal oxidizer, and a flare stack with continuous pilot and purge for each Warm Flare, Cold Flare, and Low Pressure Cold Flare.

The Project is obtaining electrical power from the BC Hydro grid; however, this may not be available for up to 5-years from the initiation of operations, therefore, a temporary continuous natural-gas fired combined cycle power plant will be required. Ksi Lisims proposes to use three barges (separate from the FLNGs) with three 54.6 MW natural gas-fired turbine-driven generators and one steam generator on each barge, for a total of nine natural gas-fired power generators and three steam-drive power generators. One natural gas-fired generator will be on standby. These will be located near the material offload facility. Facility equipment specifications are provided in Table 6.1 and Table 6.3. Detailed emission calculations for NO_X, SO_2, CO, $PM_{2.5}$, VOC, and total PAH, for the thermal oxidizer, heat medium heater, power generator, normal operation flares, worst case flare events, and marine vessels at the Project marine terminal are shown in Appendix B.

Part of the facility process involves an amine treatment plant, where sulphur compounds (i.e., H_2S and mercaptans), and CO_2 are stripped from the inlet feed gas. The waste gases (i.e., acid gases) are sent to the thermal oxidizer for safe disposal. A small amount (1.7 ppm_V) of sulphur remains in the clean gas that becomes LNG and fuel gas. Facility SO_2 emissions are calculated based upon the facility sulphur balance from the maximum inlet gas flow rate; maximum and average sulphur content assumptions; and hydrogen sulphide (H_2S) and other sulphur compounds (i.e., methyl mercaptan (CH_3SH), ethyl mercaptan (C_2H_5SH), propyl mercaptan (C_3H_7SH), and carbonyl sulphide (COS) concentrations in the inlet gas. H_2S and COS are removed during the amine treatment process which is then disposed of through the thermal oxidizer. Some sulphur remains in the LNG (1.7 ppmv) and natural gas liquid products (these are the light and heavy mercaptans). The average SO_2 emission rate is based on maximum feed gas flow rate (1,654 MMSCFD) and an average expected sulphur content (9 mg/sm^3). The maximum SO_2 emission rate is based on the maximum feed gas flow rate (1,654 MMSCFD) and maximum expected sulphur content (23 mg/sm^3).

Infrequently used, diesel firewater pumps, backup diesel-fired electrical generators, for backup emergency purposes are not carried forward into the modelling.

Two worst case flaring events are described in Section 6.2, equipment specifications and emission rates for these events are provided in Table 6.4.

While the LNG carriers (including propulsion main engine, auxiliary engine, and boiler) and assist tugboats are not a direct emission source of the operation of the facility, the proximity of these sources is important to consider in the assessment of the Project. There will be one LNG carrier at berth at one time, every 4 days or 150 LNG carrier visits per year. It is assumed it will take 3 hours to maneuver the LNG carrier into berth with the harbour tugs. The LNG carrier would be at berth loading LNG for 24 hours. To account for this timeframe in the modelling, the annual emission rates are calculated to reflect the frequency and length of both maneuvering and loading operations (i.e., 3 hours/day, 150 ship visits/year). The maximum emission rates (i.e., not an average of different ship activities) are used to predict 1-hour emission rates to understand worst case concentrations.

During maneuvering at the berth and while at berthing during loading of LNG, the LNG carrier will operate using boil-off gas. It is expected that boil-off gas will have no sulphur content; therefore, the SO_2

emissions for LNG carrier while at berth will be characterized as zero. Specifications for the LNG carrier and tugboats are provided in Table 6.5. The harbour tugboats are depicted operating using marine diesel.

The sources along the Operations Shipping Route include one LNG carrier and one escort tugboat. The modelling will consider two LNG carriers and escort tugboats as if passing along the shipping route, as such the emission rates used for modelling are doubled. This is considered conservative as passing ships of similar size to the LNG carrier is expected to be infrequent. This assessment is also considered for cumulative effects. Along the Operations Shipping Route the LNG carriers and escort tugboat will operate using marine diesel. Equipment specifications and emissions rates are provided in Table 6.6. For each model scenario and substances the source type is Area (A). If an exceedance of the applicable regulatory criteria is predicted for this conservative scenario, of two LNG carriers and tugboats passing, further investigation will be undertaken to understand the probability of the exceedance to likely occur. As this event of two LNG carriers and tugboats passing is infrequent (i.e., one LNG carrier and tugboat transiting the shipping route every 3-4 days). The location, frequency, and the main emission contributor to the exceedance area (i.e., LNG carrier, tugboat) would be examined.

Similarly, for the OWAA an area source type is used; however due to the remoteness of the area the emission rate for one LNG carrier is used and baseline is considered for cumulative effects.

Table 6.1 Stack Parameters and Emission Rates for Proposed Facility Equipment

Source Identification		Thermal Oxidizer	Heat Medium Heater	Power Generator
Unit Description		Continuous	Continuous	Continuous (temporary for up to 5-years)
Source Type		Point	Point	Point
Operational Data [a]				
Capacity— Output (Assume based on LHV)	MW	-	17.0 [b]	54.6 [b]
Capacity— Heat Input (HHV)	MW	5.48	22.7 [c]	154.6
Capacity— Heat Input (HHV)	GJ/h	19.7	81.6	556.5
Fuel Type		natural gas after Amine Treatment + Acid Gas	natural gas after Amine Treatment	Feed natural gas
Fuel Gas Consumption Rate	sm^3/h	3,904.2	1,976.1	13,580
Sulphur Content	mg/sm^3	-	-	9.0
Exhaust Gas Information [a]				
Exhaust Gas Flow Rate	kg/s	5.10	10.9	136.9
Exhaust Gas MW	kg/kmol	31.9	27.8	28.43
Exhaust Gas H_2O Content	%	9.49	16.9	8.04
Exhaust Gas O_2 Content (dry condition)	%	-	-	13.9

Table 6.1 Stack Parameters and Emission Rates for Proposed Facility Equipment

Source Identification		Thermal Oxidizer	Heat Medium Heater	Power Generator
NO_X	ppmv	156	-	-
SO_2	ppmv	-	0.10	-
CO	ppmv	100	100	-
Stack Parameters [a]				
Rain Cap	Yes/No	No	No	No
Release Direction		Vertical	Vertical	Vertical
Stack Height	m	41.3	27.9	42.0
Stack Diameter	m	1.6	1.2	2.8
Maximum Exit Velocity	m/s	7.5 [d]	17.0	24.0
Exit Temperature	°C	870	322.0	96.5
	K	1143.2	595.2	369.7
Emission Factors				
NO_X [a, e]	g/GJ (fuel input, HHV)	-	16.0	-
NO_X [a]	ppmvd@15%O_2	-	-	18
CO [a]	ppmvd@15%O_2	-	-	5
$PM_{2.5}$ [a]	mg/Nm^3 dry @ 15% O_2	-	-	3
$PM_{2.5}$ [f]	g/GJ (fuel input, HHV)	0.637	0.637	-
VOC (AP 42, U.S. EPA 1998)	lb/MMBtu (fuel input, HHV)	0.0054	0.0054	
VOC [a]	ppmvd@15%O_2			2
PAH (AP 42, U.S. EPA 1998) (See Table B.1)	lb/MMBtu (fuel input, HHV)	6.44E-07	6.44E-07	
PAH (AP 42, U.S. EPA 2000a)	lb/MMBtu (fuel input, HHV)			2.20E-06

Table 6.1 Stack Parameters and Emission Rates for Proposed Facility Equipment

Source Identification		Thermal Oxidizer	Heat Medium Heater	Power Generator
Maximum Emission Rates per Unit				
NO_X	t/d	0.0992 [g]	0.0313 [h]	0.3758 [i]
SO_2 (Average/Maximum)	t/d	0.2182 [j] / 0.5576 [k]	N/A / 0.0002 [g]	N/A / 0.0058 [l]
CO	t/d	0.0387 [g]	0.0949 [g]	0.0636 [i]
$PM_{2.5}$	t/d	0.0003 [m]	0.0012 [m]	0.0298 [i]
VOC	t/d	0.0011 [n]	0.0045 [n]	0.0146 [i]
PAH	t/d	1.31E-07 [n]	5.42E-07 [n]	1.26E-05 [o]
NO_X [e]	g/s	1.1477	0.363	4.350
SO_2 (Average/Maximum)	g/s	2.5250 / 6.4528	N/A / 0.003	N/A / 0.0674
CO	g/s	0.4478	1.099	0.7361
$PM_{2.5}$	g/s	0.0035	0.0144	0.3528
VOC	g/s	0.0127	0.0525	0.1694
PAH	g/s	1.52E-06	6.27E-06	1.46E-04

NOTES:

[a] Values provided by Ksi Lisims.

[b] Output denotes electrical power output capacity of natural gas-fired turbine generator.

[c] Stantec calculated based on thermal efficiency.

[d] For thermal oxidizer, exit velocity was Stantec calculated based on exhaust gas flow rate provided by Ksi Lisims

[e] Comply with the Multi-Section Air Pollutant Regulations (MSAPR) NOx emission limit (ECCC 2016).

[f] Canadian Energy Partnership for Environmental Innovation (CEPEI) emission factor (CEPEI 2022).

[g] Based on exhaust gas NO_X, SO_2, and CO contents.

[h] Based on achievement of NO_X emission limits established in the MSAPR (ECCC 2016).

[j] Based on emission factors shown in Siemens database provided by Ksi Lisims.

[J] Based on sulphur balance, provided by Ksi Lisims

[k] Calculated based on average SO_2 emission rate and ratio of maximum (23 mg/m^3) and average (9 mg/m^3) sulphur content in inlet gas.

[l] Based on feed gas sulphur content

[m] Based on CEPEI emission factor (CEPEI 2022).

[n] Based on U.S. EPA AP 42 emission factor (U.S.EPA 1998).

[o] Based on U.S. EPA AP 42 emission factor (U.S.EPA 2000a).

Table 6.2 Project Sulphur Balance

Parameter	Units	Onsite Power Generation	BC Hydro Grid
Inlet Sulphur			
Design Feed Gas Flow Rate [a]	Sm^3/hr	2,075,722	1,987,320
Average Sulphur Content [b]	mg/m^3	9	
Total Inlet Sulphur, Average [c]	kg/hr	18.6815	17.8859
Sulphur Outputs			
Fuel Gas Combustion Sulphur [d]	kg/hr	10.0691	9.0991
LNG Product + NGL Product, Sulphur [e]	kg/hr	8.6124	8.7868
Total Sulphur Output	kg/hr	18.6815	17.8859

NOTES:

[a] Provided by Ksi Lisims.

[b] Assumed average sulphur content for feed gas delivered via pipeline from northeast BC. Average sulphur content is consistent with recent assessments (i.e., Cedar LNG, LNG Canada).

[c] Stantec calculated.

[d] SO_2 exhaust concentrations were provided by Ksi Lisims, Stantec convert to sulphur for the purpose of the sulphur balance using the ratio of molecular weights (32/64).

[e] Stantec calculated assuming 3.2 ppmv sulphur remains in gas for LNG and NGL production.

Table 6.3 Stack Parameters and Emission Rates for the Proposed Flare (Normal Operation)

Source Identification		Warm Flare	Cold Flare	Low Pressure Flare
Unit Description		Pilot & Purge (Continuous)	Pilot & Purge (Continuous)	Pilot & Purge (Continuous)
Source Type		Point	Point	Point
Fuel Properties [a]				
Fuel Input (assumed based on LHV)	MW	0.063	0.063	0.063
Fuel Input (HHV)	MMBtu/h	0.236	0.236	0.236
Fuel Type		Gas after Amine Treatment	Gas after Amine Treatment	Gas after Amine Treatment
Fuel Flow Rate	sm^3/h	6.04	6.04	6.04
Fuel Sulphur Content	Mole (%)	0.00017	0.00017	0.00017
Stack Physical Parameters [a]				
Stack Height	m	158.0	158.0	158.0
Stack Diameter	m	0.813	1.219	0.610
Stack Pseudo Parameters [b]				
Stack Height	m	158.5	158.5	158.5
Stack Diameter	m	0.0810	0.0810	0.0810
Exit Velocity	m/s	20.0	20.0	20.0

Table 6.3 Stack Parameters and Emission Rates for the Proposed Flare (Normal Operation)

Source Identification		Warm Flare	Cold Flare	Low Pressure Flare
Exit Temperature	°C	1,000	1,000	1,000
	K	1,273	1,273	1,273
Emission Factors				
NO_X (AP 42, U.S.EPA 2018)	lb/MMBtu, heat input HHV	0.068	0.068	0.068
CO (AP 42, U.S.EPA 2018)	lb/MMBtu, heat input HHV	0.31	0.31	0.31
$PM_{2.5}$ [c]	kg/10^3 sm^3 fuel	0.065	0.065	0.065
VOC (AP 42, U.S. EPA 2018)	lb/MMBtu, heat input HHV	0.66	0.66	0.66
PAH (AP 42, U.S. EPA 1998) (See Table B.1)	lb/MMBtu, heat input HHV	6.44E-07	6.44E-07	6.44E-07
Emission Rates [a]				
SO_2 [d]	t/d	0.000001	0.000001	0.000001
NO_X [e]	t/d	0.0002	0.0002	0.0002
CO [e]	t/d	0.0008	0.0008	0.0008
$PM_{2.5}$ [f]	t/d	0.00001	0.00001	0.00001
VOC [e]	t/d	0.0017	0.0017	0.0017
PAH [e]	t/d	1.65E-09	1.65E-09	1.65E-09
SO_2	g/s	0.00001	0.00001	0.00001
NO_X	g/s	0.0020	0.0020	0.0020
CO	g/s	0.0092	0.0092	0.0092
$PM_{2.5}$	g/s	0.00011	0.00011	0.00011
VOC	g/s	0.0196	0.0196	0.0196
PAH	g/s	1.91E-08	1.91E-08	1.91E-08

NOTES:

[a] Values provided by Ksi Lisims.

[b] Pseudo stack parameters calculated following the methods in Section 10.1.1 of the Guideline (BC ENV 2022b).

[c] Gas heating value dependent PM emission factor (McEwen and Johnson 2012). Here the emission factor is calculated based on low heating value 37.3 MJ/sm^3.

[d] SO_2 calculated based on gas sulphur content 1.7 ppmv.

[e] NO, CO, VOC, and PAH emission estimations based on U.S. EPA AP-42 emission factors (U.S. EPA 2018).

[f] Calculated based on the gas heating value dependent PM emission factor (McEwen and Johnson 2012).

Table 6.4 Stack Parameters and Emission Rates for the Flare Scenario (Worst-Case)

Source Identification		Warm Flare (Blowdown)	Cold Flare (Blowdown)	Warm Flare (Thermal Oxidizer Trip)
Unit Description [a]				
Frequency		~1 per year		~1 per year
Duration		0.5 hour		350 hours
Fuel Properties [a]				
Fuel Input (assumed based on LHV)	MW	586.0	2704.4	0.379
Fuel Input (HHV)	MMBtu/h	2214.3	9999.1	1.43
Fuel Type		Gas After Amine Treatment	LNG	Acid Gases + Gas After Amine Treatment
Fuel Flow Rate	10^3 sm^3/h	57.3	135.3	3.22
Fuel Sulphur Content	ppmv	4.43	0.000076	598.9
Stack Physical Parameters [a]				
Stack Height	m	158.0	158.0	158.0
Stack Diameter	m	0.813	1.219	0.813
Stack Pseudo Parameters [b]				
Stack Height	m	193.7	232.2	159.1
Stack Diameter	m	7.88	16.9	0.201
Exit Velocity	m/s	20.0	20.0	20.0
Exit Temperature	°C	1,000	1,000	1,000
	K	1,273	1,273	1,273
Emission Factors				
NO_X (AP 42, U.S.EPA 2018)	lb/MMBtu, heat input HHV	0.068	0.068	0.068
CO (AP 42, U.S.EPA 2018)	lb/MMBtu, heat input HHV	0.31	0.31	0.31
$PM_{2.5}$ [c]	kg/10^3 sm^3 fuel	0.050	2.07	0.050
VOC (AP 42, U.S.EPA 2018)	lb/MMBtu, heat input HHV	0.66	0.66	0.66
PAH (AP 42, U.S. EPA 1998) (see Table B.1)	lb/MMBtu, heat input HHV	6.44E-07	6.44E-07	6.44E-07

Table 6.4 Stack Parameters and Emission Rates for the Flare Scenario (Worst-Case)

Source Identification		Warm Flare (Blowdown)	Cold Flare (Blowdown)	Warm Flare (Thermal Oxidizer Trip)
Emission Rates				
SO_2 [d]	t/d	0.0003	1.39E-08	0.125
NO_X [e]	t/d	0.034	0.154	0.001
CO [e]	t/d	0.156	0.703	0.005
$PM_{2.5}$ [f]	t/d	0.001	0.140	0.004
VOC [e]	t/d	0.331	1.496	0.010
PAH [e]	t/d	3.23E-07	1.46E-06	9.99E-09
SO_2	g/s	0.191	0.00001	1.45
NO_X	g/s	19.0	85.7	0.012
CO	g/s	86.5	391	0.056
$PM_{2.5}$	g/s	0.796	77.8	0.045

NOTES:

[a] Values provided by Ksi Lisims.

[b] Pseudo stack parameters calculated following the methods in Section 10.1.1 of the Guideline (BC ENV 2022b).

[c] Gas heating value dependent PM emission factor (McEwen and Johnson 2012). Here the emission factors are calculated based on low heating value of 36.8, 72.0, and 0.424 MJ/sm^3 for blowdown warm flare, blowdown cold flare, and thermal oxidizer trip warm flare scenarios, respectively.

[d] SO_2 calculated based on fuel gas sulphur content .

[e] NOx, CO, VOC, and PAH emission estimations based on U.S. EPA AP-42 emission factors (U.S. EPA 2018).

[f] $PM_{2.5}$ emission calculated based on the gas heating value dependent PM emission factor (McEwen and Johnson 2012).

Table 6.5 Terminal Marine Vessel Equipment Specification and Emission Summary

Unit Description		LNG Carrier (LNG as fuel)					Assist Harbor Tugboats (marine diesel fuel) [a]
		Main Engine	Auxiliary Engine		Boiler		
		Maneuvering	Maneuvering	Loading	Maneuvering	Loading	Maneuvering/Loading
Engine Power [b]	kW	31,200	8,020	8,020	371	371	4,778 [c]
Engine Group		Propulsion	Auxiliary	Auxiliary	Boiler	Boiler	Propulsion
Load Factor [d]		0.04 [e]	0.43	0.43	1.00 [b]	1.00 [b]	0.5
Berthing/Unberthing [b]	hour	3	3	24	3	24	3 [b]
Vessel Numbers Per Year [c]		150					3
Stack Dimensions [f]							
Height	m	50					15.0
Inside Tip Diameter	m	1.50					0.6
Exhaust Parameters [g]							
Exit Velocity	m/s	10.14					15.36
Exit Temperature	ºC	442					319
	K	715					592
Emission Factors							
SO_2 (U,S,EPA 2022)	g/kWh	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]	0.416
NOx (U.S.EPA 2022)	g/kWh	1.3	1.3	1.3	-	-	1.3
CO (U.S.EPA 2022)	g/kWh	1.3	1.3	1.3	-	-	2
$PM_{2.5}$ (U.S.EPA 2022)	g/kWh	0.03	0.03	0.03	-	-	0.033
VOC (U.S.EPA 2022)	g/kWh	0.053	0.053	0.053			0.017
NOx (AP 42, U.S.EPA 1998)	lb/MMBtu, heat input HHV	-	-	-	0.098	0.098	-
CO (AP 42, U.S.EPA 1998)	lb/MMBtu, heat input HHV	-	-	-	0.082	0.082	-
$PM_{2.5}$ (CEPEI 2022)	g/GJ, heat input HHV	-	-	-	0.637	0.637	-
PAH (AP 42, U.S.EPA 2000b)	lb/MMBtu, heat input HHV	2.69E-05	2.69E-05	2.69E-05			
PAH (AP 42, U.S. EPA 1998) (See Table B.1)	lb/MMBtu, heat input HHV				6.44E-07	6.44E-07	
PAH Mass Fraction of VOC (gas phase) (U.S. EPA 2018; U.S. EPA 2022) (See Table B.2)							3.36E-02
PAH Mass Fraction of Diesel PM (particle phase), (U.S. EPA 2018; U.S. EPA 2022) (see Table B.2)							5.36E-04

Table 6.5 Terminal Marine Vessel Equipment Specification and Emission Summary

Unit Description		LNG Carrier (LNG as fuel)					Assist Harbor Tugboats (marine diesel fuel) [a]
		Main Engine	Auxiliary Engine		Boiler		
		Maneuvering	Maneuvering	Loading	Maneuvering	Loading	Maneuvering/Loading
Emission Rates (Maximum) (assume all engines work simultaneously) [h]							
SO_2 [i]	kg/h	0.0					2.95
NO_X	kg/h	10.8					9.32
CO	kg/h	10.8					14.3
$PM_{2.5}$	kg/h	0.249					0.235
VOC	kg/h	0.440					0.122
PAH	kg/h	0.009					0.004 [j]
SO_2 [i]	g/s	0.0					0.829
NO_X	g/s	3.01					2.59
CO	g/s	3.00					3.98
$PM_{2.5}$	g/s	0.069					0.065
VOC	g/s	0.122					0.034
PAH	g/s	0.0003					0.0012 [j]
Emission Rates (Annual Average) (based on berthing/unberthing hours and vessel numbers per year) [k]							
SO_2	kg/h	0.0					0.153
NO_X	kg/h	2.19					0.479
CO	kg/h	2.19					0.736
$PM_{2.5}$	kg/h	0.050					0.012
VOC	kg/h	0.089					0.006
PAH	kg/h	0.0002					0.0002 [j]
SO_2	g/s	0.0					0.043
NO_X	g/s	0.609					0.133
CO	g/s	0.608					0.205
$PM_{2.5}$	g/s	0.014					0.003
VOC	g/s	0.025					0.002
PAH	g/s	4.98E-05					6.06E-05 [j]

Table 6.5 Terminal Marine Vessel Equipment Specification and Emission Summary

Unit Description	LNG Carrier (LNG as fuel)					Assist Harbor Tugboats (marine diesel fuel) [a]
	Main Engine	Auxiliary Engine		Boiler		
	Maneuvering	Maneuvering	Loading	Maneuvering	Loading	Maneuvering/Loading

NOTES:

[a] Harbor assist tugboats consist of three (4,778 kw) tugboats.

[b] From Cedar LNG (2022).

[c] Provided by Ksi Lisims LNG.

[d] Load factors were obtained from *Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions* (U.S. EPA 2022).

[e] Main engine load factor (4%) was estimated based on carrier maximum travel speed (23.7 knots, U.S. EPA 2022) and average travel speed at terminal.

[f] Assumed by Stantec.

[g] Stantec calculated.

[h] Emission rates are assumed maximum emission rates are presented for one LNG Carrier and four tugboats. Assumed all engines work simultaneously. Emission calculations for LNG carrier main engine and auxiliary engine are based on emission factors from U.S. EPA (2022) for LNG fuel. Emission calculations for tugboats are based on emission factors from U.S. EPA (2022) for marine diesel fuel. Emission calculations for boiler are based on U.S. EPA AP 42 emission factors (U.S. EPA 1998) for NOx and CO species and based on the Canadian Energy Partnership for Environmental Innovation (CEPEI) emission factor (CEPEI 2022) for PM2.5. Tugboat emissions will be discharged to the atmosphere evenly at three locations Figure 6.1

[i] SO_2 emissions for tugboats are based on 0.1% sulphur content in marine diesel (IMO 2008). LNG carriers will use boil-off gas for fuel while at berth. It is expected that there will be no sulphur content in the boil-off gas.

[j] PAH emissions are calculated based on VOC emissions and diesel PM emissions. The diesel PM emission = diesel $PM_{2.5}$ emission / 0.97 for C1 and C2 engines (U.S. EPA 2022).

[k] Emissions are presented for annual average emissions and are adjusted based on assumed 150 LNG carriers visits per year and 3 hours of maneuvering. Tugboat emissions will be discharged to the atmosphere evenly at three locations.

Table 6.6 Operations Shipping Route Marine Vessel Equipment Specification and Emission Summary

Unit Description		LNG Carrier (burn marine diesel)					Escort Tugboat (burn marine diesel)
		Main Engine	Auxiliary Engine		Boiler		
		Maneuvering	Maneuvering	Loading	Maneuvering	Loading	Maneuvering
Engine Make and Model [a]		2x Wärtsilä 16V50DF (15,600 kw each)	1x Wärtsilä 16V34DF	1x Wärtsilä 16V34DF	-	-	RAstar 4000-DF [b]
Engine Power [a]	kW	31,200	8,020	8,020	371	371	6,000 [b]
Engine Group		Propulsion	Auxiliary	Auxiliary	Boiler	Boiler	Propulsion
Engine rpm [c]		514	750	750	-	-	750
NO_X Emission Standard [c]		Tier II [d]	Tier III	Tier III	-	-	Tier III
Fuel Consumption [e]	g/kWh	205	217	217	300	300	205
Load Factor [e]		0.08 [f]	0.43	0	1.00 [a]	0	0.33 [f]
Shipping Speed [b]	knot	10.0	10.0	10.0	10.0	10.0	10.0
Shipping Speed	km/h	18.52	18.52	18.52	18.52	18.52	18.52
Route Length (from Project site to Triple Islands)[b]	km	101.4	101.4	101.4	101.4	101.4	101.4
Shipping Hours (one way)	hour	5.48	5.48	5.48	5.48	5.48	5.48
Vessel Numbers Per Year [b]		150					1
Stack Dimensions [g]							
Height	m	50.0					15.0
Inside Tip Diameter	m	1.50					0.6
Dispersion Parameters [h]							
Initial Sigma z		1.06					0.424
Initial Sigma y		1.06					0.424
Emission Factors (USEPA 2022)							
SO_2	g/kWh	0.40	0.42	0.42	0.59	0.59	0.40
NOx	g/kWh	10.50	2.60	2.60	2.00	2.00	2.60
CO	g/kWh	1.10	1.10	1.10	0.20	0.20	1.10
$PM_{2.5}$	g/kWh	0.17	0.17	0.17	0.19	0.19	0.17
VOC	g/kWh	0.53	0.42	0.42	0.11	0.11	0.53
PAH Mass Fraction of VOC (gas phase) (U.S. EPA 2018; U.S. EPA 2022) (See Table B.2)		3.36E-02	3.36E-02	3.36E-02	3.36E-02	3.36E-02	3.36E-02
PAH Mass Fraction of Diesel PM (particle phase), (U.S. EPA 2018; U.S. EPA 2022) (see Table B.2)		5.36E-04	5.36E-04	5.36E-04	5.36E-04	5.36E-04	5.36E-04

Table 6.6 Operations Shipping Route Marine Vessel Equipment Specification and Emission Summary

Unit Description		LNG Carrier (burn marine diesel)					Escort Tugboat (burn marine diesel)
		Main Engine	Auxiliary Engine		Boiler		
		Maneuvering	Maneuvering	Loading	Maneuvering	Loading	Maneuvering
Maximum Emission Rates (two ways) (worst-case scenario that two Carriers with one tug each pass each other along the shipping route) [i]							
SO_2 [j]	kg/h	8.36					1.57
NO_X	kg/h	92.5					10.2
CO	kg/h	21.6					4.30
$PM_{2.5}$	kg/h	2.76					0.672
VOC	kg/h	11.0					2.06
PAH [k]	kg/h	3.00					0.73
Maximum Emission Rates (two ways) applied for modelling for 1-hour concentration predictions [l]							
SO_2 [j]	g/s/m	1.25E-04					2.35E-05
NO_X	g/s/m	1.39E-03					1.53E-04
CO	g/s/m	3.24E-04					6.45E-05
$PM_{2.5}$	g/s/m	4.14E-05					1.01E-05
VOC	g/s/m	1.65E-04					3.09E-05
PAH [k]	g/s/m	5.57E-06					1.04E-06
Emission Rates (one way) applied for modelling for other averaging periods concentration predictions [l]							
SO_2 [j]	g/s/m	6.27E-05					1.18E-05
NO_X	g/s/m	6.94E-04					7.63E-05
CO	g/s/m	1.62E-04					3.23E-05
$PM_{2.5}$	g/s/m	2.07E-05					5.04E-06
VOC	g/s/m	8.24E-05					1.54E-05
PAH [k]	g/s/m	2.78E-06					5.22E-07
Annual Emission Rates (two ways) (based on 150 Carriers per year) [m]							
SO_2 [j]	kg/h	0.784					0.147
NO_X	kg/h	8.67					0.953
CO	kg/h	2.03					0.403
$PM_{2.5}$	kg/h	0.259					0.063
VOC	kg/h	1.03					0.193
PAH [k]	kg/h	0.371					0.070

Table 6.6 Operations Shipping Route Marine Vessel Equipment Specification and Emission Summary

Unit Description	LNG Carrier (burn marine diesel)					Escort Tugboat (burn marine diesel)
	Main Engine	Auxiliary Engine		Boiler		
	Maneuvering	Maneuvering	Loading	Maneuvering	Loading	Maneuvering

NOTES:

[a] From Cedar LNG (2022).

[b] Provided by Ksi Lisims LNG.

[c] Based on engine manufacturer information.

[d] According to USEPA (2022), Tier III propulsion engine operating below 25% load should be assigned the corresponding Tier II emission factor. This is likely that when work load is less than 25%, the exhaust temperature is too low for the emissions control technologies to work as intended.

[e] Fuel consumptions and load factors were obtained from Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions (U.S. EPA 2022).

[f] LNG main engine load factor (8%) was estimated based on Carrier maximum travel speed (23.7 knots, U.S. EPA 2022) and average travel speed 10 knots at the channel.
Escort tugboat engine load factor (33%) was estimated based on tugboat maximum travel speed (15 knots) and average travel speed 10 knots at the channel.

[g] Assumed by Stantec.

[h] Calculated by Stantec using stack diameter D divided by sqrt(2).

[i] Maximum 1-hour emissions are presented for two ships passing, i.e., two LNG Carrier and two escort tugboats. Emission calculations for LNG Carrier and escort tugboat are based on emission factors from U.S. EPA (2022) for marine diesel fuel.
Low load adjustment factors 2.42, 1.35, 2.45,1.61, and 2.95 from U.S. EPA (2022) were applied for LNG Carrier main engine SO_2, NO_X, CO, $PM_{2.5}$, and VOC emission estimations, respectively.

[j] SO_2 emissions are based on 0.1% sulphur content in marine diesel (IMO 2008).

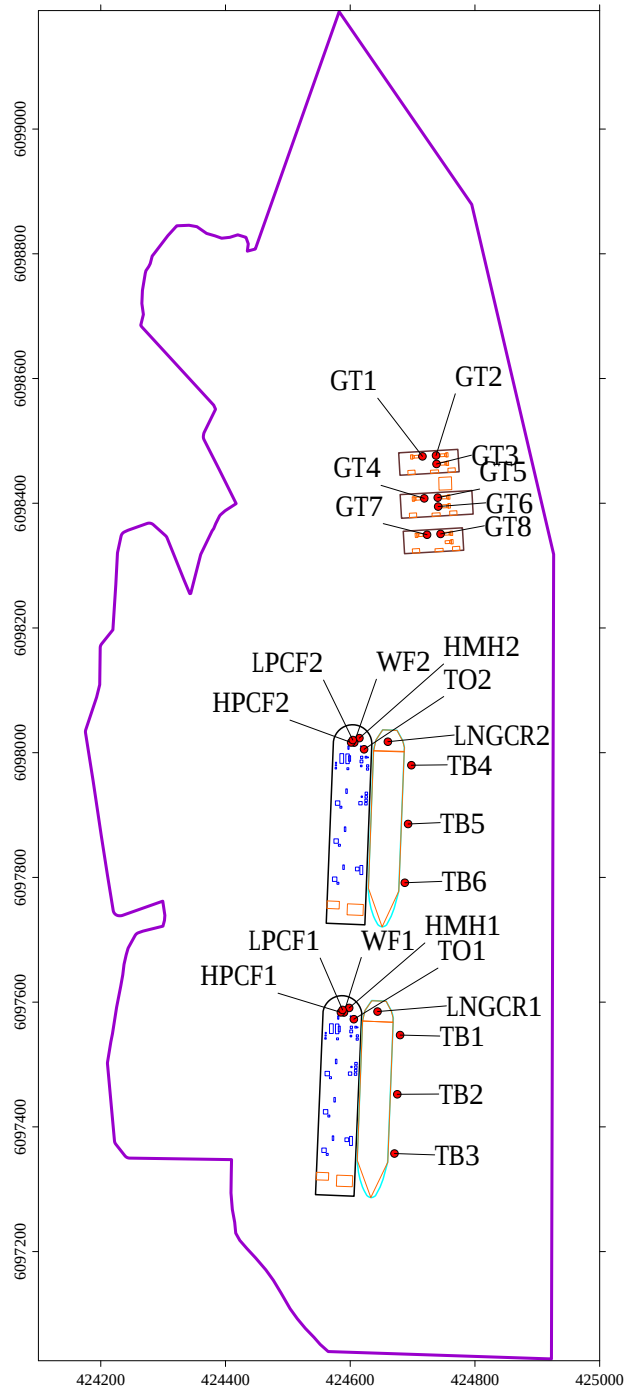
[k] PAH emissions are calculated based on VOC emissions and diesel PM emissions. The diesel PM emission = diesel $PM_{2.5}$ emission / 0.92 for ocean going engines (U.S. EPA 2022).

[l] 1-hour average emission rates are calculated based on maximum 1-hour emission rates and assumed shipping speed (18.52 km/hr). Low load adjustment factors were applied as mentioned above.

[m] Emissions are presented for annual average emissions and are adjusted based on the assumed 150 LNG Carrier visits per year and travel time along shipping route (5.5 hours).. Low load adjustment factors were applied as mentioned above in Note i.

Provide a map showing the source locations, buildings, and facility fence line.

The facility layout, showing source locations, buildings or solid structures, and the plant boundary is shown in Figure 6.1.



N

Stack ID	Stack Description
HMH1	Heat Medium Fired Heater on South Floating LNG (FLNG)
TO1	Thermal Oxidizer (Incinerator) on South FLNG
WF1	Warm Flare on South FLNG
HPCF1	HP Cold Flare on South FLNG
LPCF1	LP Cold Flare on South FLNG
HMH2	Heat Medium Fired Heater on North FLNG
TO2	Thermal Oxidizer (Incinerator) on North FLNG
WF2	Warm Flare on North FLNG
HPCF2	HP Cold Flare on North FLNG
LPCF2	LP Cold Flare on North FLNG
GT1	Gas Turbine 1
GT2	Gas Turbine 2
GT3	Gas Turbine 3
GT4	Gas Turbine 4
GT5	Gas Turbine 5
GT6	Gas Turbine 6
GT7	Gas Turbine 7
GT8	Gas Turbine 8
LNGCR1	LNG Carrier Stack
TB1	Tugboat 1
TB2	Tugboat 2
TB3	Tugboat 3
LNGCR2	LNG Carrier Stack
TB4	Tugboat 4
TB5	Tugboat 5
TB6	Tugboat 6

KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

- Ksi Lisims LNG Plant Boundary
- FLNG
- LNG Carrier
- Power Barge
- Buildings
- Drums (Cylinders)
- Stacks

Metres
0 200 400 600

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
6-1

Title
Facility Layout - Emission Sources

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

6.2 MODEL EMISSION SCENARIOS

If applicable, describe the different model emission scenarios required for the assessment if multiple options are under consideration. For example, different source characteristics (stack dimensions, emission rates) or source arrangements (locations, types, buildings) may need separate modelling runs to examine the air quality implications of different scenarios.

Eleven model scenarios have been identified to examine the air quality implications of the Project. The Base Case is based upon measured baseline (Section 7.0) as there are no existing large emission sources within the LAA/RAA that would interact with the Project emissions. Due to the remote location and lack of existing emission sources the existing air quality in the LAA/RAA is considered pristine.

The modelling scenarios will consider the Project connected to the BC Hydro grid. As well as the intermediate timeframe (up to 5-years) with on-site power generation sources. The modelling scenarios are called the Project-Alone Case (BC Hydro Option), Project-Alone Case (On-site Power Generation), Application Case (BC Hydro Option), Application Case (On-site Power Generation), Cumulative Case (BC Hydro Option), and Cumulative Case (On-site Power Generation). Two scenarios considering credible worst case flaring events will be modelled separately (Flaring Case(s)). There are three scenarios considered for the Operations Shipping Route, including the Operations Shipping Route (Project-Alone), Operations Shipping Route (Application Case), and Operations Shipping Route (Cumulative Case). Similarly for the Open Water Assessment Area; three scenarios are considered: Project-Alone, Application Case, and Cumulative Case

Emission summaries for each modelling scenario are provided below.

Project-Alone Case (BC Hydro Option): will include the proposed Project equipment only, after connection to the BC Hydro grid, operating at hourly, daily, and annual emission rates consistent with full equipment capacity. A summary of emissions is shown in Table 6.7. Units designated as backup, emergency, or on standby will be depicted in the modelling exercise as not operating.

Table 6.7 Emissions Summary for Project-Alone Case (BC Hydro Option)

Facility [a,b]	Emissions (tonnes/year)					
	NO_X	SO_2	$PM_{2.5}$	CO	VOC	PAH
Heat Medium Heater (2)	21.5	0.15	0.9	65	3.1	0.00037
Thermal Oxidizers (2)	68	150	0.2	27	0.8	0.00009
Flares (5)	0.30	0.0011	0.02	1.4	2.9	0.000003
Marine Sources (4) [c]	23	1.3	0.5 [d]	26	0.8	0.0034
Project-Alone Case (BC Hydro Option)	**113**	**151**	**1.6**	**119**	**7.6**	**0.004**

NOTES:

[a] Number presented in brackets indicated the number of operating units for each emissions source type.

[b] For annual emissions a plant availability factor of 0.94 was applied for all sources except for marine sources which are intermittent sources.

[c] Marine sources are based on the annual average emission rates in Table 6.5.

[d] $PM_{2.5}$ emissions from diesel exhaust from marine sources (i.e.,harbour tugboats) assisting the LNG carrier into the berth. This activity occurs for 3-hours every 3 to 4 days when a LNG carrier arrives at Site. During maneuvering and while at berth the LNG carrier will operate on boil-off gas (LNG gas vapours).

Project-Alone Case (On-site Power Generation): will include the proposed Project equipment, including on-site power generation sources, operating at hourly, daily, and annual emission rates consistent with full equipment capacity. A summary of emissions is shown in Table 6.8. Units designated as backup, emergency, or on standby will be depicted in the modelling exercise as not operating.

Table 6.8 Emissions Summary for Project-Alone Case (On-site Power Generation)

Facility [a,b]	Emissions (tonnes/year)					
	NO_X	SO_2	$PM_{2.5}$	CO	VOC	PAH
Heat Medium Heater (2)	21.5	0.15	0.89	65	3.1	0.00037
Thermal Oxidizers (2)	68	150	0.21	27	0.8	0.00009
Power Generators (8)	1,032	16	84	175	40	0.035
Flares (5)	0.30	0.0011	0.02	1.4	2.9	0.000003
Marine Sources (4) [c]	23	1.3	0.55 [d]	26	0.8	0.0034
Project-Alone Case (On-Site Power Generation)	**1,145**	**167**	**86**	**294**	**48**	**0.039**

NOTES:

[a] Number presented in brackets indicated the number of operating units for each emissions source type.

[b] For annual emissions a plant availability factor of 0.94 was applied for all sources except for marine sources which are intermittent sources.

[c] Marine sources are based on the annual average emission rates in Table 6.5.

[d] $PM_{2.5}$ emissions from diesel exhaust from marine sources (i.e.,harbour tugboats) assisting the LNG carrier into the berth. This activity occurs for 3-hours every 3 to 4 days when a LNG carrier arrives at Site. During maneuvering and while at berth the LNG carrier will operate on boil-off gas (LNG gas vapours).

Application Case (BC Hydro Option) will include the Project sources, after connection to the BC Hydro grid, with baseline added (Table 8.5).

Application Case (On-site Power Generation) will include the Project sources, and on-site power generation sources, with baseline added (Table 8.5).

Cumulative Case (BC Hydro Option): will include the Project sources, with baseline added (Table 8.5) (Application Case (BC Hydro Option)) (Table 6.7) and emissions from the Westcoast Connector Gas Transmission Project, specifically the K5 Nasoga compressor station (located approximately 18 km southeast of the Project Site). An emissions summary for the K5 Nasoga compressor station is provided in Table 6.9. There are no other past or present projects within the air quality LAA/RAA that will interact with emissions from the Project.

Table 6.9 Cumulative Case with BC Hydro Option

Facility	Emissions (tonnes/year)					
	NO_X	**SO_2**	**$PM_{2.5}$**	**CO**	**VOC**	**PAH**
Project-Alone Case (BC Hydro Option)	113	152	1.6	119	8.2	0.004
K5 Nasoga Compressor Station [a]	756	27	62	685	851	0.064 [b]
Total	**872**	**179**	**64**	**807**	**859**	**0.068**

NOTES:

[a] Source: Westcoast Connector Gas Transmission Ltd., 2014.

[b] Calculated based on AP 42 gas turbine PAH emission factor 2.20E-06 lb/MMBtu (U.S.EPA 2000a), reciprocating engine PAH emission factor 1.41E-04 lb/MMBtu (U.S. EPA 2000b), and heater PAH emission facto 7.44E-07 lb/MMBtu (U.S EPA 1998).

Cumulative Case (On-site Power Generation): will include the Project sources, including on-site power generation sources, with baseline added (Table 8.5) (Application Case (On-Site Power Generation)) (Table 6.8) and emissions from the Westcoast Connector Gas Transmission Project, specifically the K5 Nasoga compressor station (located approximately 18 km southeast of the Project Site). An emissions summary for the K5 Nasoga compressor station is provided in Table 6.10. There are no other past or present projects within the air quality LAA/RAA that will interact with emissions from the Project.

Table 6.10 Cumulative Case with On-site Power Generation

Facility	Emissions (tonnes/year)					
	NO_X	SO_2	$PM_{2.5}$	CO	VOC	PAH
Project-Alone Case (On-Site Power Generation)	1,148	168	86	297	48	0.039
K5 Nasoga Compressor Station [a]	756	27	62	685	851	0.064 [b]
Total	**1,904**	**195**	**148**	**982**	**899**	**0.103**

NOTES:

[a] Source: Westcoast Connector Gas Transmission Ltd., 2014.

[b] Calculated based on AP 42 gas turbine PAH emission factor 2.20E-06 lb/MMBtu (U.S.EPA 2000a), reciprocating engine PAH emission factor 1.41E-04 lb/MMBtu (U.S. EPA 2000b), and heater PAH emission facto 7.44E-07 lb/MMBtu (U.S EPA 1998).

Flaring Case(s): will include two worst case flaring events. One event is an emergency blowdown of both FLNGs through the warm and cold flares simultaneously, this represents the event with the largest volume of sweet natural gas to evaluate NO_X and $PM_{2.5}$. Emissions for this emergency blowdown event are provided in Table 6.11. The second worst case even is to evaluate high sulphur flare event which could occur if one thermal oxidizer tripped. Emissions for the thermal oxidizer trip flare even are provided in Table 6.12.

Table 6.11 Emergency Blowdown Flare Event

Facility	Emissions (g/s)					
	NO_X	SO_2 [b]	$PM_{2.5}$	CO	VOC	PAH
Warm Flare [a]	19	0.19	0.8	87	184	0.0002
Cold Flare [a]	86	0.000008	78	391	831	0.0008
Project-Alone Flare Case	**105**	**0.2**	**79**	**477**	**1,015**	**0.001**

NOTES:

Emissions are based on 0.5 hours duration.

[a] Estimated frequency for both warm flare and cold flare is once per annum, duration 0.5 hour for each flare.

[b] SO_2 emission estimations were based on the gas flow rate and gas composition including sulphur content (1.7 ppm_V) provided by Ksi Lisims.

Table 6.12 Thermal Oxidizer Trip Flare Event

Facility	Emissions (g/s)					
	NO_X	SO_2	$PM_{2.5}$	CO	VOC	PAH
Warm Flare (Thermal Oxidizer trip) [a]	0.01	1.45 [b]	0.04	0.06	0.12	1.16E-07
One Thermal Oxidizer Normal Operation	1.15	2.52	0.003	0.45	0.013	1.52E-06
Heat Medium Heater (2)	0.7	0.005	0.03	2.2	0.052	1.25E-05
Power Generators (8)	35	0.54	2.8	5.9	1.36	1.17E-03
Flares (5)	0.01	0.00004	0.0005	0.05	0.1	9.57E-08
Marine Sources (4) [c]	0.7	0.04	0.017	0.81	0.03	1.10E-04
Project-Alone Case (On-Site Power Generation)	**38**	**4.6**	**2.9**	**9.6**	**1.8**	**0.001**

NOTES:

[a] Estimated frequency for Thermal Oxidizer trip is once per annum, duration 350 hours.

[b] SO_2 emission estimation is based on the gas flow rate and gas composition including sulphur content provided by Ksi Lisims LNG.

[c] Annual average emission rates.

Operations Shipping Route (Project Alone): Occasionally LNG carriers and other large marine vessels are in the vicinity of each other for a short period of time as they travel along the shipping routes. For the purpose of this assessment to determine the worst case concentrations, modelling consists of two LNG carriers and associated escort tugboats (i.e., one for each LNG carrier) as if passing along the entire shipping route. Operating at hourly, daily, and annual emission rates. An emission summary is provided in Table 6.13.

Table 6.13 Operations Shipping Route (Project Alone)

Facility	Emissions (tonnes/year)					
	NO_X	SO_2	$PM_{2.5}$	CO	VOC	PAH
Operations Shipping Route Emissions	84.3	8.2	2.8	21.3	10.7	0.36
Total	**84.3**	**8.2**	**2.8**	**21.3**	**10.7**	**0.36**

Operations Shipping Route (Application Case): Will include the Operational Shipping Route (Project Alone) Case plus baseline(Table 8.5).

Operations Shipping Route (Cumulative Case): Will include the Operational Shipping Route with baseline added (Table 6.12) (Operations Shipping Route Application Case) and emissions from the Westcoast Connector Gas Transmission Project, specifically the K5 Nasoga compressor station. An emissions summary for the K5 Nasoga compressor station is provided in Table 6.14. There are no other past or present projects within the air quality LAA/RAA that will interact with emissions from the Project.

Table 6.14 Operations Shipping Route (Cumulative Case)

Facility	Emissions (tonnes/year)					
	NO_X	SO_2	$PM_{2.5}$	CO	VOC	PAH
Operations Shipping Route Emissions	84.3	8.2	2.8	21.3	10.7	0.36
K5 Nasoga Compressor Station [a]	756	27	62	685	851	0.064 [b]
Total	**1,901**	**195**	**148**	**980**	**862.0**	**0.42**

NOTES:

[a] Source: Westcoast Connector Gas Transmission Ltd., 2014.

[b] Calculated based on AP 42 gas turbine PAH emission factor 2.20E-06 lb/MMBtu (U.S.EPA 2000a), reciprocating engine PAH emission factor 1.41E-04 lb/MMBtu (U.S. EPA 2000b), and heater PAH emission facto 7.44E-07 lb/MMBtu (U.S EPA 1998).

6.3 SOURCE EMISSION RATE VARIABILITY

Do emissions have sub-hourly variation (e.g., blow-down flares with high emission peaks during the hour)? If so, describe the approach to assess air quality implications of those sub-hourly high emission peaks.

The worst case flaring events described in Section 5.2 occur for less than 1-hour which likely decline over the duration of the event. For modelling the flare emission rates are kept constant at the maximum emission rate for the duration of the flare event. Maximum emissions are calculated for the duration of the flare event (i.e., 30 minutes) then scaled to the 1-hour time frame (i.e., 30 minutes/60 minutes) for input into the modelling.

Describe the approach to assess air quality implications under the 25, 50, 75% emission scenario. See Section 3.4.2 (BC ENV 2022b).

Reduced capacity emission scenarios are not applicable for this facility. Equipment is assessed as operating at 100% capacity continuously.

If there are batch processes, provide a temporal emission profile (emission rate vs time) for each batch process.

There are no batch processes associated with the Project.

Describe anticipated abnormal emission scenarios (e.g., start-up, shut-down, maintenance of control works) and their anticipated frequency of occurrence. See Section 3.4.3. (BC ENV 2022b))

Flares are used to safety dispose of gases and vapours during planned and unplanned shutdown and startup of gas facilities. The worst case scenario, as described in Section 5.2, for the largest volume flared is a result of an emergency fire event occurring on the FLNG. In this event the facility would be depressured and flared. This event is infrequent, once in the lifetime of the facility, and estimated to occur for 30 minutes.

The worst case flare event with highest SO_2 emissions is a result of a thermal oxidizer malfunction. It is assumed this type of event would require the thermal oxidizer to be offline for an extended duration for repair. Flaring would occur for 350 hours. This event is expected to be infrequent occur once every 5-years of operation.

7.0 APPLICABLE AIR QUALITY OBJECTIVES

Effects on air quality are determined, in part, by comparing predicted ground-level concentrations of the substances to the applicable air quality objectives. Air quality objectives are used to gauge current and historical air quality and guide decisions on environmental effects assessments and authorizations. The regulatory criteria in British Columbia for NO_2, SO_2, $PM_{2.5}$, and CO applicable to this assessment are shown in Table 7.1 (BC ENV 2021a).

Table 7.1 British Columbia Air Quality Objectives

Substance	Averaging Interval	Air Quality Objective ($\mu g/m^3$)
NO_2	1-hour	113[a]
	Annual	32[b]
SO_2	1-hour	183[c]
	Annual	13[d]
$PM_{2.5}$	24-hour	25[e]
	Annual	8[f]
CO	1-hour	14,300
	8-hour	5,500

NOTES:

[a] Achievement for 1-hour NO_2 is based on 3-year average of the annual 98th percentile of daily 1-hour maximum. This requires the extraction of the highest predicted 1-hour value at each location for each day, followed by the calculation of the 98th percentile (the eighth highest) of those 365 values for each year, then average the three annual values.

[b] Achievement for annual NO_2 is based on the average of all 1-hour average concentrations over a single calendar year

[c] Achievement for 1-hour SO_2 is based on 3-year average of the annual 99th percentile of daily 1-hour maximum. This requires the extraction of the highest predicted 1-hour value at each location for each day, followed by the calculation of the 99th percentile (the fourth highest) of those 365 values for each year, then average the three annual values.

[d] Achievement for SO_2 is based on the average of 1-hour concentrations averaged over one year

[e] Achievement for $PM_{2.5}$ is based on annual 98th percentile of daily average, average over one year

[f] Achievement for $PM_{2.5}$ is based on annual average, average over one year

SOURCE: BC ENV 2021a

Regulatory agencies have expressed an interest in referencing objectives other than the AQO in this assessment. Specifically, they are interested in referencing the Canadian Ambient Air Quality Standards (CAAQS) for other years and the United States National Ambient Air Quality Standards (NAAQS), due the proximity (< 1 km) to the Canada-US boarder. Table 7.2 lists the CAAQS for the year 2025 for NO_2 and SO_2, and 2020 for $PM_{2.5}$, and Table 7.3 lists the NAAQS. Note, there are no CCME objectives for CO. These objectives are collectively referred to as “other regulatory criteria”.

Table 7.2 2025 Canadian Air Quality Standards

Substance	Averaging Interval	Air Quality Objective ($\mu g/m^3$)
NO_2	1-hour	79[a]
	Annual	23[b]
SO_2	1-hour	170[c]
	Annual	11[d]
$PM_{2.5}$	24-hour	27
	Annual	8.8
NOTES: The other regulatory criteria are for the year 2025 for NO_2 and SO_2, and 2020 for $PM_{2.5}$. The statistical forms for each are the same as for the applicable regulatory criteria Table 7.1 .		
SOURCE: CCME 2021		

Table 7.3 United States National Air Quality Standards

Substance	Averaging Interval	Air Quality Standard ($\mu g/m^3$)
NO_2	1-hour	188
	Annual	100
SO_2	1-hour	196
	3-hour	1,300
$PM_{2.5}$	24-hour	35
	Annual	12
PM_{10}	24-hour	150
CO	1-hour	40,065
	8-hour	10,303

NOTES:

[a] Achievement for 1-hour NO_2 is based on 3-year average of the annual 98th percentile of daily 1-hour maximum. This requires the extraction of the highest predicted 1-hour value at each location for each day, followed by the calculation of the 98th percentile (the eighth highest) of those 365 values for each year, then average the three annual values.

[b] Achievement for annual NO_2 is based on the average of all 1-hour average concentrations over a single calendar year

[c] Achievement for 1-hour SO_2 is based on 3-year average of the annual 99th percentile of daily 1-hour maximum. This requires the extraction of the highest predicted 1-hour value at each location for each day, followed by the calculation of the 99th percentile (the fourth highest) of those 365 values for each year, then average the three annual values.

[d] Achievement for 3-hour SO_2 is based on the rolling average of 1-hour concentrations one year. Not to be exceeded more than once per year.

[e] Achievement for $PM_{2.5}$ is based on annual 98th percentile of daily average, average over three years

[f] Achievement for $PM_{2.5}$ is based on annual average, average over three years

SOURCE: United States Environmental Protection Agency (U.S. EPA) 2021

8.0 BASELINE CONCENTRATION

Indicate method used to determine baseline concentrations for each pollutant (Section 8.1):

___X__monitoring data (Section 8.1.1 and 8.1.2)
_____establish monitoring program (Section 8.1.3)
_____modelled sources (Section 8.1.5)
_____other method (describe)

It is useful in this type of study to know the predicted incremental air quality contribution of the source or sources being modelled. It is also important to know about the cumulative effects on air quality. This is especially important when comparing model predictions to ambient objectives. The cumulative air quality is calculated by accounting for the contribution from all sources except the source or sources being modelled and adding that to the predicted increment from the Project. That contribution is termed 'baseline' in British Columbia.

The Guideline (BC ENV 2022b: Section 8.1) states that baseline may be determined from air quality monitoring data or may be estimated from modelling other contributing sources or a combination of both. Choosing the appropriate baseline concentration can be critical in assessing overall air quality. In order of priority, the information sources used to establish the baseline concentration level are:

- A network of long-term ambient monitoring stations near the source under study
- Long-term ambient monitoring at a different location that is adequately representative; and
- Modelled baseline

Within the LAA/RAA there are limited continuous emission sources. Influences on air quality in the LAA/RAA may include marine traffic, heating, cooking, and traffic emissions within the community of Gingolx; and emissions that are transported into the LAA/RAA from other regions. Natural background sources are also considered including wildfires and volcano activity. Steady wind flows from the Coastal mountains and from the Pacific Ocean continually bring clean air to the LAA/RAA. Overall, the existing air quality in the LAA/RAA is considered to be pristine. To consider the existing baseline air quality in the LAA/RAA ambient monitoring data will be used from other representative locations.

If existing monitoring data to be used, complete the following table: Representative Air Quality Measurements, including station name, location, period of record, contaminants measured.

Measured concentrations for NO_2, SO_2, $PM_{2.5}$, and CO were reviewed for a number of existing continuous monitoring stations in BC that were deemed representative of the study areas by considering similarities in emission sources (i.e., industrial, transportation, home heating), terrain influence, and meteorology. The monitoring stations reviewed included Prince Rupert Fairview, Kitamaat Village, Kitimat Whitesail, Kitimat Riverlodge, Smithers St. Josephs, and Quesnel Senior Secondary. The north coast passive monitoring results collected as part of the LNG Canada Project (LNGC Canada 2014a, 2014b) were also considered.

These continuous monitoring stations are part of the BC ENV monitoring network and are subject to calibration and maintenance standard operating procedures, which include monthly equipment checks and twice-yearly audits (BC ENV 2022b). Data are validated through review and analysis during a three-month process by the BC ENV air data validation team (BC ENV 2022b).

Continuous monitoring data are derived from the most recent and representative years of ambient air quality data in BC ENV's annual summaries of BC ambient air quality data (BC ENV 2021b). Data from monitoring stations is used in the baseline determination if the quarterly data validity meets or is greater than the minimum 75% threshold. A summary of monitoring station locations and substances reviewed are provided in Table 8.1.

For the LNG Canada Project, a passive monitoring network was developed in the north coast area at locations that did not have nearby continuous monitoring (LNG Canada 2014a). Passive samplers were deployed at 13 locations. Passive samples are exposed to ambient air for up to 30 days then replaced and sent for analysis at an accredited laboratory. Data validation and quality control are carried out at the laboratory and follow required protocols. Location information and substances monitored are provided in Table 8.2.

Table 8.3 provides a statistical summary of the substances measured at the monitoring locations reviewed, including Prince Rupert Fairview, Kitamaat Village, Kitimat Whitesail, Kitimat Riverlodge, Smithers St. Josephs, and Quesnel Senior Secondary. The temporal variability observed in the ambient monitoring data can be attributed to nearby and regional emissions and varying meteorological conditions. Data from years with uncommonly high concentrations (i.e., attributable to the presence of wildfire smoke) or low concentrations are not included in the calculations. Once the representative years are determined the average of these years are used to calculate the baseline concentrations. Table 8.4 provides the average concentrations measured at north coast passive monitoring locations. All measured concentrations reviewed are less than the AQOs. (Table 7.1).

Table 8.1 Summary of Monitoring Stations Locations and Substances Monitored

Monitoring Station	Elevation (m asl)	Location (UTM NAD83)			Data Period	Substances Monitored			
		m E	m N	Zone		NO_2	SO_2	$PM_{2.5}$	CO
Prince Rupert Fairview	15	412,002	6,016,925	9	2019 to 2021	x	x	x	-
Smithers St. Joseph	495	617,236	6,072,203	9	2010 and 2011	-	-	-	x
Kitamaat Village	5	522,907	5,980,599	9	2019 to 2021	-	x	x	-
Kitimat Whitesail	94	523,617	5,991,026	9	NO_2: 2020, 2021 SO_2 & $PM_{2.5}$: 2019 to 2021	x	x	x	-
Kitimat Riverlodge	18	521,509	5,989,567	9	2019 to 2021	-	x	x	-
Quesnel Senior Secondary School	490	534,024	5,870,353	10	NO_2, SO_2, $PM_{2.5}$:2019 to 2021 CO: 2011	x	x	x	x

Table 8.2 Summary of North Coast Passive Monitoring Sites for LNG Canada (LNG Canada, 2014)

Monitoring Station	Description	Elevation (m asl)	Location (UTM NAD83)			Substance Monitored			
			m E	m N	Zone	NO_2	SO_2	$PM_{2.5}$	CO
Lakelse Lake	Rural, 35 km NNE of Kitimat	120	527,424	6,025,585	9	x	x	-	-
Kitimat Haul Road	Industrial, Kitimat	21	519,504	5,986,811	9	x	x	-	-
Kitamaat Village	Residential, 8 km SSE of Kitimat	13	522,873	5,980,605	9	x	x	-	-
Terrace 1	Residential, 2 km SW of Terrace	68	526,994	6,038,371	9	x	x	-	-
Old Town	Remote, coastal	11	484,637	5,942,480	9	x	x	-	-
Gil Island	Remote, coastal	15	482,596	5,902,485	9	x	x	-	-
Promise Island	Remote, coastal	17	484,254	5,918,141	9	x	x	-	-
Terrace 2	Residential 2 km W of Terrace	65	521,472	6,041,946	9	x	x	-	-
Gitaus	Rural, 15 km NE of Terrace	151	538,192	6,051,415	9	x	x	-	-
Metlakatla	Remote, coastal	41	406,427	6,022,488	9	x	x	-	-
McCauley Island	Remote, coastal	11	410,573	5,942,805	9	x	x	-	-
Dolphin Island	Remote, coastal	17	402,148	5,956,540	9	x	x	-	-
Kitsumkalum Lake	Remote, 24 km NW of Terrace	156	514,828	6,062,139	9	x	x	-	-
NOTES: Data periods: NO_2, SO_2 2013-2014 Co-located samples were deployed at each location									
SOURCE: LNG Canada (2014b)									

Table 8.3 Summary Statistics for BC Continuous Ambient Air Quality Monitoring Stations

Statistic	NO_2 [a, b]		SO_2 [c,d]		$PM_{2.5}$ [e,f]			CO [g,h]	
	Prince Rupert Fairview	Kitimat Whitesail	Prince Rupert Fairview	Kitamaat Village	Prince Rupert Fairview	Kitamaat Village	Kitimat Whitesail	Smithers St. Josephs	Quesnel Senior Secondary School
	$\mu g/m^3$								
Maximum	60.9	37.6	7.7	121.4	15.1	15.0	14.9	2,026.5	1,934.9
99 Percentile	34.2	30.3	5.0	7.8	9.9	9.6	10.4	1,030.4	993.8
98 Percentile	29.7	21.7	3.9	4.5	8.5	8.5	8.6	881.6	804.9
90 Percentile	19.2	13.5	2.6	0.7	5.6	6.1	5.7	509.5	446.5
50 Percentile	5.6	5.6	1.0	0.3	2.7	3.1	2.9	263.3	214.1
25 Percentile	2.3	3.4	0.5	0.1	1.6	2.0	1.8	206.1	171.7
10 Percentile	0.8	2.4	0.5	0.0	1.0	1.3	1.0	160.3	143.1
Minimum	0.0	1.5	0.3	0.0	0.1	0.3	0.2	28.6	10.3
Annual Average [i]	8.1	1.0	0.7	0.7	3.1	3.5	3.3	311.8	267.2
3-year Average [j,k]	54.6	27.0	5.2	40.9	8.5	8.5	8.6	N/A	N/A

NOTES:

[a] Statistics for NO_2 are for the daily 1-hour maximum

[b] NO_2 monitoring data from Prince Rupert Fairview is for 2019 and 2020 and for Kitimat Whitesail is for 2020 and 2021

[c] Statistics for SO_2 are for the daily 1-hour maximum

[d] SO_2 monitoring data from Prince Rupert Fairview is for 2019 and 2020 and for Kitamaat Village is for 2019, 2020, and 2021

[e] Statistics for $PM_{2.5}$ are for the 24-hour average

[f] $PM_{2.5}$ monitoring data from Prince Rupert Fairview is for 2019 and 2020, and for Kitamaat Village and Kitimat Whitesail is for 2019, 2020, and 2021

[g] Statistics for CO are for the 1-hour average

[h] CO Monitoring data from Smither St. Josephs for 2010 and 2011 and for Quesnel Senior Secondary School is for 2011

[i] Annual averages are calculated using all hourly values

[j] For NO_2 and SO_2 3-year average is of the 98th and 99th percentile of the daily 1-hour maximum, respectively, for direct comparison to the AQO. However only 2-years of data are available for the Fairview station, therefore values presented are the 2-year average of the daily 1-hour maximums.

[k] For $PM_{2.5}$ the 3-year average is the 98th percentile of the daily average (24-hour) for direct comparison to the AQO. The 2-year average is calculated with the available data at the Fairview station. Kitimat Whitesail and Kitamaat Village station both have 3-years of data.

Table 8.4 Average Concentration Measured by Passive Monitoring for LNG Canada Project (LNG Canada, 2014)

Monitoring Station	Description	SO_2	NO_2
		µg/m³	µg/m³
Lakelse Lake 1	Rural, 35 km NNE of Kitimat	0.73	5.04
Lakelse Lake 2		0.77	2.85
Kitimat Haul Road 1	Industrial, Kitimat	10.11	8.56
Kitimat Haul Road 2		9.59	8.87
Kitamaat Village 1	Residential, 8 km SSE of Kitimat	1.55	2.75
Kitamaat Village 2		2.06	2.85
Terrace 1-1	Residential, 2 km SW of Terrace	0.50	4.01
Terrace 1-2		0.39	4.58
Old Town 1	Remote, coastal	1.45	2.16
Old Town 2		1.38	2.77
Gil Island 1	Remote, coastal	0.64	2.45
Gil Island 2		0.65	1.99
Promise Island 1	Remote, coastal	1.05	3.68
Promise Island 2		1.17	3.34
Terrace 2-1	Residential, 2 km W of Terrace	0.55	3.59
Terrace 2-2		0.43	6.07
Gitaus 1	Rural, 15 km NE of Terrace	0.42	3.50
Gitaus 2		0.42	2.84
Metlakatla 1	Remote, coastal	0.75	4.73
Metlakatla 2		0.59	3.86
McCauley Island 1	Remote, coastal	0.36	1.72
McCauley Island 1		0.65	1.74
Dolphin Island 1	Remote, coastal	0.79	1.25
Dolphin Island 2		0.26	1.55
Kitsumkalum Lake 1	Remote, 24 km NW of Terrace	0.36	1.41
Kitsumkalum Lake 2		0.39	1.22
NOTES: Data periods: NO_2, SO_2 2013-2014			
SOURCE: LNG Canada (2014c)			

For NO_2 and SO_2, baseline was developed from the average of passive monitoring results presented in Table 8.4 using results from the remote coastal locations, as these are most representative of the Project area. The passive monitoring locations are shown in Figure 8.1. These coastal locations have similar baseline air quality as the Project study areas as each location had limited influence from major emission sources (i.e., industry, community), and some influence from intermittent and mobile marine vessels emissions. The NO_2 baseline determined from passive monitoring (2.6 µg/m^3 for 1-hour and annual average) is similar to the 25th percentile of measured NO_2 values at Prince Rupert Fairview (2.3 µg/m^3) and the 10th percentile at Kitimat Whitesail (2.4 µg/m^3), respectively. Similarly, the baseline value for SO_2 determined from passive monitoring (0.8 µg/m^3 for 1-hour and annual average) is equivalent the 90th percentile at Kitamaat Village (0.7 µg/m^3) and 50th percentile for Prince Rupert Fairview (1.0 µg/m^3) (Table 8.3).

Section 8.1.4 of the Guideline (BC ENV 2022b) recommends developing baseline values using high percentile values which characterize baseline as a large increment of measured values (i.e., the 98th percentile for other substances hourly and daily averages, and the mean values for annual averages). These values represent the greatest effects of all local industrial sources, natural background concentrations (globally and regionally), plus minor sources (local home heating, vehicle emissions, food preparation, and road dust). However, due to the remote location of the Project and the pristine existing air quality conditions, a high percentile baseline value is not considered representative of the Project Site As seen with the passive NO_2 and SO_2 monitoring data compared to continuous monitoring data that was reviewed. The continuous monitoring data is collected in more populated areas often near large industrial sources; therefore, to determine representative baseline for $PM_{2.5}$ and CO lower percentile baseline values are selected. This is consistent with approaches taken in recent environmental assessments in BC (Cedar LNG 2022). This approach is expected to result in representative cumulative concentrations and introduces an acceptable level of uncertainty regarding baseline conditions within the study areas. The addition of baseline from monitoring locations outside of the study areas is not expected to overstate the magnitude of residual effects associated with the Project and the confidence in the assessment is high.

Existing sources of $PM_{2.5}$ in the community of Gingolx are intermittent and include fugitive dust from mechanical disturbance or wind erosion, wood burning (i.e., home heating, controlled outdoor burning, wildfires), and minor sources including on-road and marine transportation. These activities and sources of $PM_{2.5}$ are similar to that experienced in Kitamaat Village. The Kitamaat Village monitoring station is shown on Figure 8.1. On this basis, the measured 98th percentile of the 24-hour average, and annual average $PM_{2.5}$ concentration, equivalent to the BC AQO statistic, at Kitamaat Village is used for baseline in the community of Gingolx (Table 8.5).

For areas outside of Gingolx, baseline is considered to be pristine, and it is proposed to use a lower percentile value from the Kitamaat Village monitoring data to determine baseline in these other areas. A review of published literature based upon monitoring data and supported by dispersion modelling demonstrate an annual average background concentration for the natural areas of the US northwest coast of approximately 2 µg/m^3. The background concentration is primarily influenced by trans-Pacific transportation of European aerosols and Sahara dust (McKendry 2006, Keating et al 2005). There is consistency in concentration measurements over a large monitoring area consisting of the Oregon and

Washington states which suggests this value is also representative of background concentrations in similar pristine areas of BC (McKendry 2006, Jaffe et al. 2005).

Consistent with published studies that demonstrate a background concentration of approximately 2 µg/m^3, the 25th percentile 24-hour $PM_{2.5}$ concentrations from Kitamaat Village (2.0 µg/m^3) is used as the annual average $PM_{2.5}$ baseline concentration for the areas outside of Gingolx. To align with this annual average, the 50th percentile 24-hour $PM_{2.5}$ concentration (3.1 µg/m^3) is used as the baseline 24-hour average concentration for portions of the LAA/RAA outside of Gingolx (Table 8.5).

The main emission source of CO is from fuel combustion (i.e., gasoline, natural gas, diesel, wood). Sources of CO in the Project study area include intermittent marine vessels, on-road transportation, residential heating, and outdoor burning. Background levels of CO have decrease drastically over the past several decades with advancement of vehicle emission controls like catalytic convertors (Agency for Toxic Substances and Disease Registry (ATSDR) 2012). The US EPA estimates through monitoring in remote coastal areas, the annual average background CO in the Northern Hemisphere is 0.12 ppmv (137.4 µg/m^3) and a maximum of 0.20 ppmv (229.0 µg/m^3) during winter months when dispersion is poor due to more stable air masses (US EPA 2000). Urban areas tend to have higher CO concentrations proportionally to the volume of vehicle traffic and large stationary combustion sources that are present (ATSDR 2012). Measurements at Smithers St. Joseph and Quesnel Senior Secondary School are influenced by higher occurrences of activities that produce CO as a result of the larger population in those towns (i.e., transportation, residential heating, industrial sources). On this basis and to align with background values, the 50th percentile 1-hour average CO measured at St. Josephs (263.3 µg/m^3) (Table 8.5) is used for the Project's 1-hour baseline value and the St. Joseph's 25th percentile 8-hour average value (223.0µg/m^3) (Table 8.5) was considered in the identification of the Project's 8-hour baseline value. The Smithers St. Joesph's monitoring station is shown in Figure 8.1.

Baseline concentrations for Ksi Lisims LNG air quality assessment are provided in Table 8.5.



Metres

KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Elevation (m)
2800
2000
1500
1000
500
0

☆ Ksi Lisims LNG Plant

● Continuous Monitoring Stations

▲ North Coast Passive Monitoring Sites for LNG Canada

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
8.1

Title
Baseline Monitoring Station Locations

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Table 8.5 Summary of Baseline

Substance	Averaging Period	Baseline Concentration ($\mu g/m^3$)
NO_2	1-hour	2.6
	Annual	
SO_2	1-hour	0.8
	Annual	
$PM_{2.5}$ (for Gingolx)	24-hour	8.5
	Annual	3.5
$PM_{2.5}$ (LAA/RAA outside of Gingolx)	24-hour	3.1
	Annual	2.0
CO	1-hour	263.3
	8-hour	223.0

NOTES:

For NO_2 and SO_2 baseline concentrations were determined from the north coast passive monitoring conducted for the LNG Canada Project (LNG Canada 2014c)

For $PM_{2.5}$ and CO, baseline air quality data were developed by Stantec from ENV 1998-2020 summary spreadsheets (ENV 2021b). Conversions from ppb to $\mu g/m^3$ assume Standard conditions of 20°C and 101.325 kPa.

NO_2: The 1-hour and annual baseline NO_2 concentration was determined based on the average of the monthly average concentrations for remote coastal passive monitoring locations. Monitoring occurred for 2013 and 2014.

SO_2: The 1-hour and annual baseline SO_2 concentration was determined based on the average of the monthly average concentrations for remote coastal passive monitoring locations. Monitoring occurred for 2013 and 2014.

$PM_{2.5}$ (for Gingolx): The 24-hour $PM_{2.5}$ baseline was determined based on an average of the 98th percentile of the 24-hour averages for 2019, 2020, and 2021.

The annual $PM_{2.5}$ baseline was determined based on the average of the annual average for 2019, 2020, and 2021.

Baseline $PM_{2.5}$ was determined using the three most recent years of data from the most representative station: Kitamaat Village (BAM1020).

$PM_{2.5}$ (LAA/RAA outside of Gingolx): The 24-hour $PM_{2.5}$ baseline was determined based on an average of the 50th percentile of the 24-hour averages for 2019, 2020, and 2021.

The annual $PM_{2.5}$ baseline was determined based on the average of the 25th percentile of 1-hour values for 2019, 2020, and 2021.

Baseline $PM_{2.5}$ was determined using the three most recent years of data from the most representative station: Kitamaat Village (BAM1020).

CO: The 1-hour CO baseline was determined based on the average of the 50th percentile of 1-hour averages. The 8-hour baseline was determined based on the average of the 25th percentile of the 8-hour averages. Baseline was determined using the two most recent years (2010-2011) of data from the nearest representative station: Smithers St. Joseph School.

If baseline concentrations are anticipated to change in the future due to planned significant reductions or increases in emissions, provide a description of how these will be accounted for (e.g., construction of a nearby new facility or the planned decommissioning of a currently operating facility) and the uncertainties involved in estimating future emissions.

As there are no existing large emission sources in the LAA/RAA, current air quality conditions are considered pristine for which the baseline values summarized in Table 8.5 are considered representative. Besides the Ksi Lisims LNG Project, there are no other foreseeable future projects proposed within LAA/RAA. Changes to baseline in the near future are expected to be a result of the Project. On this basis no additional future baseline concentrations are considered.

For NO_2 models, provide a description of how NO_2 chemistry, location and proximity of urban regions relative to the modelled source, and proximity of nearby large industrial or transportation sources of NO_X are considered when selecting the baseline dataset (Section 3.3.2, BC ENV 2022d).

The Project Site is remote and located on Pearse Island. Current air quality conditions are considered pristine. Please see discussion of baseline determination above.

For NO_2 models, if refined baseline options are proposed (Section 3.3.2,BC ENV 2022d), show the baseline value(s) in the form of each sequential step (e.g., show the 98th percentile of daily 1-hour maximum and the 98th percentile of monthly hour-of-day values if proposing to use the Monthly Hour-of-Day option).

Refined baseline is not proposed for this assessment.

If the Monte Carlo method (Section 3.3.2.1, BC ENV 2022d) is applied for NO_2 baseline, submit the computer code used to generate results.

Monte Carlo is not proposed for this assessment.

9.0 BUILDING DOWNWASH

Potential for building downwash. Please provide rationale if building downwash is not modelled.

If building downwash included, provide a site map to indicate buildings to be processed by BPIP-PRIME, and complete the Table.

Building Profile Input Program for PRIME (BPIPPRM) can be used to prepare downwash related input for the Plume rise Model Enhancements (PRIME) building downwash algorithm. BPIPPRM can determine whether a stack is subjected to wake effects from a structure(s), and calculate building heights (BH) and projected building widths (PBW) for cases when the plume is affected by building wakes.

In multiple building situations, BPIPPRM determines building separation distances and will fill in the gap between the buildings under specific circumstances if they are “sufficiently close”. With the addition of more buildings and stacks, a maze of influence zones results, and BPPPRM automates these calculations for these complicated situations.

There is potential for building downwash from structures on the FLNGs, power barges, and LNG carriers. Most structures on the FLNG and power barges are open without walls so that air can freely flow through, reducing the effects of building downwash. These structures are also below stack height. However, there are some features on the FLNGs and power barges that could influence downwash; therefore, these have been included in BPIP-PRIME. The LNG carrier shape is a large, closed structure, generally covering the full length of the LNG carrier deck. Due to this large structure and relative height to the FLNGs these structures have been included in BPIP-PRIME. Structure dimensions are provided in Table 9.1 and locations are shown on Figure 6.1

Two LNG carriers are shown in Figure 6.1, however only one will be at berth at one time. Both LNG carriers will be modelled for building downwash to determine the worst case dispersion.

Building downwash will be modelled consistent with Section 7.6 in the Guideline (BC ENV 2022b).
For sloped or peaked roofs, the building height is equivalent to halfway between the trough and the peak, consistent with Ministry direction. Building dimensions are provided in Table 9.1 and building locations are shown on Figure 6.1.

Table 9.1 Building Dimensions

Building ID	Description	Length (m)	Width (m)	Height (m)[a]
South FLNG / LNG Carrier				
1	Working Block on FLNG	17.8	25.5	33.0
2	Transformer on FLNG	12.2	19.7	30.0
3	LNG Carrier Working Block	17.8	49.3	28.0
4	LNG Carrier Deck	223.6	63.4	18.0
46	Acid Gas KO Drum on South FLNG	1.5	1.5	30.0
47	Inlet Filter / Separator on South FLNG	2.9	2.9	35.0
48	Dehy Filter / Separator on South FLNG	1.5	1.5	42.0
49	Amine Flash Drum on South FLNG	3.6	3.6	37.5
50	Amine Contactor on South FLNG	4.6	4.6	64.9
51	Mercury Removal Drum on South FLNG	3.5	3.5	36.0
52	Mercury Removal Drum on South FLNG	3.5	3.5	36.0
53	Amine KO Drum on South FLNG	2.6	2.6	43.4
54	Dehydrator on South FLNG	4.0	4.0	39.0
55	Dehydrator on South FLNG	4.0	4.0	39.0
56	Dehydrator on South FLNG	4.0	4.0	39.0
57	Dehydrator on South FLNG	4.0	4.0	39.0
58	Condensate Stabilizer Reflux Drum on South FLNG	2.2	2.2	46.0
59	Heavies Fractionator on South FLNG	5.4	5.4	48.5
60	LNG Flash Drum on South FLNG	14.5	4.6	46.4
61	BOG Suction Drum on South FLNG	6.0	6.0	47.4
62	Heat Medium Drain/Storage Drum on South FLNG	5.5	1.9	26.0
63	Warm Flare KO Drum on South FLNG	15.6	6.0	33.5
64	Cold Flare KO Drum on South FLNG	15.6	5.5	33.5
65	Heating Medium Expansion Drum on South FLNG	9.1	3.2	62.0
66	Amine regenerator on South FLNG	3.1	3.1	68.8
67	Lean Amine Charcoal Filter on South FLNG	2.4	2.4	35.5
68	Amine Sump Charcoal Filter on South FLNG	2.0	2.0	35.5
69	Dump Drum on South FLNG	1.9	1.9	34.0
70	Refrigerant Suction Drum on South FLNG	7.1	7.1	39.5
71	Refrigerant Interstage Drum on South FLNG	7.3	2.4	45.0
72	Heavies Drum on South FLNG	3.2	3.2	33.0
73	Refrigerant Suction Drum on South FLNG	7.1	7.1	39.5
74	Refrigerant Interstage Drum on South FLNG	7.3	2.4	45.0

Table 9.1 Building Dimensions

Building ID	Description	Length (m)	Width (m)	Height (m)[a]
75	Heavies Drum on South FLNG	3.2	3.2	33.0
76	Refrigerant Suction Drum on South FLNG	7.1	7.1	39.5
77	Refrigerant Interstage Drum on South FLNG	7.3	2.4	45.0
78	Heavies Drum on South FLNG	3.2	3.2	33.0
North FLNG / LNG Carrier				
5	Working Block on FLNG	17.8	25.5	33.0
6	Transformer on FLNG	12.2	19.7	30.0
7	North LNG Carrier Working Block	17.8	49.3	28.0
8	North LNG Carrier Deck	283	63.4	18.0
79	Acid Gas KO Drum on North FLNG	1.5	1.5	30.0
80	Inlet Filter / Separator on North FLNG	2.9	2.9	35.0
81	Dehy Filter / Separator on North FLNG	1.5	1.5	42.0
82	Amine Flash Drum on North FLNG	3.6	3.6	37.5
83	Amine Contactor on North FLNG	4.6	4.6	64.9
84	Mercury Removeal Drum on North FLNG	3.5	3.5	36.0
85	Mercury Removeal Drum on North FLNG	3.5	3.5	36.0
86	Amine KO Drum on North FLNG	2.6	2.6	43.4
87	Dehydrator on North FLNG	4.0	4.0	39.0
88	Dehydrator on North FLNG	4.0	4.0	39.0
89	Dehydrator on North FLNG	4.0	4.0	39.0
90	Dehydrator on North FLNG	4.0	4.0	39.0
91	Condensate Stabilizer Reflux Drum on North FLNG	2.2	2.2	46.0
92	Heavies Fractionator on North FLNG	5.4	5.4	48.5
93	LNG Flash Drum on North FLNG	14.5	4.6	46.4
94	BOG Suction Drum on North FLNG	6.0	6.0	47.4
95	Heat Medium Drain/Storage Drum on North FLNG	5.5	1.9	26.0
96	Warm Flare KO Drum on North FLNG	15.6	6.0	33.5
97	Cold Flare KO Drum on North FLNG	15.6	5.5	33.5
98	Heating Medium Expansion Drum on North FLNG	9.1	3.2	62.0
99	Amine regenerator on North FLNG	3.1	3.1	68.8
100	Lean Amine Charcoal Filter on North FLNG	2.4	2.4	35.5
101	Amine Sump Charcoal Filter on North FLNG	2.0	2.0	35.5
102	Dump Drum on North FLNG	1.9	1.9	34.0
103	Refrigerant Suction Drum on North FLNG	7.1	7.1	39.5

Table 9.1 Building Dimensions

Building ID	Description	Length (m)	Width (m)	Height (m)[a]
104	Refrigerant Interstage Drum on North FLNG	7.3	2.4	45.0
105	Heavies Drum on North FLNG	3.2	3.2	33.0
106	Refrigerant Suction Drum on North FLNG	7.1	7.1	39.5
107	Refrigerant Interstage Drum on North FLNG	7.3	2.4	45.0
108	Heavies Drum on North FLNG	3.2	3.2	33.0
109	Refrigerant Suction Drum on North FLNG	7.1	7.1	39.5
110	Refrigerant Interstage Drum on North FLNG	7.3	2.4	45.0
111	Heavies Drum on North FLNG	3.2	3.2	33.0
Power Barges				
5	Transformer 1 on North Power Barge	6.8	11.6	22.0
6	Transformer 2 on North Power Barge	6.7	11.9	22.0
7	Control Room 1 on North Power Barge	5.1	12.9	22.0
8	GT1 working block 1 on North Power Barge	6.8	2.9	35.8
9	GT1 working block 2 on North Power Barge	6.8	3.2	34.0
10	GT1 working block 3 on North Power Barge	4.2	7.2	23.7
11	GT2 working block 1 on North Power Barge	6.9	2.8	35.8
12	GT2 working block 2 on North Power Barge	4.4	2.8	34.0
13	GT2 working block 3 on North Power Barge	4.5	7.4	23.7
14	GT3 working block 1 on North Power Barge	6.9	2.9	35.8
15	GT3 working block 2 on North Power Barge	4.6	2.9	34.0
16	GT3 working block 3 on North Power Barge	4.7	7.2	23.7
17	Transformer 3 on Middle Power Barge	7.3	11.5	22.0
18	Transformer 4 on Middle Power Barge	7.0	11.6	22.0
19	Control Room 2 on Middle Power Barge	5.3	13.1	22.0
20	GT4 working block 1 on Middle Power Barge	7.3	2.8	35.8
21	GT4 working block 2 on Middle Power Barge	7.3	3.2	34.0
22	GT4 working block 3 on Middle Power Barge	4.9	7.3	23.7
23	GT5 working block 1 on Middle Power Barge	7.2	2.9	35.8
24	GT5 working block 2 on Middle Power Barge	4.8	2.6	34.0
25	GT5 working block 3 on Middle Power Barge	4.8	7.6	23.7
26	GT6 working block 1 on Middle Power Barge	7.3	3.0	35.8
27	GT6 working block 2 on Middle Power Barge	4.9	2.6	34.0
28	GT6 working block 3 on Middle Power Barge	4.9	7.5	23.7
29	Transformer 5 on South Power Barge	6.9	11.7	22.0

Table 9.1 Building Dimensions

Building ID	Description	Length (m)	Width (m)	Height (m)[a]
30	Transformer 6 on South Power Barge	6.6	11.7	22.0
31	Control Room 3 on South Power Barge	5.0	13.0	22.0
32	GT7 working block 1 on South Power Barge	6.8	2.8	35.8
33	GT7 working block 2 on South Power Barge	7.0	3.1	34.0
34	GT7 working block 3 on South Power Barge	4.5	7.2	23.7
35	GT8 working block 1 on South Power Barge	6.8	2.8	35.8
36	GT8 working block 2 on South Power Barge	4.6	2.8	34.0
37	GT8 working block 3 on South Power Barge	4.5	7.4	23.7
38	GT9 working block 1 on South Power Barge	6.9	2.8	35.8
39	GT9 working block 3 on South Power Barge	4.5	7.2	23.7
40	GT9 working block 3 on South Power Barge	4.5	7.2	23.7
41	Sea Water Intake Between North and Middle Power Barge	20.3	20.4	22.0

NOTE:
[a] Building height is the average of peak and eave, above the water line (sea level).

10.0 GEOPHYSICAL DATA INPUT

10.1 TOPOGRAPHY AND LAND USE DATA

Terrain data (specify source of data) and an elevation map for the model domain:

- NASA 3-second Shuttle RADAR Topography Mission files (SRTM3) terrain data (~90 m resolution) (USGS 2022). Available at https://earthexplorer.usgs.gov/
- *Land use data (specify source of data) and a land use map for the Facility Assessment CALMET model domain:*
- 2015 30 m North American Land Cover data (CEC 2020). Available at: http://www.cec.org/north-american-environmental-atlas/land-cover-30m-2015-landsat-and-rapideye/
- *Land use data (specify source of data) and a land use map for Operation Shipping Route assessment and OWAA CALMET model domains:*
  - 2005 250 m North American Land Cover data (CEC 2010). Available at: http://www.cec.org/north-american-environmental-atlas/land-cover-2005-modis-250m/

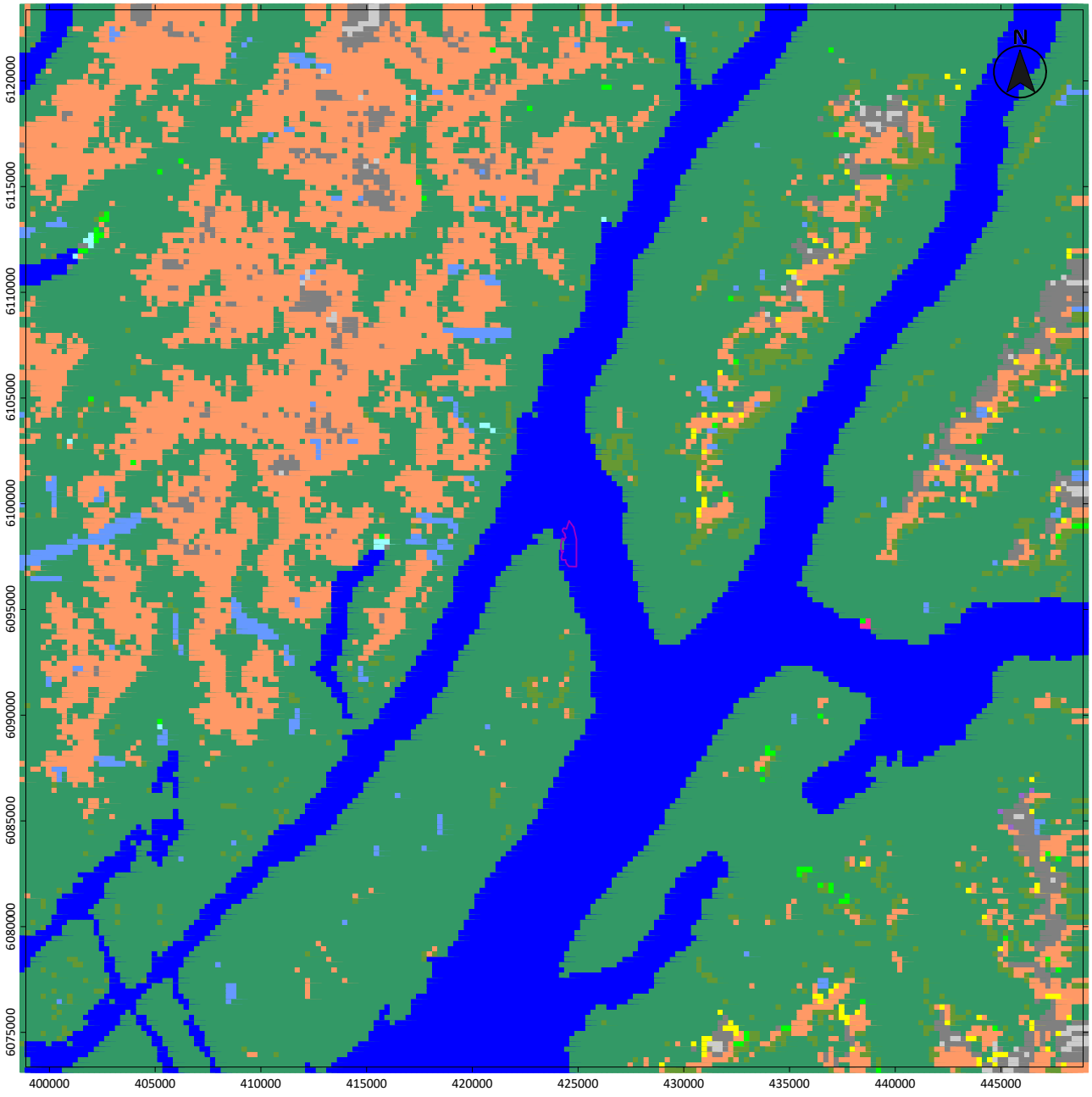
10.1.1 Surface Characteristics

For this Level 3 Assessment the five recommended seasonally varied surface characteristics (surface roughness length, albedo, Bowen ratio, soil heat flux, vegetation leaf area index, and anthropogenic heat flux) are used for the dispersion modelling study consistent with Section 4.4 in the Guideline (BC ENV 2022b).

The 30 m resolution CEC land cover data (CEC 2020) is employed by CALMET to develop a 250 m resolution land use file. Figure 10.1 illustrates the land-use classes in the CALMET model domain for the Facility assessment. Based on the 250 m CALMET grid resolution data, the domain is comprised of 57.6% evergreen forest, 19.6% water, 17.3% shrub rangeland, 2.5% mixed forest, 2.4% barren land, 0.3% rangeland, 0.2% snow or ice, 0.2% deciduous forest, 0.05% wetland and 0.01% urban land.

The 250 m resolution CEC land cover data (CEC 2010) is employed by CALMET to develop a 1 km resolution land use file for the Operation Shipping Route assessment. Figure 10.2 illustrates the land-use classes in the CALMET model domain for the Operation Shipping Route assessment. Based on the 1 km grid resolution data, the domain is comprised of 49.2% evergreen forest, 33.6% water, 7.8% shrub rangeland, 3.6% wetland, 2.8% rangeland, 1.3% deciduous forest, 0.8% barren land, 0.4% tundra, 0.2% mixed forest, 0.2% snow or ice, and 0.1% urban land.

The 250 m resolution CEC land cover data (CEC 2010) is employed by CALMET to develop a 2 km resolution land use file for the OWAA. Figure 10.3 illustrates the land-use classes in the CALMET model domain for the OWAA. Based on the 2 km grid resolution data, the domain is comprised of 80.4% water, 15.7% evergreen forest, 2.3% wetland, 1.1% rangeland, 0.3% shrub rangeland, 0.2% mixed forest, and 0.03% urban land.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

- Urban Land
- Rangeland
- Shrub Rangeland
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Small Water Body
- Large Water Body
- Wetland
- Barren Land
- Tundra
- Snow or Ice

Ksi Lisims LNG Plant Boundary

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

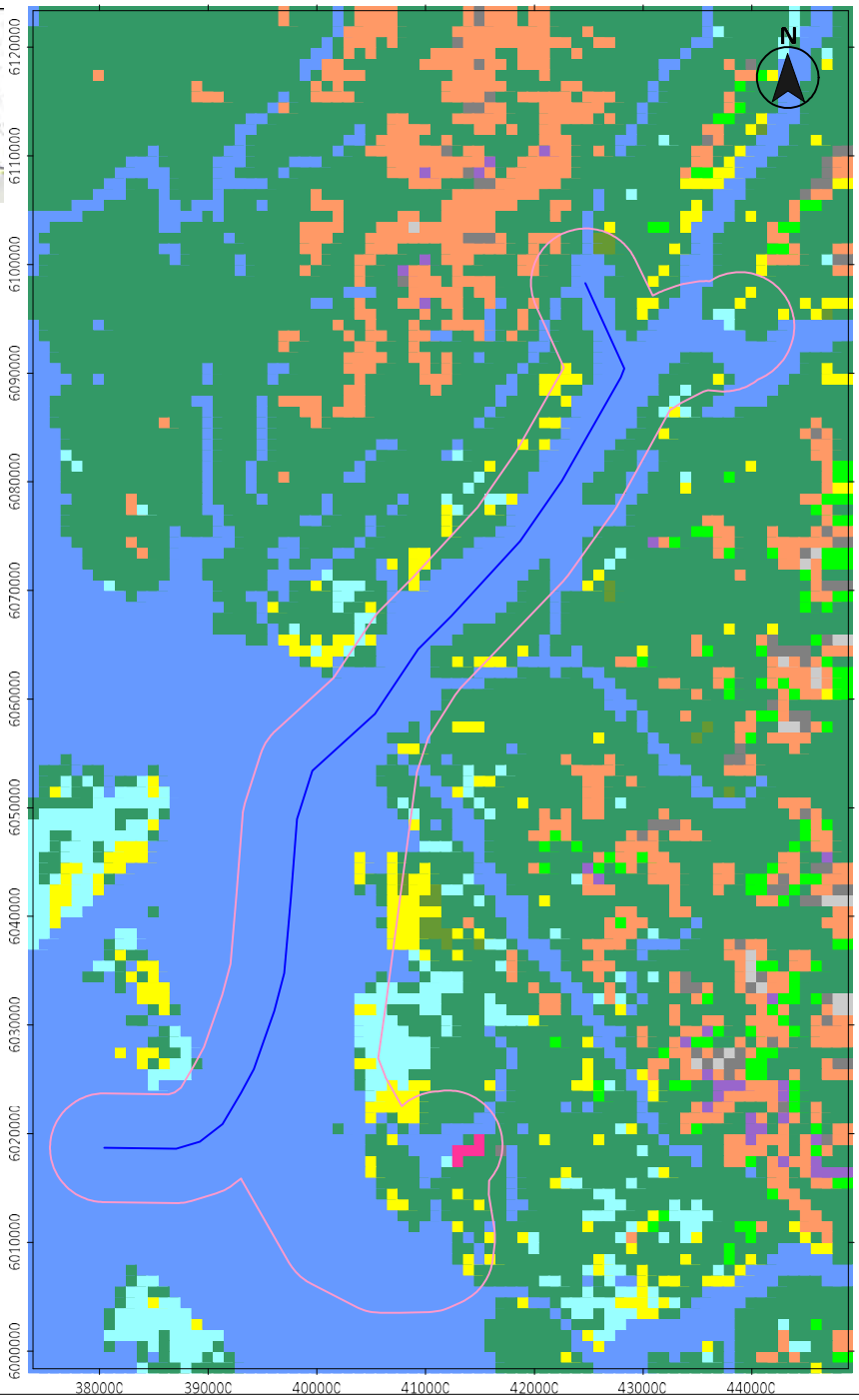
Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
10.1

Title
CALMET Land Use Classification
for Facility Assessment

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Shipping Boundary
Shipping Route

- Urban Land
- Rangeland
- Shrub Rangeland
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Water
- Wetland
- Barren Land
- Tundra
- Snow or Ice

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

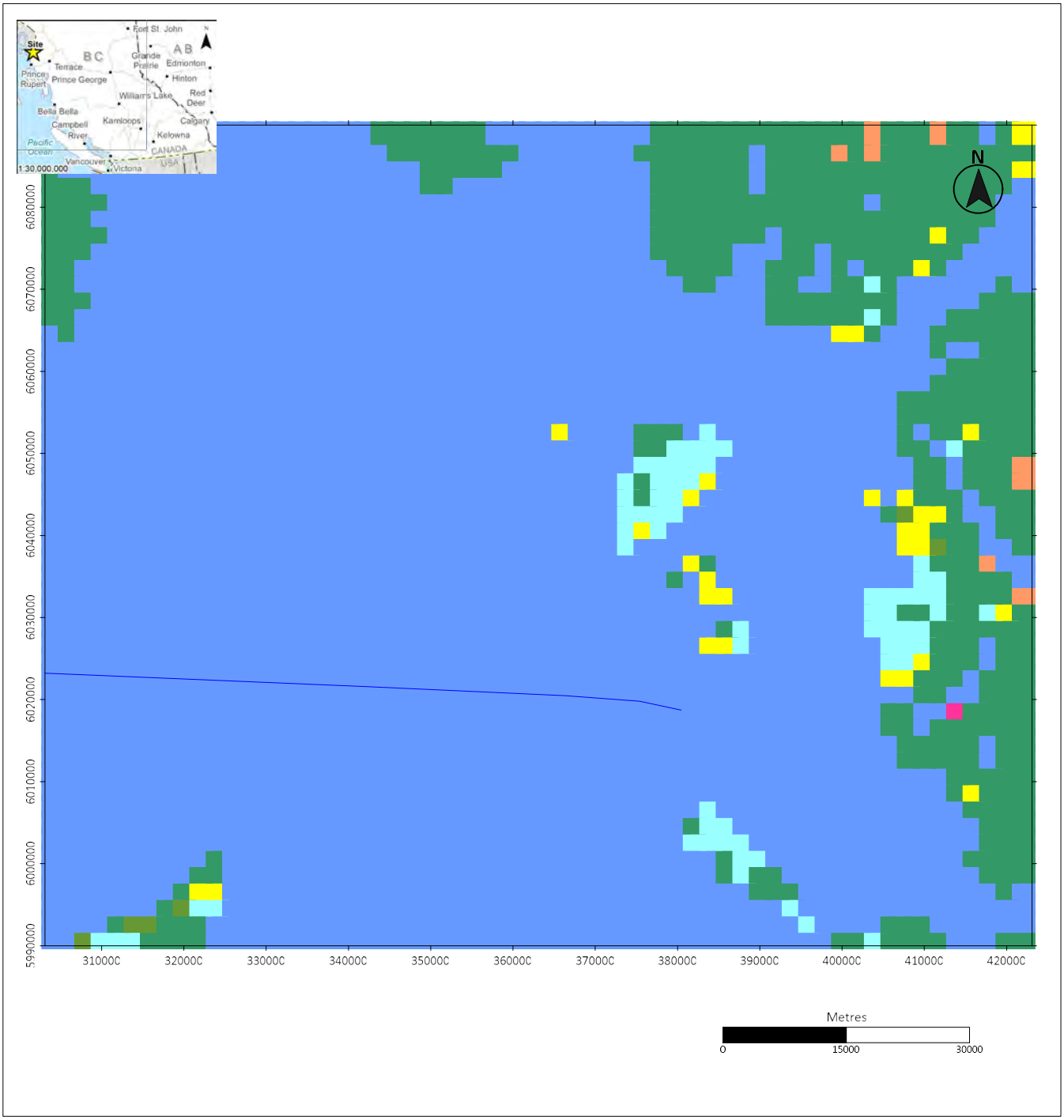
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Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
10.2

Title
CALMET Land use Classification
for Operation Shipping Route Assessment

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada; Stantec; Rockies LNG; Maxar

- Urban Land
- Rangeland
- Shrub Rangeland
- Evergreen Forest
- Mixed Forest
- Water
- Wetland

Shipping Route

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
10.3

Title
CALMET Land use Classification for Open Water Assessment

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10.2 METEOROLOGICAL DATA INPUT (FOR LEVEL 2 AND 3 ASSESSMENTS ONLY)

10.2.1 Surface Meteorological Data

Surface meteorological data will not be used in this assessment.

10.2.2 Upper-Air Meteorological Data

Upper air meteorological data will not be used in this assessment.

10.3 NUMERICAL WEATHER PREDICTION MODEL OUTPUT

The proposed numerical weather prediction model output use is as follows:

- BC ENV 2011-2015 4 km grid Weather Research Forecast (WRF) output.
- CALMET: Surface station data is not available in the Facility LAA/RAA, Operations Shipping Route LAA/RAA or OWAA. Modelling will proceed in WRF-only mode.

11.0 TREATMENTS

11.1 NO TO NO_2 CONVERSION

Identify the method to be used. Please note that the results of total conversion must be presented as part of all model reports, regardless of the conversion method selected for the project. (Section 3.2, BC ENV 2022d). Specify the considerations given to ambient concentrations, characteristics of modelled sources, and availability of relevant monitoring data when selecting the NO_2 modelling method indicated above.

NO to NO_2 conversion will be carried out using the ambient ratio method 2 (ARM 2) consistent with Section 3.2.1.2 and Appendix A of the Guidance for NO_2 Dispersion Modelling in British Columbia (NO_2 Guidance) (BC ENV 2022c. Existing air quality in the LAA/RAAs is considered pristine and there is no monitoring data available, on this basis, the Coastal Sites ARM 2 curve will be used to convert NO to NO_2, as provided in the NO_2 Guidance (BC ENV 2022c).

11.2 CHEMICAL TRANSFORMATION

Specify transformation method and provide details on inputs if secondary $PM_{2.5}$, acid deposition or visibility effects are to be estimated. Depending on the transformation method, this could include ammonia, ozone, hydrogen peroxide concentrations, nighttime loss and formation rates for nitrates and sulphates.

All of the required and recommended switch settings outlined in Section 7.8 of the 2022 Guideline (BC ENV 2022b) will be used. Ammonia, ozone, hydrogen peroxide concentrations, nighttime loss and formation rates for nitrates and sulphates are not applicable for this assessment.

11.2.1 Acidification Effects

Acid deposition model predictions by CALPUFF rely upon the transport and dispersion processes, the predictions of atmospheric chemistry, and predictions for wet and dry deposition rates within the model. The physical and chemical processes associated with predicting acid deposition are highly complex, dependent upon numerous variables which are often difficult to measure and are highly temporarily and spatially variable. Chemistry schemes in models differ from one model to the next and continue to evolve.

Dry deposition rates vary for each gas, dependent upon factors such as meteorology, biological, and surface variables. Dry deposition velocities are uncertain as dry deposition is difficult to measure directly and there exists a wide range of values in published literature for a given substance. Wet deposition is controlled by different processes including the gas/liquid concentration equilibrium, dissociation, and chemical reactions in solution. Models simplify wet deposition processes by assuming the rate of removal is proportional to the pollutant concentration by volume of precipitation. This simplification does not account for variation in the rate of gaseous absorption into raindrops, the liquid/gas vapour pressure

equilibrium which may limit absorption, and variations in equilibrium controlled by factors like precipitation pH. Acid deposition model predictions should be interpreted with an understanding of the uncertainty associated with the necessary simplifications of the complex chemical and physical process.

The chemical transformation scheme (MCHEM = 6) will be turned on per Section 7.8 of the Guideline (BC ENV 2022b). Counter to the Guideline (BC ENV 2022b), the aqueous phase chemistry flag (MAQCHEM) and Liquid Water Content flag (MLWC) will be turned off. Stantec has conducted extensive CALPUFF model performance analysis of recent deposition measurements with and without the MAQCHEM option in Kitimat. Specifically, total sulphur deposition measurements collected as part of the Rio Tinto (RT) Sulphur Dioxide Environmental Effects Monitoring Program (EEMP) were compared to CALPUFF model predictions to evaluate accuracy of sulphur deposition predictions and understand model performance and prediction bias. CALPUFF model estimates of total sulphur deposition (using MCHEM=6, RIVAD/ARM3 with ISORROPIA) were predicted for both the Coho Flats and Lakelse Lake sites and compared to total (wet plus dry) measured deposition rates at these locations for model runs both with and without the new aqueous phase enhanced chemistry and deposition option (MAQCHEM).

Predicted sulphur deposition rates for the CALPUFF model runs including the new aqueous phase enhanced chemistry and deposition model option (i.e., MAQCHEM=1) were found to significantly overpredict measured deposition rate (600% to 700%) at both Coho Flats and Lakelse Lake. The magnitude of overprediction is consistent with poor model performance. The predicted deposition rates when this model option is disabled (i.e., MAQCHEM=0) were found to also overpredict measured deposition rates; however, were acceptable from a model performance perspective (40% to 90%). The overprediction bias is likely attributable to the high precipitation rates and relative humidity on the north coast. There are no known published validation studies of CALPUFF using MAQCHEM=1 in a similar setting. Based upon the results of this comparison, it is recommended that the aqueous phase enhancement model option not be used (i.e., MAQCHEM=0) for the dispersion modelling for the Ksi Lisims LNG Project.

The predicted deposition of pollutants containing sulphur and nitrogen will be developed by dispersion modelling and then used by other disciplines (including, water quality, vegetation, and soils) to assess the acidification effects. Results will not be presented in the air quality section.

11.2.2 Secondary Particulate Formation

CALPUFF model will be used to predict secondary $PM_{2.5}$ formation attributable to precursor SO_2 and NO_X emissions.

11.3 PARTICLE DEPOSITION

If non-recommended particle size distributions (see Section 3.6) are used, provide Table of particle emission (including heavy meals if modelled) size/density distribution and indicate the basis for the Table.

As course particulate emissions are expected to be small to negligible, it is not assessed and therefore particle deposition is not a model output.

11.4 STAGNATION

Provide an estimate of the frequency of stagnation based on local meteorological data if available.

This assessment employs the CALPUFF dispersion modelling system since it can treat zero wind speeds and causality explicitly. This assessment will summarize frequency of calm conditions.

11.5 SHORE/COASTAL EFFECTS

Provide an estimate of the frequency of stagnation based on local meteorological data if available.

The combination of high-resolution prognostic model data (WRF) and high resolution CALMET (250 m) will be used to represent the complexities of land sea meteorology. The CALPUFF sub-grid-scale Thermal Internal Boundary Layer option (Shore/Coastal Effects) will not be included since the 250 m grid CALMET model gives adequate resolution of the land/water boundary in the study area.

11.6 PLUME CONDENSATION (FOGGING) AND ICING

Indicate if this will be included (Section 10.6).

Plume condensation and freezing (Fogging and Icing) is not selected as an option because the combustion source plumes have substantial buoyancy and momentum, and they are not particularly moisture laden. Condensing or freezing plumes near ground level are not expected.

12.0 QUALITY MANAGEMENT PROGRAM

12.1 MODEL INPUT DATA

Indicate the tests that will be undertaken to assure the quality of the inputs, for geophysical data, meteorological data, NWP data.

The CALMET Appendix for the technical data report will include plots and graphs depicting:

- Contour plots of topography and land use for the entire CALMET model domain.
- WRF raw data quality assurance and quality control checks (annual wind rose, monthly temperature comparison with the Prince Rupert Airport surface meteorological station). These checks will be completed using both 2011-2013 raw WRF files and 2014-2015 BC ENV supplied CALWRF files as 2014-2015 raw WRF files are no longer available for purchase.
- Wind field maps (surface and different elevations) for select periods where topographic influences (channeling, thermally driven flows) would be evident.
- Frequency distributions of various meteorological parameters (annual, seasonal) such as PG-stability class, mixing heights.
- Plots of hourly average parameters such as temperature, mixing height, precipitation at key locations (seasonal and annual).
- Selected wind fields as vector plots.

Note: All model input and output files will be submitted to the BC ENV upon request.

12.2 MODEL OUTPUT DATA

For CALMET/CALPUFF applications, provide a list of the tests conducted to confirm the quality of the model output (intermediate pre-processing files and concentration/deposition predictions). With respect to the pre-processed files that are prepared for CALPUFF input, there are several tests listed in Section 9.1.1 and 9.1.2 to check the output from the pre-processing utility programs to confirm that they have been properly processed. The quality of the meteorological outputs will be tested to ensure that specific data treatments have been applied properly. For CALMET output there are several tests listed in Section 9.1 in the Guideline (BC ENV 2022b) to test the quality of the generated meteorological fields.

The model inputs for this assessment include emission sources (locations and elevation) and emission characteristics, geographic and land use data, and meteorological data. All these data are subject to Stantec's quality management system wherein they are subject to scrutiny by a qualified Quality Reviewer and Independent Reviewer. All quality assurance related materials will be presented in dedicated Appendices to the Technical Data Report (CALMET and CALPUFF).

The quality of the meteorological outputs will be tested to ensure that specific data treatments have been applied properly. The CALMET Appendix for the technical data report will include plots and graphs as listed in Section 11.1.

12.3 MODEL PERFORMANCE EVALUATION

For Level 3 Assessments, indicate whether an assessment of model performance will be conducted as quality assurance for the project (Section 9.0, BC ENV 2022b). If not, provide rationale.

The Project Site is located in a remote area on Pearce Island. The LAA/RAA has little influence from industrial or domestic emission sources. Air quality at the Project Site is considered pristine. Due to the lack of existing emission sources in the LAA/RAA, there is no Base Case emission scenario modelled for this assessment. Similarly, there are no ambient monitoring station in the LAA/RAA. On this basis, it is not possible to conduct a standard model performance evaluation of comparing the Base Case predicted concentrations to measurements.

Inputs for the modelling including emissions rates, meteorological inputs, and baseline values will be quality assured as described above. The US EPA and other regulatory agencies have conducted extensive testing of the CALPUFF model, including evaluating uncertainties in input values, limitations of model physics, and representation of the random nature of the atmosphere by a model, leading to the accepted use of the CALPUFF in regulatory decisions. For assessments that cannot complete a model performance evaluation the US EPA (2005) recommends decision makes to use modelling as a ‘best estimate’ of effects based on understanding that the assessment follows a sound modelling methodology and used representative inputs for the Project.

Note: All model input and output files will be submitted to the BC ENV upon request.

If any of the advanced processing methods like Monte Carlo are applied, the computer code used to generate results should also be included in the submittal.

There are no advanced processing methods proposed for the assessment.

13.0 MINISTRY REVIEW OF PLAN AND REVISIONS

A modelling plan can change over the course of developing the air quality assessment so acceptance of the initial submission of the plan is on the basis of the best information provided to date. Changes to the plan (additions, modifications) should be noted and agreed to with the BC ENV as necessary. An updated Dispersion Modelling Plan may be necessary.

Ministry Acceptance of Plan

Name: _____

Date: _____

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Appendix A CALMET MODEL OPTIONS

Table A.1 Project Specific CALMET Model Options

Parameter	Default	Project	Comment
Wind Field Model Options:			
IEXTRP	-4	1	No extrapolation is done for no-obs mode model run
ICALM	0 or 1	0	Extrapolate surface winds even if calm
BIAS	0	12*0	Layer-dependent biases modifying the weights of surface and upper air stations
IPROG	2,4 or 14	14	Use gridded prognostic wind field model output fields as input to the diagnostic wind field model (from WRF 3D.DAT)
Radius of Influence Parameters:			
LVARY	F	F	Use varying radius of influence
RMAX1	-	N/A	Maximum radius of influence over land in the surface layer (km) – no surface stations used
RMAX2	-	N/A	Maximum radius of influence over land aloft (km) – no surface stations used
Other Wind Field Input Parameters:			
TERRAD	-	5	Radius of influence of terrain features (km)
R1	-	N/A	Relative weighting of the first guess field and observations in the surface layer (km) – no surface stations used
R2	-	N/A	Relative weighting of the first guess field and observations in the layers aloft (km) – no surface station used
Relative Humidity Parameters:			
IRHPROG	0	1	Use RH from WRF/3D file
Temperature Parameters:			
ITPROG	0	2	Use WRF/3D for surface and upper air temperature data

Appendix B EMISSIONS INVENTORY

B.1 OPERATIONAL PHASE EMISSION CALCULATIONS

Detailed NO_X, SO_2, CO, $PM_{2.5}$, VOC, and PAH emission calculations are provided for the Project floating LNG Facility and marine vessels at berth. Natural gas-fired emission sources including the thermal oxidizer, heat medium heater, power generator, and normal operation flare sources. Harbour tugboats will use marine diesel while assessing the LNG carriers into berth. The LNG carrier will use LNG while maneuvering and while at berth. Calculations for the marine vessels are provided below.

Calculation inputs and natural gas emission factors used for the thermal oxidizer, heat medium heater, and power generator are provided in Table 6.1 of the Dispersion Modelling Plan. Note that the SO_2 emission rate for the thermal oxidizer was provided by Ksi Lisims directly based on the Project sulphur balance (Dispersion Modelling Plan Table 6.2). The emission calculations for normal operation flaring and worst case flare events correspond to the inputs and emission values presented in Table 6.3 and Table 6.4 of the Dispersion Modelling Plan. Marine diesel and LNG emission factors used for the harbour tugboats and LNG carriers while maneuvering and at berth are provided in Table 6.5.

Note that PAH emission factor for NG external combustion source is combined from 16 PAH species AP 42 emission factors (U.S. EPA 1998). See Table B.1 for detail.

The PAH emission factors for marine diesel are obtained from *Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions* (U.S. EPA 2022) and from *Speciation Profiles and Toxic Emission Factors for Nonraod Engines in MOVES2014b* (U.S.EPA 2018). See Table B.2 for detail. The PAH species exist in both gas phase and particle phase. The PAH emissions were estimated using VOC emission rates for gas phase PAH and using diesel PM emission rates for particle phase PAH.

Table B.1 Natural Gas External Combustion Source PAH Emission Factors

PAH Species	lb/MMscf [a]	lb/MMBtu [b]
Acenaphthene	1.80E-06	1.76E-09
Acenaphthylene	1.80E-06	1.76E-09
Anthracene	2.40E-06	2.35E-09
Benz(a)anthracene	1.80E-06	1.76E-09
Benzo(a)pyrene	1.20E-06	1.18E-09
Benzo(b)fluoranthene	1.80E-06	1.76E-09
Benzo(g,h,i)perylene	1.20E-06	1.18E-09
Benzo(k)fluoranthene	1.80E-06	1.76E-09
Chrysene	1.80E-06	1.76E-09
Dibenzo(a,h)anthracene	1.20E-06	1.18E-09
Fluoranthene	3.00E-06	2.94E-09
Fluorene	2.80E-06	2.75E-09
Phenanthrene	1.70E-05	1.67E-08
Pyrene	5.00E-06	4.90E-09
Indeno(1,2,3,c,d)pyrene	1.80E-06	1.76E-09
Naphthalene	6.10E-04	5.98E-07
Total PAH		**6.44E-07**

NOTES:

[a] U.S. EPA AP 42 emission factor (U.S. EPA 1998)

[b] To convert from $1b/10^6$ scf to lb/MMBt, divide by 1,020

Table B.2 Marine Diesel PAH Emission Factors

PAH Species	Mass Fraction	
	Basis of VOC	**Basis of Diesel PM [a]**
Acenaphthene	5.09E-05 [b]	0 [c]
Acenaphthylene	1.18E-04 [b]	0 [c]
Anthracene	3.44E-04 [b]	2.90E-05 [c]
Benz(a)anthracene	7.81E-06 [c]	8.82E-06 [b]
Benzo(a)pyrene	0 [c]	4.18E-06 [b]
Benzo(b)fluoranthene	0 [c]	8.35E-06 [b]
Benzo(g,h,i)perylene	5.70E-06 [c]	7.55E-06 [c]
Benzo(k)fluoranthene	0 [c]	4.18E-06 [b]
Chrysene	7.68E-06 [c]	1.63E-05 [b]
Dibenzo(a,h)anthracene	0 [c]	8.65E-06 [b]
Fluoranthene	1.45-04 [c]	8.97E-05 [b]
Fluorene	1.64E-04 [b]	7.98E-05 [c]
Phenanthrene	1.36E-03 [b]	2.37E-04 [c]
Pyrene	1.30E-04 [c]	3.37E-05 [b]
Indeno(1,2,3,c,d)pyrene	0 [c]	8.35E-06 [b]
Naphthalene	3.13E-02 [b]	0 [c]
Total PAH	**3.36E-02**	**5.36E-04**

NOTES:

[a] For conservative purpose, use diesel PM not diesel $PM_{2.5}$

[b] U.S. EPA (2022)

[c] Emission factors for "Tier 2, Tier 3, & Tier 4: no DPF" engine (U.S. EPA 2018)

Thermal Oxidizer

$$NOx\ emission\ rate\ (t/d) = \left(\frac{Exhaust\ gas\ flow\ rate\ \left(\frac{kg}{s}\right)}{Exhaust\ gas\ MW\ \left(\frac{kg}{kmol}\right)}\right) * \frac{NOx\ content\ (ppmv)}{10^6} * NOx\ MW\ \left(\frac{kg}{kmol}\right) *$$

$$* Unit\ conversion\ \left(\frac{3600\ s}{1\ h}\right) * Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ \left(\frac{1\ tonne}{10^3 kg}\right)$$

$$CO\ emission\ rate\ (t/d) = \left(\frac{Exhaust\ gas\ flow\ rate\ \left(\frac{kg}{s}\right)}{Exhaust\ gas\ MW\ \left(\frac{kg}{kmol}\right)}\right) * \frac{CO\ content\ (ppmv)}{10^6} * CO\ MW\ \left(\frac{kg}{kmol}\right) * Unit\ conversion\ \left(\frac{3600\ s}{1\ h}\right) * Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ \left(\frac{1\ tonne}{10^3 kg}\right)$$

$$PM_{2.5}\ emission\ rate\ (t/d) = PM_{2.5}\ emission\ factor\ \left(\frac{g}{GJ}\right) * Heat\ input\ (HHV)\ \left(\frac{GJ}{h}\right) * Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ \left(\frac{1\ tonne}{10^6 g}\right)$$

$$VOC\ emission\ rate\ (t/d) = VOC\ emission\ factor\ \left(\frac{lb}{MMBtu}\right) * Heat\ input\ (HHV)\ \left(\frac{MMBtu}{h}\right) * Unit\ conversion\ \left(\frac{kg}{2.205\ lb}\right) * Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ \left(\frac{1\ tonne}{10^3 kg}\right)$$

$$PAH\ emission\ rate\ (t/d) = PAH\ emission\ factor\ \left(\frac{lb}{MMBtu}\right) * Heat\ input\ (HHV)\ \left(\frac{MMBtu}{h}\right) * Unit\ conversion\ \left(\frac{kg}{2.205\ lb}\right) * Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ \left(\frac{1\ tonne}{10^3 kg}\right)$$

Heat Medium Heater

$$NOx\ emission\ rate\ (t/d) = NOx\ emission\ factor\ \left(\frac{g}{GJ}\right) * Heat\ input\ (HHV)\ \left(\frac{GJ}{h}\right) * Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ \left(\frac{1\ tonne}{10^6 g}\right)$$

$$SO_2\ emission\ rate\ (t/d) = \left(\frac{Exhaust\ gas\ flow\ rate\ \left(\frac{kg}{s}\right)}{Exhaust\ gas\ MW\ \left(\frac{kg}{kmol}\right)}\right) * \frac{SO_2\ content\ (ppmv)}{10^6} * SO_2\ MW\ \left(\frac{kg}{kmol}\right) * Unit\ conversion\ \left(\frac{3600\ s}{1\ h}\right) * Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ \left(\frac{1\ tonne}{10^3 kg}\right)$$

$$VOC\ emission\ rate\ (t/d)$$
$$= VOC\ emission\ factor\ \left(\frac{lb}{MMBtu}\right) * \ Heat\ input\ (HHV)\left(\frac{MMBtu}{h}\right)$$
$$* \ Unit\ conversion\ \left(\frac{kg}{2.205\ lb}\right) * Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ (\frac{1\ tonne}{10^3 kg})$$

The CO,$PM_{2.5}$, and PAH emission calculation approaches for the heat medium heater are the same as for the thermal oxidizer.

Power Generator

$$NOx\ emission\ rate\ (t/d)$$
$$= \left(\frac{Exhaust\ gas\ flow\ rate\ \left(\frac{kg}{s}\right)}{Exhaust\ gas\ MW\ \left(\frac{kg}{kmol}\right)}\right) * \frac{(100 - water\ content\ (\%))}{100}$$
$$* \left(\frac{(20.9 - dry\ O_2\ content\ (\%))}{(20.9 - 15)}\right) * \frac{NOx\ emission\ factor\ (ppmvd@15\%\ O_2)}{10^6}$$
$$* \ NOx\ MW\ \left(\frac{kg}{kmol}\right) * Unit\ conversion\ \left(\frac{3600\ s}{1\ h}\right) * \ Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right)$$
$$* Unit\ conversion\ (\frac{1\ tonne}{10^3 kg})$$

$$SO_2\ emission\ rate\ (t/d)$$
$$= Fuel\ consumption\ \left(\frac{sm^3}{h}\right)$$
$$* Sulphur\ content\ \left(\frac{mg}{sm^3}\right) * Sulphur\ to\ SO_2\ conversion\ factor\ \left(\frac{64}{32}\right)$$
$$* \ Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ (\frac{1\ tonne}{10^9 mg})$$

$$CO\ emission\ rate\ (t/d)$$
$$= \left(\frac{Exhaust\ gas\ flow\ rate\ \left(\frac{kg}{s}\right)}{Exhaust\ gas\ MW\ \left(\frac{kg}{kmol}\right)}\right) * \frac{(100 - water\ content\ (\%))}{100}$$
$$* \left(\frac{(20.9 - dry\ O_2\ content\ (\%))}{(20.9 - 15)}\right) * \frac{CO\ emission\ factor\ (ppmvd@15\%\ O_2)}{10^6}$$
$$* \ CO\ MW\ \left(\frac{kg}{kmol}\right) * Unit\ conversion\ \left(\frac{3600\ s}{1\ h}\right) * \ Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right)$$
$$* Unit\ conversion\ (\frac{1\ tonne}{10^3 kg})$$

$$PM_{2.5}\ emission\ rate\ (t/d)$$
$$= \left(\frac{Exhaust\ gas\ flow\ rate\ \left(\frac{kg}{s}\right)}{Exhaust\ gas\ MW\ \left(\frac{kg}{kmol}\right)}\right)$$
$$* \ Molar\ volume\ conversion\ factor\ at\ normal\ condition \left(\frac{22.414\ m^3}{kmol}\right)$$
$$* \frac{\left(100 - water\ content\ (\%)\right)}{100} * \left(\frac{\left(20.9 - dry\ O_2\ content\ (\%)\right)}{(20.9 - 15)}\right)$$
$$* PM_{2.5}\ emission\ factor\ (\mathrm{mg/Nm^3\ dry\ @15\%}\ O_2) * Unit\ conversion\ \left(\frac{3600\ s}{1\ h}\right)$$
$$* \ Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ \left(\frac{1\ tonne}{10^9 mg}\right)$$

$$VOC\ emission\ rate\ (t/d)$$
$$= \left(\frac{Exhaust\ gas\ flow\ rate\ \left(\frac{kg}{s}\right)}{Exhaust\ gas\ MW\ \left(\frac{kg}{kmol}\right)}\right) * \frac{\left(100 - water\ content\ (\%)\right)}{100}$$
$$* \left(\frac{\left(20.9 - dry\ O_2\ content\ (\%)\right)}{(20.9 - 15)}\right) * \frac{VOC\ emission\ factor\ (ppmvd@15\%\ O_2)}{10^6}$$
$$* \ VOC\ MW\ \left(\frac{kg}{kmol}\right) * Unit\ conversion\ \left(\frac{3600\ s}{1\ h}\right) * \ Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right)$$
$$* Unit\ conversion\ \left(\frac{1\ tonne}{10^3 kg}\right)$$

The PAH emission calculation approach for the power generator is the same as for the thermal oxidizer.

Normal Operation and Worst Case Flares

$$SO_2\ emission\ rate\ (t/d) = Fuel\ flow\ rate\ \left(\frac{sm^3}{h}\right) * Sulphur\ content\ \left(\frac{mole\ percent}{100}\right) \div Molar\ volume\ conversion\ factor\ at\ standard\ condition\left(\frac{23.6449\ m^3}{kmol}\right) * SO_2\ MW\ \left(\frac{kg}{kmol}\right) * Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ \left(\frac{1\ tonne}{1000\ kg}\right)$$

$$NOx\ emission\ rate\ (t/d) = NOx\ emission\ factor\ \left(\frac{lb}{MMBtu}\right) * Heat\ input\ (HHV)\left(\frac{MMBtu}{h}\right) * Unit\ conversion\ \left(\frac{kg}{2.205\ lb}\right) * Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ \left(\frac{1\ tonne}{1000\ kg}\right)$$

$$CO\ emission\ rate\ (t/d) = CO\ emission\ factor\ \left(\frac{lb}{MMBtu}\right) * Heat\ input\ (HHV)\left(\frac{MMBtu}{h}\right) * Unit\ conversion\ \left(\frac{2.205\ kg}{lb}\right) * Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ \left(\frac{1\ tonne}{1000\ kg}\right)$$

$$PM_{2.5}\ emission\ rate\ (t/d) = Fuel\ flow\ rate\ \left(\frac{sm^3}{h}\right) * PM_{2.5}\ emission\ factor\ \left(\frac{kg}{1000\ sm^3}\right) * Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ \left(\frac{1\ tonne}{1000\ kg}\right)$$

$$VOC\ emission\ rate\ (t/d) = VOC\ emission\ factor\ \left(\frac{lb}{MMBtu}\right) * Heat\ input\ (HHV)\left(\frac{MMBtu}{h}\right) * Unit\ conversion\ \left(\frac{kg}{2.205\ lb}\right) * Unit\ conversion\ \left(\frac{24\ h}{1\ d}\right) * Unit\ conversion\ \left(\frac{1\ tonne}{1000\ kg}\right)$$

The PAH emission calculation approach for the power generator is the same as for the thermal oxidizer.

Marine Vessels at the Project Terminal

LNG Carrier Main Engine and Auxiliary Engine (burn LNG)

$$Maximum\ NO_x\ emission\ rate\ (kg/h) = Engine\ power\ (kW) * Load\ factor * NO_x\ emission\ factor\ \left(\frac{g}{kWh}\right) * Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right)$$

$$Maximum\ CO\ emission\ rate\ (kg/h)$$
$$= Engine\ power\ (kW) * Load\ factor * CO\ emission\ factor\ \left(\frac{g}{kWh}\right) *$$
$$* Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) Maximum\ PM_{2.5}\ emission\ rate\ (kg/h)$$
$$= Engine\ power\ (kW) * Load\ factor * PM_{2.5}\ emission\ factor\ \left(\frac{g}{kWh}\right) *$$
$$* Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right)$$

$$Maximum\ VOC\ emission\ rate\ (kg/h)$$
$$= Engine\ power\ (kW) * Load\ factor * VOC\ emission\ factor\ \left(\frac{g}{kWh}\right) *$$
$$* Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right)$$

$$Maximum\ PAH\ emission\ rate\ \left(\frac{kg}{h}\right)$$
$$= PAH\ emission\ factor\ \left(\frac{lb}{MMBtu}\right) * Heat\ input\ (HHV)\left(\frac{MMBtu}{h}\right)$$
$$* Unit\ conversion\ \left(\frac{kg}{2.205\ lb}\right)$$

$$Anual\ Average\ emission\ rate\ of\ each\ species\left(\frac{kg}{h}\right)$$
$$= maximum\ emission\ rate\left(\frac{kg}{h}\right) * Berthing\ and\ unberthing\ hours\ (h)$$
$$* LNG\ Carrrier\ numbers\ per\ year\ \left(\frac{number}{year}\right) * Unit\ conversion\left(\frac{1\ day}{24\ h}\right)$$
$$* Unit\ conversion\left(\frac{1\ year}{365\ day}\right)$$

Boiler (burn LNG)

$$Maximum\ NO_x\ emission\ rate\ (kg/h)$$
$$= NO_x\ emission\ factor\ \left(\frac{lb}{MMBTU}\right) * Heat\ input\ (HHV)\left(\frac{MMBtu}{h}\right)$$
$$* Unit\ conversion\ \left(\frac{kg}{2.205\ lb}\right)$$

$$Maximum\ CO\ emission\ rate\ (kg/h)$$
$$= CO\ emission\ factor\ \left(\frac{lb}{MMBTU}\right) * Heat\ input\ (HHV)\left(\frac{MMBtu}{h}\right)$$
$$* Unit\ conversion\ \left(\frac{kg}{2.205\ lb}\right)$$

$$Maximum\ PM_{2.5}\ emission\ rate\ \left(\frac{kg}{h}\right) = PM_{2.5}\ emission\ factor\ \left(\frac{g}{GJ}\right) * Heat\ input\ (HHV)\left(\frac{GJ}{h}\right) * Unit\ conversion\ \left(\frac{kg}{1000g}\right)$$

$$Maximum\ VOC\ emission\ rate\ (kg/h) = VOC\ emission\ factor\ \left(\frac{lb}{MMBTU}\right) * Heat\ input\ (HHV)\left(\frac{MMBtu}{h}\right) * Unit\ conversion\ \left(\frac{kg}{2.205\ lb}\right)$$

The maximum PAH emission calculation approach for the boiler is the same as for the LNG Carrier *Main Engine and Auxiliary Engine* (burning LNG).

The annual average emission calculation approach for the boiler is the same as for the LNG Carrier *Main Engine and Auxiliary Engine* (burning LNG).

Harbor Tugboats (burn marine diesel)

$$Maximum\ SO_2\ emission\ rate\ \left(\frac{kg}{h}\right) = Engine\ power\ (kW) * Load\ factor * SO_2\ emission\ factor\ \left(\frac{g}{kWh}\right) * * Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * number\ of\ tugboat$$

$$Maximum\ NO_x\ emission\ rate\ \left(\frac{kg}{h}\right) = Engine\ power\ (kW) * Load\ factor * NO_x\ emission\ factor\ \left(\frac{g}{kWh}\right) * * Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * number\ of\ tugboat$$

$$Maximum\ CO\ emission\ rate\ (kg/h) = Engine\ power\ (kW) * Load\ factor * CO\ emission\ factor\ \left(\frac{g}{kWh}\right) * * Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * number\ of\ tugboat$$

$$Maximum\ PM_{2.5}\ (diesel\ PM_{2.5})\ emission\ rate\ (kg/h) = Engine\ power\ (kW) * Load\ factor * PM_{2.5}\ emission\ factor\ \left(\frac{g}{kWh}\right) * * Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * number\ of\ tugboat$$

$$Maximum\ VOC\ emission\ rate\ (kg/h) = Engine\ power\ (kW) * Load\ factor * VOC\ emission\ factor\ \left(\frac{g}{kWh}\right) * * Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * number\ of\ tugboat$$

$$Maximum\ PAH\ emission\ rate\ \left(\frac{kg}{h}\right)$$
$$= PAH\ emission\ factor\ basis\ of\ VOC * maximum\ VOC\ emission\ rate\ \left(\frac{kg}{h}\right)$$
$$* PAH\ emission\ factor\ basis\ of\ diesel\ PM * maximum\ diesel\ PM_{2.5}\ emission\ rate\ \left(\frac{kg}{h}\right)$$
$$* Conversion\ factor\ from\ diesel\ PM2.5\ to\ toal\ diesel\ PM\ \left(\frac{1}{0.97}\right)$$

The annual average emission calculation approach for all species is the same as for the LNG Carrier *Main Engine and Auxiliary Engine* (burning LNG).

B.2 OPERATIONS SHIPPING ROUTE EMISSIONS

Marine sources here include emissions from marine vessels (i.e., LNG Carriers and escort tugboats) travelling in the ocean channel, between the Project site and Triple Island. The Project expects up to 150 Carrier visits per year. There is one escort tugboat per Carrier visit. Both LNG Carriers and tugboats are assumed to run on marine diesel during the shipping activities in the channel. Marine vessel engine information, load factors, shipping speed, stack parameters, emission factors, and emission rates of SO_2, NO_X, CO, $PM_{2.5}$, VOC, and PAH are shown in Table 6.6.

Note that LNG Carrier main engine is less efficient at low load (<20%, U.S. EPA 2022) and fuel consumption tends to increase. The low load adjustment factors were applied for adjusting main engine emission estimations.

The maximum emission rates of SO_2, NO_X, CO, $PM_{2.5}$, VOC, and PAH in Table 6.6 are estimated based on the worst-case scenario, i.e., two Carriers with one tug each pass each other along the channel shipping route. The corresponding emission rates in unit of g/s/m are applied for the air dispersion modelling for 1- hour concentration predictions for conservative purpose. The one way shipping emission rates in unit of g/s/m are applied for other averaging periods concentration predictions. The annual average emission rates of SO_2, NO_X, CO, $PM_{2.5}$, VOC, and PAH in Table 6.6 are estimated based on the 150 Carriers per year.

LNG Carrier Main Engine (burn marine diesel)

$$Maximum\ SO_2\ emission\ rate\ \left(\frac{kg}{h}\right)$$
$$= Engine\ power\ (kW) * Load\ factor * SO_2\ emission\ factor\ \left(\frac{g}{kWh}\right) *$$
$$* Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * Low\ load\ adjustment\ factor\ for\ SO_2$$
$$* two\ wasy\ travelling\ (2)$$

$$Maximum\ NO_x\ emission\ rate\ \left(\frac{kg}{h}\right)$$
$$= Engine\ power\ (kW) * Load\ factor * \ NO_x\ emission\ factor\ \left(\frac{g}{kWh}\right) *$$
$$* Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * Low\ load\ adjustment\ factor\ for\ NO_x$$
$$* two\ wasy\ travelling\ (2)$$

$$Maximum\ CO\ emission\ rate\ (kg/h)$$
$$= Engine\ power\ (kW) * Load\ factor * \ CO\ emission\ factor\ \left(\frac{g}{kWh}\right) *$$
$$* Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * Low\ load\ adjustment\ factor\ for\ CO$$
$$* two\ wasy\ travelling\ (2)$$

$$Maximum\ PM_{2.5}\ emission\ rate\ (kg/h)$$
$$= Engine\ power\ (kW) * Load\ factor * \ PM_{2.5}\ emission\ factor\ \left(\frac{g}{kWh}\right) *$$
$$* Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * Low\ load\ adjustment\ factor\ for\ PM_{2.5}$$
$$* two\ wasy\ travelling\ (2)$$

$$Maximum\ VOC\ emission\ rate\ \left(\frac{kg}{h}\right)$$
$$= Engine\ power\ (kW) * Load\ factor * \ VOC\ emission\ factor\ \left(\frac{g}{kWh}\right) *$$
$$* Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * Low\ load\ adjustment\ factor\ for\ VOC$$
$$* two\ wasy\ travelling\ (2)$$

$$Maximum\ PAH\ emission\ rate\ \left(\frac{kg}{h}\right)$$
$$= PAH\ emission\ factor\ basis\ of\ VOC * \ maximum\ VOC\ emission\ rate\ \left(\frac{kg}{h}\right)$$
$$* \ PAH\ emission\ factor\ basis\ of\ diesel\ PM * \ maximum\ diesel\ PM_{2.5}\ emission\ rate\ \left(\frac{kg}{h}\right)$$
$$* Conversion\ factor\ from\ diesel\ PM2.5\ to\ toal\ diesel\ PM\ for\ ocean\ going\ vessel\ \left(\frac{1}{0.92}\right)$$

$$Maximum\ emission\ rate\ of\ each\ species(g/s/m)\ during\ one\ hour$$
$$= maximum\ emission\ rate\ \left(\frac{kg}{h}\right) \div Shipping\ distance\ per\ hour\ (km)$$
$$* Unit\ conversion\left(\frac{1h}{3600s}\right)$$

$$Anual\ Average\ emission\ rate\ of\ each\ species\left(\frac{kg}{h}\right)$$
$$= maximum\ emission\ rate\left(\frac{kg}{h}\right) * Berthing\ and\ unberthing\ hours\ (h)$$
$$* LNG\ Carrrier\ numbers\ per\ year\ \left(\frac{number}{year}\right) *\ Unit\ conversion\left(\frac{1\ day}{24\ h}\right)$$
$$* Unit\ conversion\left(\frac{1\ year}{365\ day}\right)$$

LNG Carrier Auxiliary Engine and Boiler and Escort Tugboat (burn marine diesel)

$$Maximum\ SO_2\ emission\ rate\ \left(\frac{kg}{h}\right)$$
$$= Engine\ power\ (kW) * Load\ factor *\ SO_2\ emission\ factor\ \left(\frac{g}{kWh}\right) *$$
$$* Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * two\ wasy\ travelling\ (2)$$

$$Maximum\ NO_x\ emission\ rate\ \left(\frac{kg}{h}\right)$$
$$= Engine\ power\ (kW) * Load\ factor *\ NO_x\ emission\ factor\ \left(\frac{g}{kWh}\right) *$$
$$* Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * two\ wasy\ travelling\ (2)$$

$$Maximum\ CO\ emission\ rate\ (kg/h)$$
$$= Engine\ power\ (kW) * Load\ factor *\ CO\ emission\ factor\ \left(\frac{g}{kWh}\right) *$$
$$* Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * two\ wasy\ travelling\ (2)$$

$$Maximum\ PM_{2.5}\ emission\ rate\ (kg/h)$$
$$= Engine\ power\ (kW) * Load\ factor *\ PM_{2.5}\ emission\ factor\ \left(\frac{g}{kWh}\right) *$$
$$* Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * two\ wasy\ travelling\ (2)$$

$$Maximum\ VOC\ emission\ rate\ \left(\frac{kg}{h}\right)$$
$$= Engine\ power\ (kW) * Load\ factor *\ VOC\ emission\ factor\ \left(\frac{g}{kWh}\right) *$$
$$* Unit\ conversion\ \left(\frac{1\ kg}{1000\ g}\right) * two\ wasy\ travelling\ (2)$$

The maximum emission rate calculation approach for PAH is the same as for the LNG Carrier Main Engine (burning marine diesel). The maximum emission rate of each species in unit of g/s/m is the same as for the LNG Carrier Main Engine (burning marine diesel). The annual average emission rate calculation approach for all species is the same as for the LNG Carrier Main Engine (burning marine diesel).

APPENDIX B

CALMET

1 Appendix B CALMET

Appendix B CALMET

B.1 INTRODUCTION

This appendix provides technical details and assumptions regarding the application of the CALMET model to determine the meteorology for dispersion modelling of proposed Ksi Lisims LNG Project. The CALMET modelling was completed following the British Columbia (BC) Air Quality Dispersion Modelling Guideline (the Guideline) (BC ENV, 2022). The appendix focuses on model input data preparation and an overview of main CALMET predicted parameters.

For the air quality assessment completed for the Project, the CALMET meteorological model (Scire et al., 2000) was run for a five-year period, January 1, 2011 to December 31, 2015. The selection of a five-year period is consistent with the Guideline (BC ENV 2022). CALMET was run in no-observation mode using Weather Research and Forecasting (WRF) model data (BC ENV, 2018).

B.2 CALMET APPLICATION

The CALMET model is available from the model developer's (i.e., Exponent, Inc.) web site (http://www.src.com/calpuff/calpuff1.htm). The current United States Environmental Protection Agency (US EPA) version of CALMET is Version 5.8.4, level 130731. For this assessment, a more recent version, Version 6.50 - Level 150223 was adopted.

A 50 km by 50 km CALMET model domain at 250 m grid resolution was selected for the assessment (see Section C.3). With this grid spacing, it was possible to maximize run time and file size efficiencies while still capturing large-scale terrain feature influences on wind flow patterns.

To simulate transport and dispersion processes, it is also important to simulate representative vertical profiles of wind direction, wind speed, temperature, and turbulence intensity within the atmospheric boundary layer (i.e., the layer within about 2,000 m of the Earth's surface). To capture this vertical structure, twelve vertical layers were selected. CALMET defines a vertical layer as the midpoint between two faces (i.e., thirteen faces correspond to twelve layers, with the lowest layer always being ground level or 10 m). The vertical faces used in this study are 0 m, 20 m, 40 m, 80 m, 120 m, 280 m, 520 m, 880 m, 1,320 m, 1,820 m, 2,380, 3,000 m and 4,000 m.

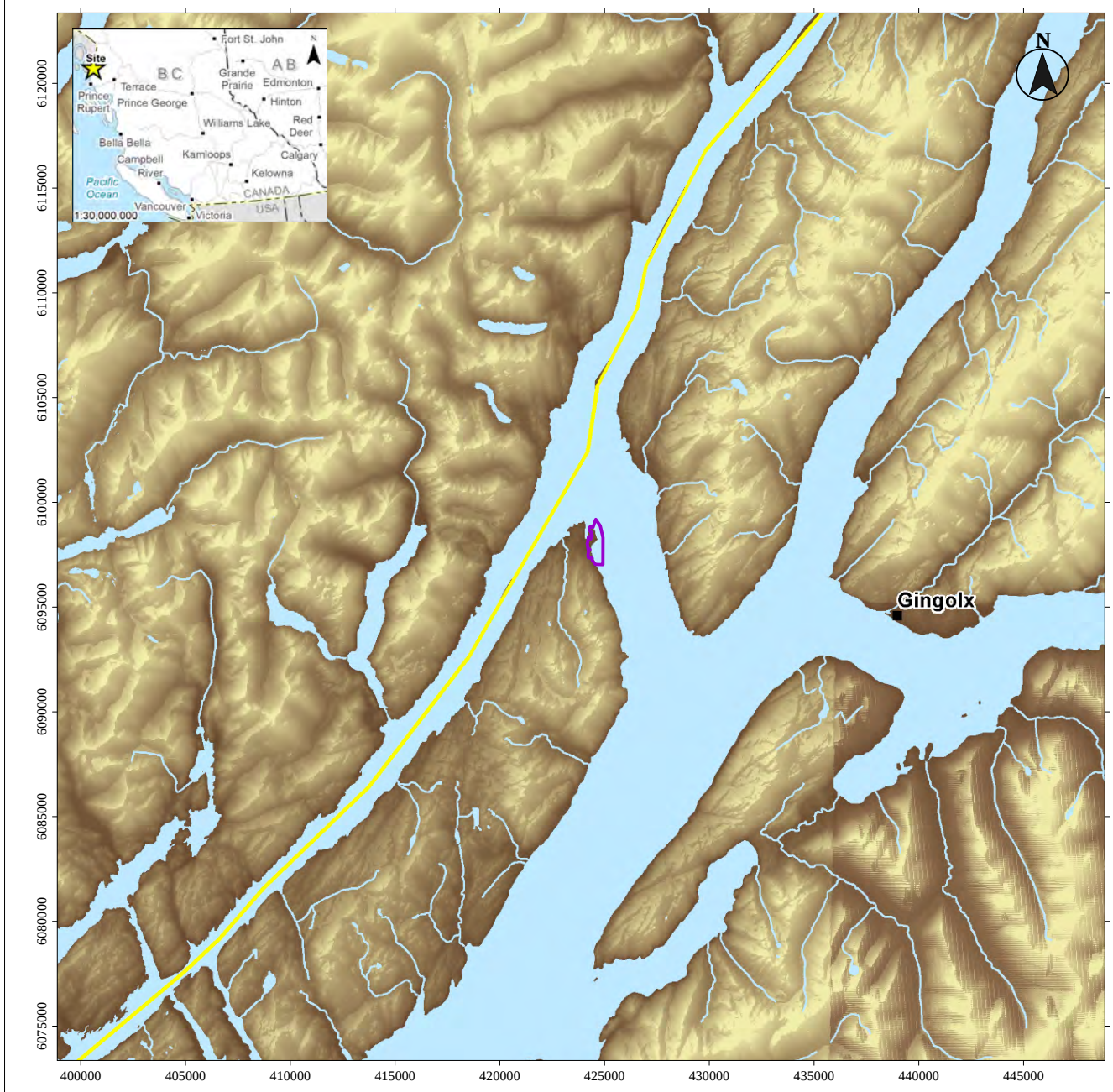
The BC ENV WRF 4 km dataset for the years 2011–2015 (BC ENV, 2018) was used as an initial guess field. The CALMET model was then used to adjust this initial guess field for the kinematic effects of terrain, slope flows, and terrain blocking effects using the finer scale terrain data to produce a modified wind field.

B.3 MODEL DOMAIN

The CALMET domain adopted for the Project extends from approximately north of 54.797 degrees latitude to 55.254 degrees latitude, and from west of 130.573 degrees longitude to 129.804 degrees longitude as shown in Figure B.1. The CALMET Domain covers a 50 km by 50 km (2,500 km^2) area. The extents (described above in decimal degrees) are provided in Table B.1 as UTM coordinates.

Table B.1 CALMET Model Domain (50 km by 50 km) Coordinates

Domain Corner	Location (UTM NAD 83, Zone 9)	
	East (m)	North (m)
Northwest	398880	6123360
Southwest	398880	6073360
Southeast	448880	6073360
Northeast	448880	6123360



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary
Site
Gingolx
International Boundary
Watercourse
Waterbody
Ground Elevation (m)
High : 1652
Low : 0

Metres
0 5000 10000 15000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
B-1

Title
CALMET Model Domain and Terrain

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B.4 TOPOGRAPHY AND LAND COVER

B.4.1 Topography

Valleys and elevated terrain features influence surface wind flow patterns. Terrain data that are used to define these features were obtained from National Aeronautics and Space Administration (NASA) 3-second Shuttle RADAR Topography Mission files (SRTM3) terrain data (~90 m resolution) (USGS 2022).

A general overview of the terrain within the CALMET domain is presented in Figure B.1. Terrain in the region is complex with elevations ranging from 0 to 1,673 meters above sea level (m asl). The base elevation at the proposed Project site is approximately 0 m asl.

B.4.2 Land-Cover Data

In addition to terrain elevation data, the CALMET model uses surface parameters such as surface roughness length, albedo, Bowen ratio, leaf area index, soil heat flux, and anthropogenic heat flux to provide input to calculate surface heat flux and mechanical turbulence.

For this assessment, the North American Land Cover data (CEC, 2020) set was used to determine land use categories for the CALMET model. The 2015 North American Land Cover data set was produced as part of the North American Land Change Monitoring System (NALCMS); a trilateral effort between the Canada Centre for Remote Sensing, the United States Geological Survey, and three Mexican organizations including the National Institute of Statistics and Geography, National Commission for the Knowledge and Use of the Biodiversity and the National Forestry Commission of Mexico. The resulting 2015 Land Cover of North America data are at a resolution of 30 m.

This land cover information was then converted into the fractional land-use data file by the CALMET CTGPROC program. Five seasons (shown in Table B.2) were determined based on Table 4.5 of the Guidelines (BC ENV, 2022). A slight adjustment to the months of April, May, August and November was recommended by BC ENV to improve representation of transitional months. Table B.3 to Table B.7 provide seasonal values for surface roughness (z0), albedo, Bowen ratio, soil heat flux, anthropogenic heat flux and leaf area index (LAI). The selected values are consistent with section 4.4 of the Guidelines (BC ENV, 2022) and CALMET User Guide (Scire et al. 2000). The latter was used in the absence of a specific recommendation in the Guidelines (BC ENV, 2022). Using the fractional land use data from CTGPROC, CALMET MAKEGEO pre-processor calculates the dominant land use for each cell and computes weighted surface parameters based on seasonal values provided in Table B.3 to Table B.7.

Based on the 250 m grid resolution data, the domain is comprised of 57.6 percent evergreen forest, 19.6 percent water, 17.3 percent shrub rangeland, 2.5 percent mixed forest, 2.4 percent barren land, 0.3 percent rangeland, 0.2 percent snow or ice, 0.2 percent deciduous forest, 0.05 percent wetland, 0.01 percent tundra and 0.01 percent urban land (Figure B.2).

Table B.2 Five Seasons Applied in CALMET Modeling for the Latitude of 50° to 55° N

Season	BC ENV 2022 Guideline Definitions	Months
1	Midsummer with lush vegetation	June, July and August 1-15
2	Autumn with cropland that has not been harvested	August 16-31 and September
3	Winter 1, later autumn after frost, no snow on the ground	October and November
4	Winter 2, snow on the ground and subfreezing	December, January, February, March 1-15
5	Transitional spring with partially green short annuals	March 16-31, April and May

Table B.3 CALMET Land-use Characterization and Associated Geophysical Parameters for the Season 1 (Mid-Summer)

NALCMS Code	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux (fraction)	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index	CALMET Code	CALMET Land Cover Type
1	1.300	0.120	0.300	0.150	0.000	5.000	42	Evergreen Forest
2	1.300	0.120	0.300	0.150	0.000	5.000	42	
3	1.300	0.120	0.300	0.150	0.000	5.000	42	
4	1.300	0.160	0.300	0.150	0.000	3.400	41	Deciduous Forest
5	1.300	0.160	0.300	0.150	0.000	3.400	41	
6	1.300	0.140	0.300	0.150	0.000	4.500	43	Mixed Forest
7	0.300	0.180	1.000	0.150	0.000	4.500	32	Shrub Rangeland
8	0.300	0.180	1.000	0.150	0.000	4.500	32	
9	0.150	0.200	0.500	0.150	0.000	1.000	30	Rangeland
10	0.150	0.200	0.500	0.150	0.000	1.000	30	
11	0.200	0.300	0.500	0.150	0.000	0.000	80	Tundra
12	0.200	0.300	0.500	0.150	0.000	0.000	80	
13	0.200	0.300	0.500	0.150	0.000	0.000	80	
14	0.200	0.140	0.100	0.300	0.000	0.200	60	Wet Land
15	0.200	0.200	0.500	0.150	0.000	2.000	20	Agricultural Land
16	0.050	0.200	1.500	0.150	0.000	0.000	70	Barren Land
17	0.540	0.160	0.800	0.250	8.000	0.300	10	Urban or Build-up
18	0.001	0.100	0.100	1.000	0.000	0.000	51	Small Water Body
19	0.200	0.700	0.500	0.150	0.000	0.000	90	Snow and Ice
20	0.001	0.100	0.100	1.000	0.000	0.000	54	Bays and Estuaries

NOTES:
For latitude 50° to 55° N, Season 1 (Mid-Summer) = June, July and August 1-15; W/m^2 = watts per square metre

Table B.4 CALMET Land-use Characterization and Associated Geophysical Parameters for Season 2 (Autumn)

NALCMS Code	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux (fraction)	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index	CALMET Code	CALMET Land Cover Type
1	1.300	0.120	0.800	0.150	0.000	5.000	42	Evergreen Forest Land
2	1.300	0.120	0.800	0.150	0.000	5.000	42	
3	1.300	0.120	0.800	0.150	0.000	5.000	42	
4	1.300	0.160	1.000	0.150	0.000	1.900	41	Deciduous Forest Land
5	1.300	0.160	1.000	0.150	0.000	1.900	41	
6	1.300	0.140	0.900	0.150	0.000	3.500	43	Mixed Forest Land
7	0.300	0.180	1.500	0.150	0.000	0.000	32	Shrub Rangeland
8	0.300	0.180	1.500	0.150	0.000	0.000	32	
9	0.150	0.200	0.700	0.150	0.000	1.000	30	Rangeland
10	0.150	0.200	0.700	0.150	0.000	1.000	30	
11	0.200	0.300	0.500	0.150	0.000	0.000	80	Tundra
12	0.200	0.300	0.500	0.150	0.000	0.000	80	
13	0.200	0.300	0.500	0.150	0.000	0.000	80	
14	0.200	0.140	0.100	0.300	0.000	0.200	60	Wet Land
15	0.200	0.200	0.700	0.150	0.000	1.500	20	Agricultural Land
16	0.050	0.200	1.500	0.150	0.000	0.000	70	Barren Land
17	0.540	0.160	1.000	0.250	12.000	0.200	10	Urban or Build-up
18	0.001	0.100	0.100	1.000	0.000	0.000	51	Small Water Body
19	0.200	0.700	0.500	0.150	0.000	0.000	90	Snow and Ice
20	0.001	0.100	0.100	1.000	0.000	0.000	54	Bays and Estuaries

NOTES:
For latitude 50° to 55° N, Season 2 (Autumn) = August 16-31 and September; W/m^2 = watts per square metre

Table B.5 CALMET Land-use Characterization and Associated Geophysical Parameters for Season 3 (Winter 1)

NALCMS Code	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux (fraction)	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index	CALMET Code	CALMET Land Cover Type
1	1.300	0.120	0.800	0.150	0.000	5.000	42	Evergreen Forest Land
2	1.300	0.120	0.800	0.150	0.000	5.000	42	
3	1.300	0.120	0.800	0.150	0.000	5.000	42	
4	0.600	0.170	1.000	0.150	0.000	0.100	41	Deciduous Forest Land
5	0.600	0.170	1.000	0.150	0.000	0.100	41	
6	0.950	0.140	0.900	0.150	0.000	2.300	43	Mixed Forest Land
7	0.300	0.180	1.500	0.150	0.000	0.000	32	Shrub Rangeland
8	0.300	0.180	1.500	0.150	0.000	0.000	32	
9	0.020	0.180	0.700	0.150	0.000	1.000	30	Rangeland
10	0.020	0.180	0.700	0.150	0.000	1.000	30	
11	0.200	0.300	0.500	0.150	0.000	0.000	80	Tundra
12	0.200	0.300	0.500	0.150	0.000	0.000	80	
13	0.200	0.300	0.500	0.150	0.000	0.000	80	
14	0.200	0.140	0.100	0.300	0.000	0.100	60	Wet Land
15	0.020	0.180	0.700	0.150	0.000	1.000	20	Agricultural Land
16	0.050	0.200	1.500	0.150	0.000	0.050	70	Barren Land
17	0.500	0.180	1.000	0.250	21.000	0.100	10	Urban or Build-up
18	0.001	0.100	0.100	1.000	0.000	0.000	51	Small Water Body
19	0.200	0.700	0.500	0.150	0.000	0.000	90	Snow and Ice
20	0.001	0.100	0.100	1.000	0.000	0.000	54	Bays and Estuaries

NOTES:
For latitude 50° to 55° N, Season 3 (Winter 1) = October and November, W/m^2 = watts per square metre

Table B.6 CALMET Land-use Characterization and Associated Geophysical Parameters for Season 4 (Winter 2)

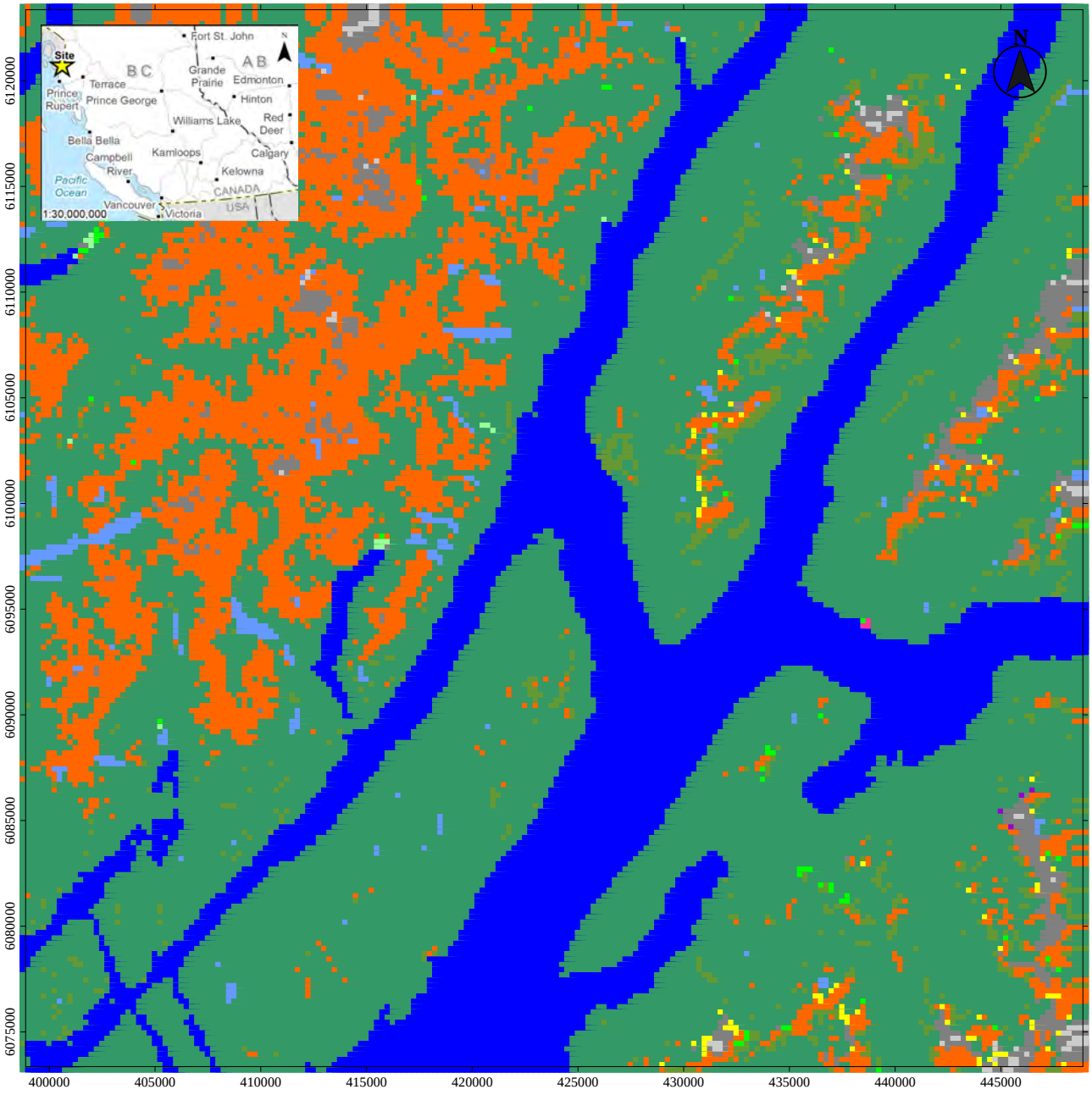
NALCMS Code	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux (fraction)	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index	CALMET Code	CALMET Land Cover Type
1	1.300	0.350	0.500	0.150	0.000	5.000	42	Evergreen Forest Land
2	1.300	0.350	0.500	0.150	0.000	5.000	42	
3	1.300	0.350	0.500	0.150	0.000	5.000	42	
4	0.500	0.500	0.500	0.150	0.000	0.000	41	Deciduous Forest Land
5	0.500	0.500	0.500	0.150	0.000	0.000	41	
6	0.900	0.420	0.500	0.150	0.000	2.300	43	Mixed Forest Land
7	0.150	0.500	0.500	0.150	0.000	0.000	32	Shrub Rangeland
8	0.150	0.500	0.500	0.150	0.000	0.000	32	
9	0.010	0.600	0.500	0.150	0.000	1.000	30	Rangeland
10	0.010	0.600	0.500	0.150	0.000	1.000	30	
11	0.200	0.300	0.500	0.150	0.000	0.000	80	Tundra
12	0.200	0.300	0.500	0.150	0.000	0.000	80	
13	0.200	0.300	0.500	0.150	0.000	0.000	80	
14	0.100	0.300	0.500	0.300	0.000	0.000	60	Wet Land
15	0.010	0.600	0.500	0.150	0.000	0.000	20	Agricultural Land
16	0.050	0.600	0.500	0.150	0.000	0.000	70	Barren Land
17	0.500	0.450	0.500	0.150	17.000	0.000	10	Urban or Build-up
18	0.002	0.700	0.500	0.150	0.000	0.000	51	Small Water Body
19	0.200	0.700	0.500	0.150	0.000	0.000	90	Snow and Ice
20	0.002	0.700	0.500	0.150	0.000	0.000	54	Bays and Estuaries

NOTES:
For latitude 50° to 55° N, Season 4 (Winter 2) = December, January, February, March 1-15; W/m^2 = watts per square metre

Table B.7 CALMET Land-use Characterization and Associated Geophysical Parameters for Season 5 (Transitional Spring)

NALCMS Code	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux (fraction)	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index	CALMET Code	CALMET Land Cover Type
1	1.300	0.120	0.700	0.150	0.000	5.000	42	Evergreen Forest Land
2	1.300	0.120	0.700	0.150	0.000	5.000	42	
3	1.300	0.120	0.700	0.150	0.000	5.000	42	
4	1.000	0.160	0.700	0.150	0.000	0.800	41	Deciduous Forest Land
5	1.000	0.160	0.700	0.150	0.000	0.800	41	
6	1.150	0.140	0.700	0.150	0.000	3.300	43	Mixed Forest Land
7	0.300	0.180	1.000	0.150	0.000	0.000	32	Shrub Rangeland
8	0.300	0.180	1.000	0.150	0.000	0.000	32	
9	0.030	0.140	0.300	0.150	0.000	1.000	30	Rangeland
10	0.030	0.140	0.300	0.150	0.000	1.000	30	
11	0.200	0.300	0.500	0.150	0.000	0.000	80	Tundra
12	0.200	0.300	0.500	0.150	0.000	0.000	80	
13	0.200	0.300	0.500	0.150	0.000	0.000	80	
14	0.200	0.140	0.100	0.300	0.000	0.100	60	Wet Land
15	0.030	0.140	0.300	0.150	0.000	1.000	20	Agricultural Land
16	0.050	0.200	1.500	0.150	0.000	0.000	70	Barren Land
17	0.520	0.160	0.800	0.250	15.000	0.200	10	Urban or Build-up
18	0.001	0.100	0.100	1.000	0.000	0.000	51	Small Water Body
19	0.200	0.700	0.500	0.150	0.000	0.000	90	Snow and Ice
20	0.001	0.100	0.100	1.000	0.000	0.000	54	Bays and Estuaries

NOTES:
For latitude 50° to 55° N, Season 5 (Transitional Spring) = March 16-31, April and May; W/m^2 = watts per square metre



KSI LISIMS LNG

Ksi Lisims LNG Plant Boundary

- Urban Land
- Rangeland
- Shrub Rangeland
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Small Water Body
- Large Water Body
- Wetland
- Barren Land
- Tundra
- Snow or Ice

Metres

0 5000 10000 15000

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
B-2

Title
Land Use Classification within CALMET Model Domain

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B.5 METEOROLOGICAL INPUTS

The CALMET model requires the input of surface and upper air meteorological fields. There are no surface and upper air station located within the CALMET domain. For this application, CALMET model was run in no-observation mode (BC ENV, 2021) by using WRF model data (BC ENV, 2018) for the period of January 1, 2011 to December 31, 2015.

B.6 BC ENV 2011–2015 WRF DATA

While WRF model predictions have been compared to observations at surface and upper air stations in order to provide assurance that the outputs can be used for dispersion modelling purposes (BC ENV, 2015), the outputs are predictions that may not necessarily be representative for the study area. For this reason, BC ENV recommends that WRF data users assess the representativeness of the WRF output at their particular location (BC ENV, 2021).

Figure B.3 shows the WRF grid point locations based on 4 km grid resolution within the 50 km by 50 km CALMET model domain.

The ECCC Prince Rupert Airport station was used to determine the representativeness of the WRF data. Prince Rupert Airport station is located approximately 80 km to the south of the Project site and it's the nearest weather station with valid hourly data for the 2011-2015 period. Wind speed, wind direction and temperature data at lowest model level were extracted from WRF data and compared to the measurements for the five period from 2011 to 2015.

Figure B.4 compares the wind roses generated from the WRF model predictions with the wind rose based on measurements for Prince Rupert Airport station, respectively. Both measured and predicted wind roses show the most frequent winds are from southeast.

Figure B.5 compares the monthly average surface temperatures from the WRF model predictions with measurements at Prince Rupert Airport station. The WRF model predictions show warm bias but still in reasonable agreement with observations throughout the five-year period.

Since the WRF model predictions and measurements are similar for the locations of the Prince Rupert Airport station that are located close to the Project site, the WRF model predictions should also be representative of meteorological conditions in the model domain.



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Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary
Site
Gingolx
International Boundary
Watercourse
Waterbody
Ground Elevation (m)
High : 1652
Low : 0

Metres
0 5000 10000 15000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
B-3

Title
BC ENV WRF 4km Grids
within CALMET Model Domain

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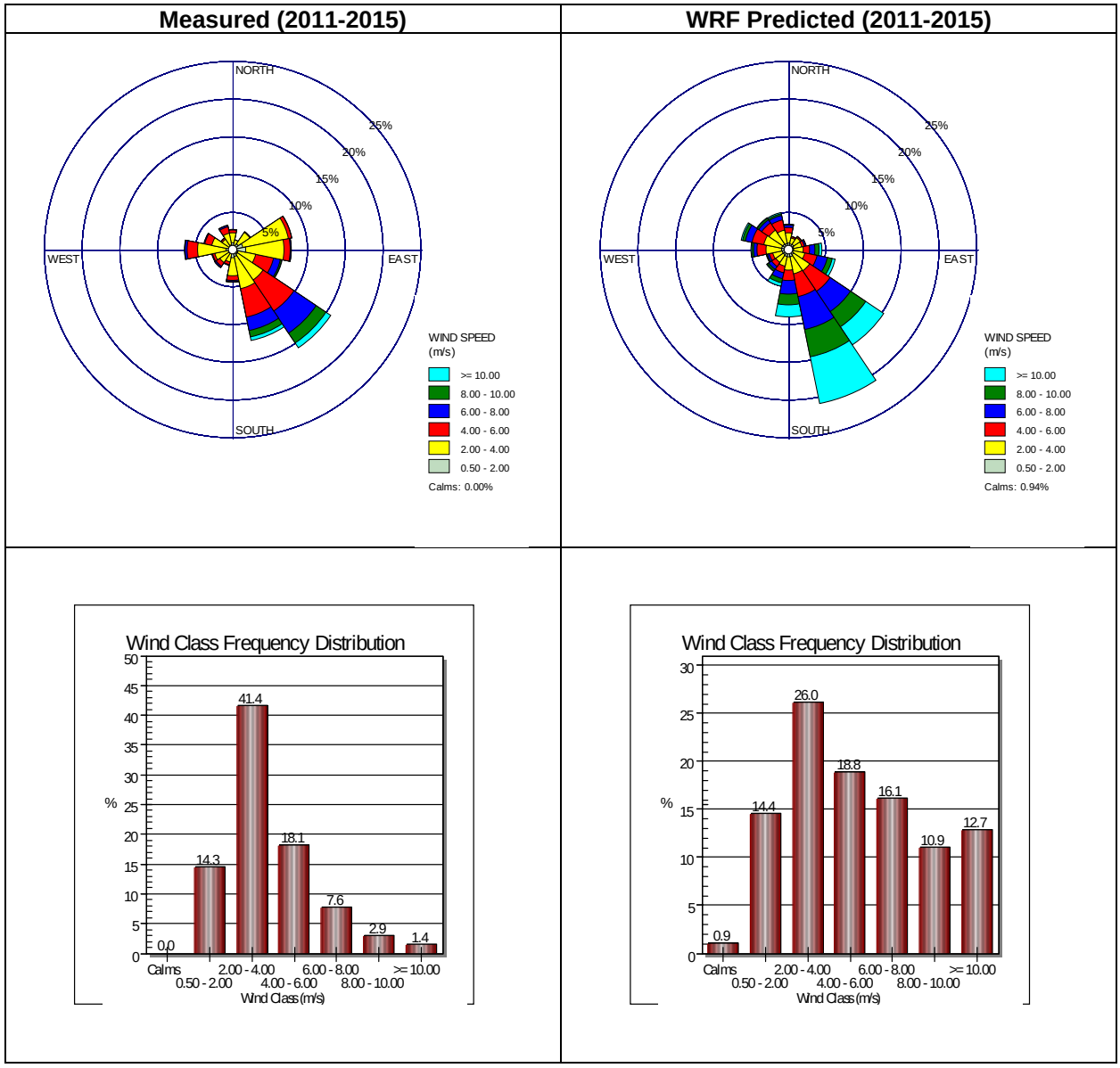


Figure B.4 Comparison of Measured and WRF predicted Wind Roses and Wind Class Frequency at Prince Rupert Airport Station (2011-2015)

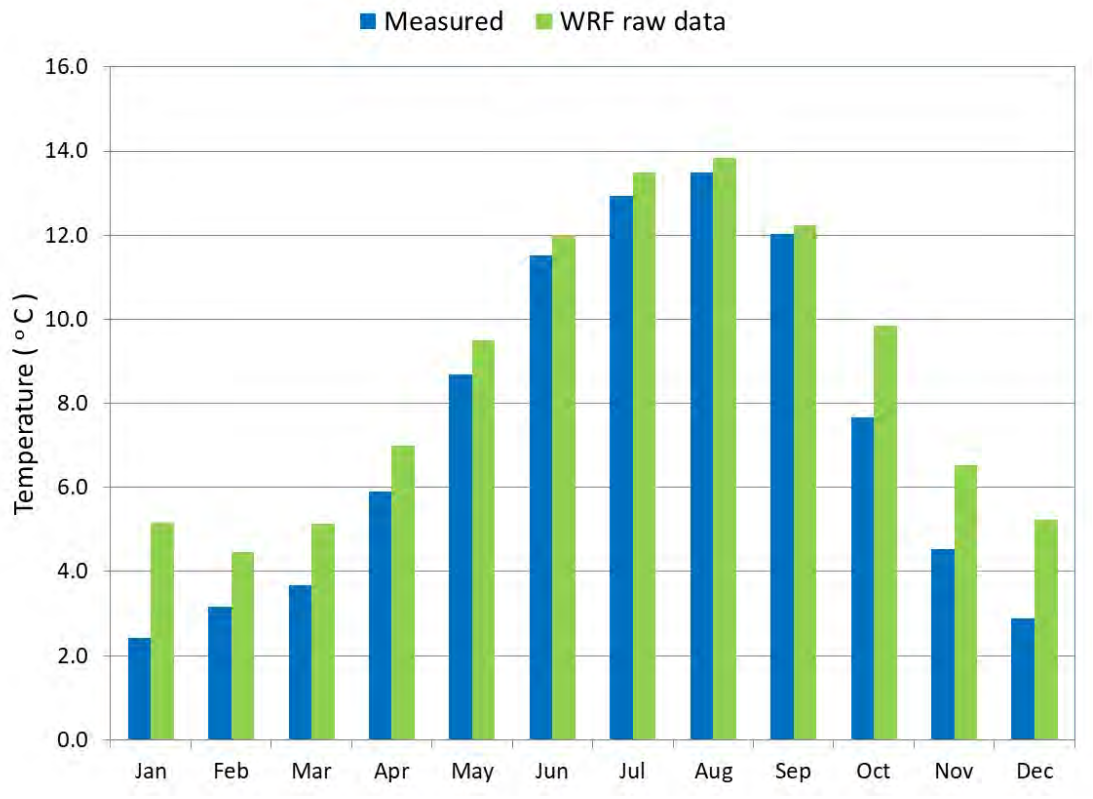


Figure B.5 Comparison of Measured and Predicted Monthly Average Temperature at Prince Rupert Airport Station (2011–2015)

B.7 CALMET PREDICTIONS

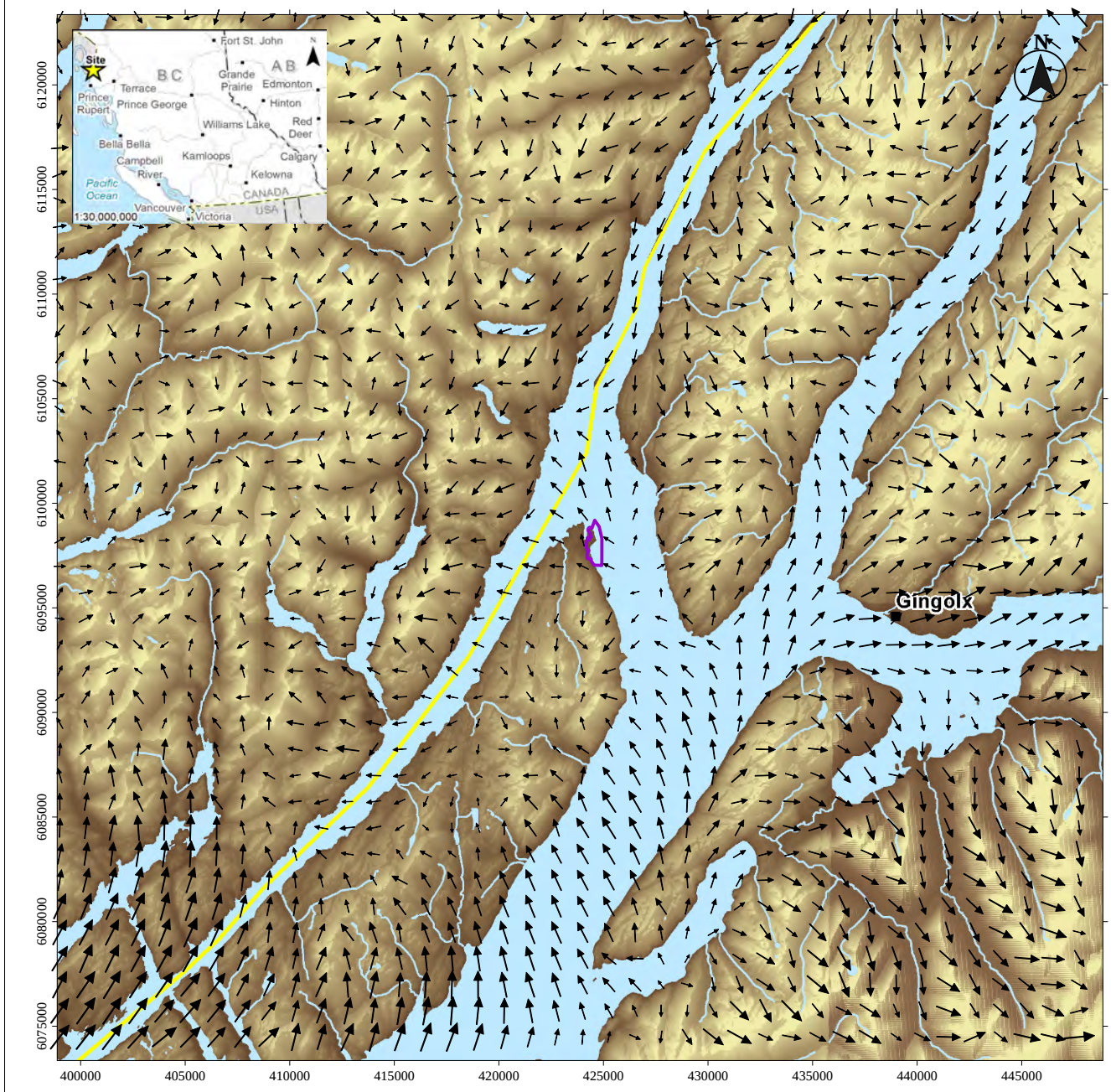
In order to assess the value of the WRF-CALMET model approach for this assessment, CALMET output surface and elevated winds, surface temperature, mixing height and PG stability class data were extracted at the Project Site for analysis. These are the main parameters that influence transport and dispersion of emissions (Scire et al., 2000).

B.7.1 Predicted Surface Winds Field

The CALMET model can provide surface wind vector plots for all the grid points across a model domain. Three plots were generated to represent unstable, stable, and neutral conditions for the near-field model domain. The three sample wind vector plots are described below:

- Figure B.6 shows the wind field as a vector plot at 1200 LST on July 12, 2012, for convective (i.e., unstable) conditions (PG class B). Winds in the southwest and middle portion of the domain tend to be from the south, whereas those in the rest part of the domain tend to be less organized. The predicted winds at the Project site are mainly from the southeast.
- Figure B.7 shows the wind field as a vector plot at 0500 LST on January 10, 2012, for stable conditions (PG class F). The winds in the water parts of the domain tend to be from west or northwest, whereas those in the other part of the domain tend to be less organized. The predicted winds at the Project site are mainly from the west.
- Figure B.8 shows the wind field as a vector plot at 1800 LST on November 4, 2012, for high wind speed (i.e., neutral) conditions. Under these conditions, winds are from the south across most of the domain. The predicted winds at the Project site are mainly from the south with a wind speed of 17.7 m/s.

The vector plots were not selected to represent a specific meteorological condition; they are provided to show the variability of the airflow that can occur over the 50 km by 50 km area during any given hour. Departures of the predicted vector plots from the actual wind field for a given hour are to be expected given the nature of modelling and the relatively low density of actual observations across the region. The predicted values, however, are preferable to assuming a homogeneous wind field across the domain for each hour, based on the local terrain influences that are reflected in the measured data.



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Ksi Lisims LNG Plant Boundary
Site
Gingolx
International Boundary
Watercourse
Waterbody
Ground Elevation (m)
High : 1652
Low : 0

Metres
0 5000 10000 15000

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Stantec

Project Location
Pearse Island, BC

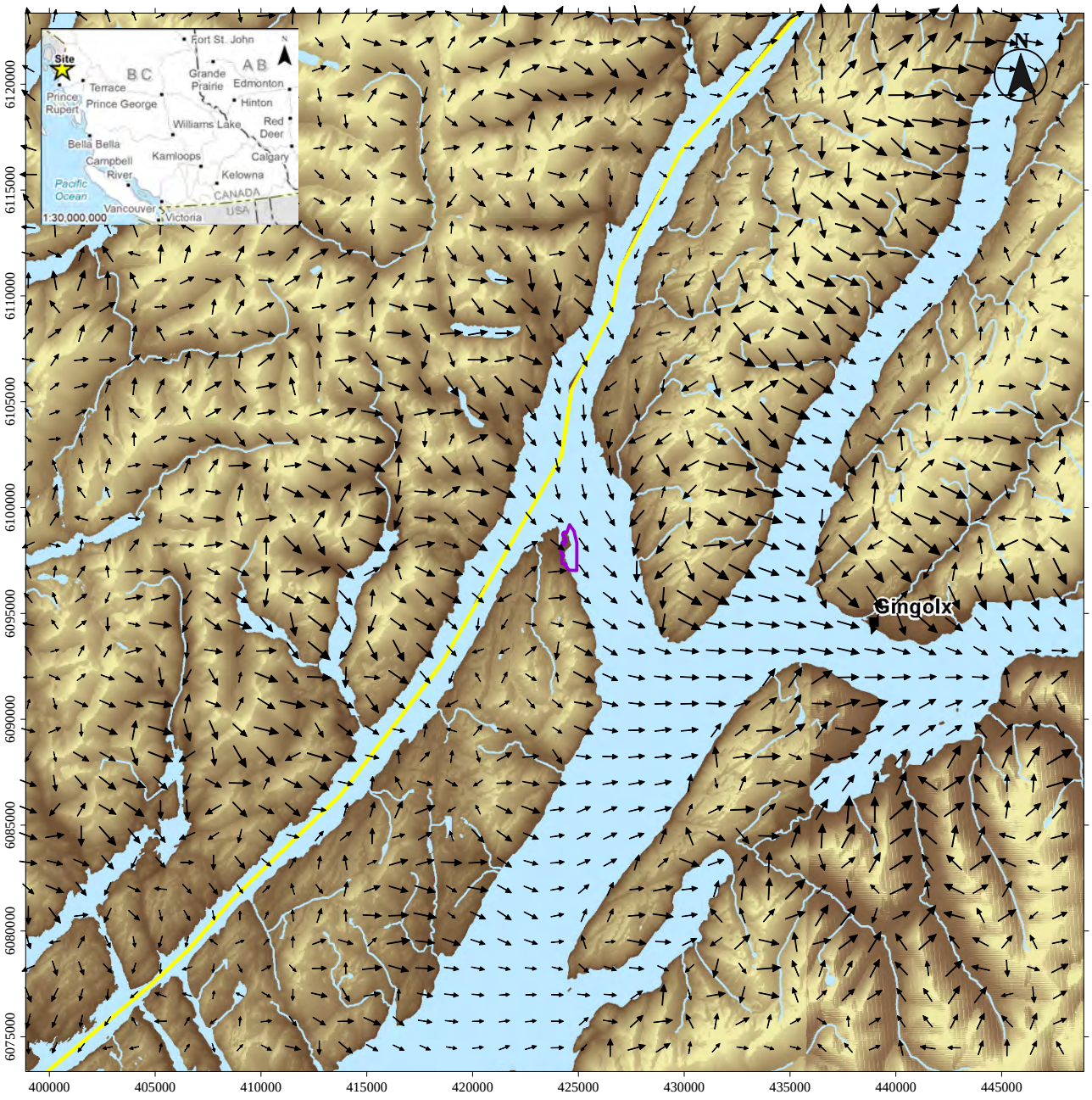
Project Number 123221820

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Figure No.
B-6

Title
Predicted Surface Wind Field
for Unstable Conditions
(1200 LST July 12, 2012)

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Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary
Site
Gingolx
International Boundary
Watercourse
Waterbody
Ground Elevation (m)
High : 1652
Low : 0

Metres
0 5000 10000 15000

Stantec

Project Location
Pearse Island, BC

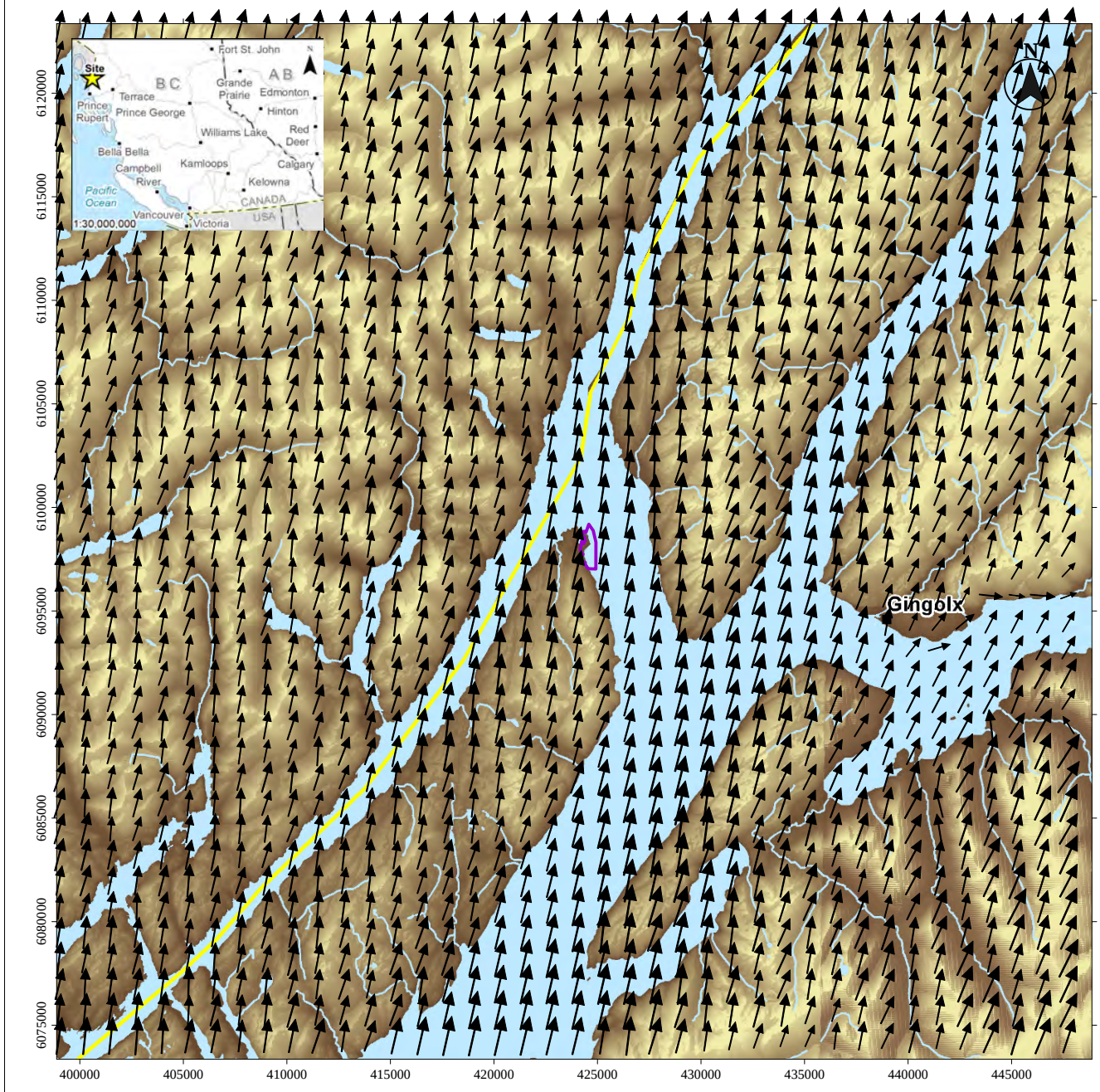
Project Number 123221820

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Natural Gas Liquefaction and Marine Terminal

Figure No.
B-7

Title
Predicted Surface Wind Field
for Stable Conditions
(0500 LST January 10, 2012)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary
Site
Gingolx
International Boundary
Watercourse
Waterbody
Ground Elevation (m)
High : 1652
Low : 0

Metres
0 5000 10000 15000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
B-8

Title
Predicted Surface Wind Field
for High Winds Conditions
(1800 LST November 4, 2012)

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B.7.2 Predicted Winds at Project Site

Figure B.9 shows the wind roses predicted by CALMET for the Project site at various elevations above ground (10 m, 60 m, 100 m and 200 m). The results indicate:

- At all four levels, winds are mainly from north and south. Higher winds are also mainly from the southwest. This is likely due to local topography surrounding the Project Site.
- Wind speed increases with increasing height above the ground.

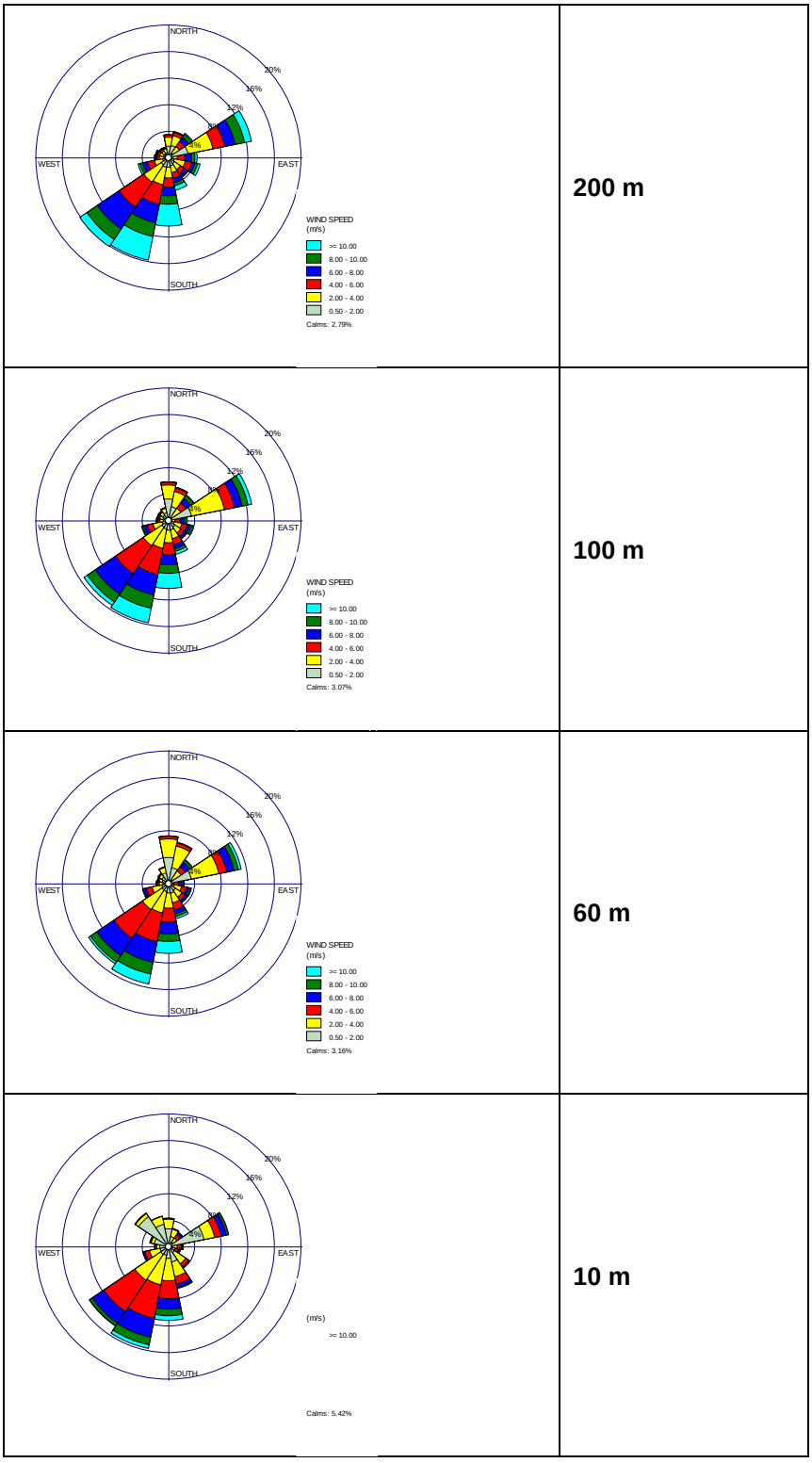


Figure B.9 CALMET Predicted Wind Roses at 4 Levels at the Project Site (2011–2015)

B.7.3 Predicted Surface Temperatures at Project Site

Figure B.10 shows the monthly average surface temperatures predicted by CALMET for the Project site for 2011–2015. The predicted monthly temperatures indicate similar and reasonable seasonal surface temperature variations.

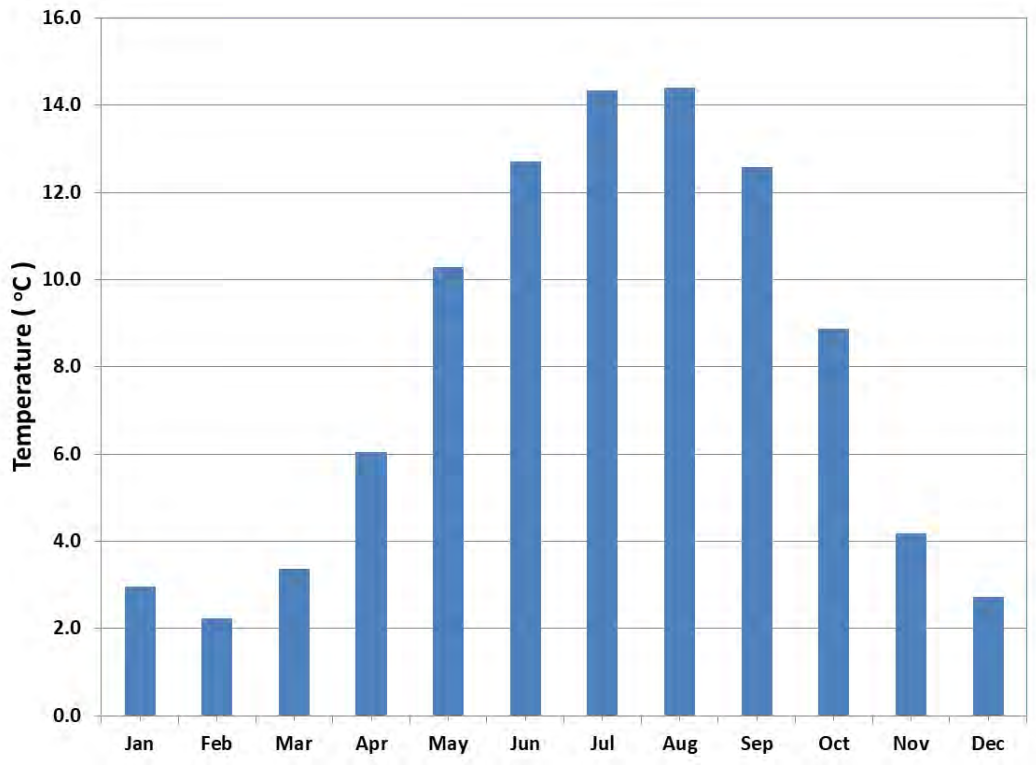


Figure B.10 CALMET Predicted Monthly Average Surface Temperature at the Project site (2011–2015)

B.7.4 Predicted Mixing Heights

CALMET predicted seasonal mean diurnal mixing heights extracted at the Project Site for 2011–2015 are provided in Figure B.11 (definitions of five seasons refer to Table B.2). Extractions are as per the CALMET user guide (Scire, J.S., F.R. Robe, M.E. Ferneau, and R.J. Yamartino, 2000). The results show:

- Season 1 (mid-summer): The mean maximum values are about 941 m.
- Season 2 (autumn): The mean maximum afternoon values are about 871 m.
- Season 3 (winter 1): The mean maximum afternoon values are about 750 m.
- Season 4 (winter 2): The mean maximum afternoon values are about 774 m.
- Season 5 (transitional spring): The mean maximum afternoon values are about 1,050 m.

The convective mixing process dominates during the day, leading to maximum mixed layer depths during the afternoon. The minimum values for each season are predicted to occur during the night.

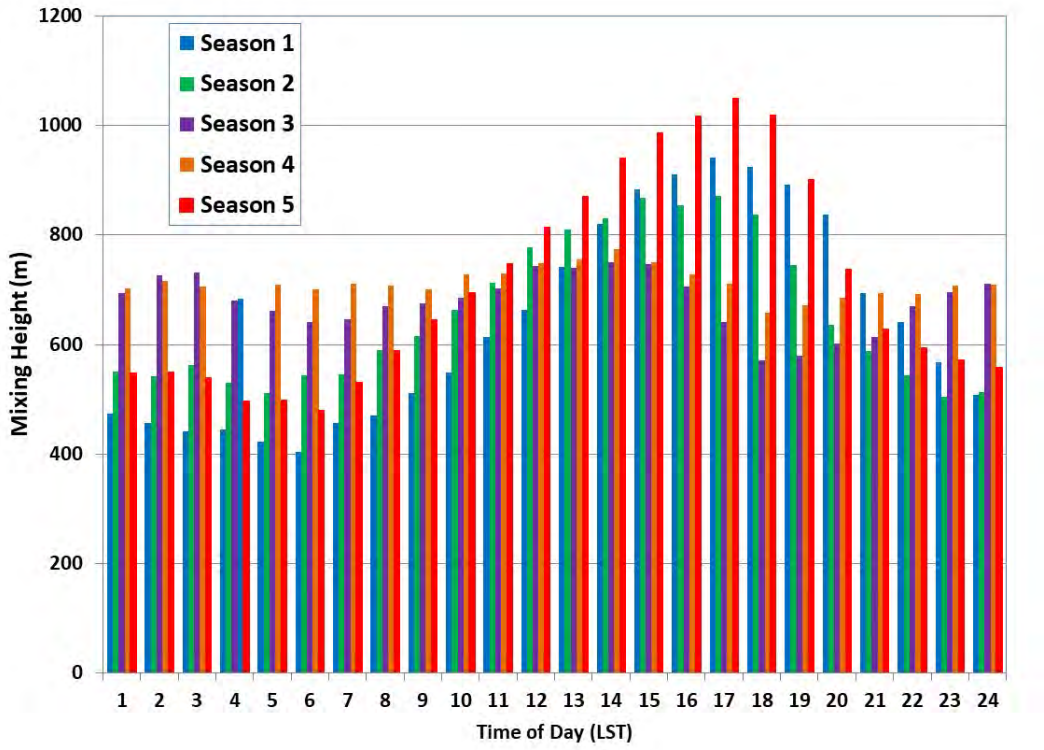


Figure B.11 CALMET Predicted Mean Diurnal Mixing Heights at the Project site (2011–2015)

B.7.5 Predicted Atmospheric Stability Class

Table B.8 provides the stability class frequency distributions based on the CALMET model predictions for the Project site. Figure B.12 shows the frequency distributions of predicted seasonal PG stability classes at the Project site on a diurnal basis.

- The neutral condition (Stability Class D) Neutral conditions are most frequent during the fall (season 3) and winter (season 4), during both day and night. This is due to the combination of high winds and persistent cloud cover, which are present in the area during the fall and winter storm season.
- Unstable conditions (Stability Classes A, B and C) are more frequent during the summer and spring seasons (seasons 1, 2 and 5), and are associated with daytime periods, clear skies and low wind speeds.
- Stable conditions (Stability Classes E and F) are more frequent during nighttime periods.

Table B.8 Predicted Stability Class Frequency Distributions (%) at the Project Site (2011–2015)

	Number of Hours	A	B	C	D	E	F
Season 1	9120	1.3	8.3	10.8	64.4	4.0	11.3
Season 2	5520	0.8	6.0	9.6	63.2	3.1	17.3
Season 3	7320	0.0	1.7	6.4	68.5	4.0	19.3
Season 4	12624	0.0	0.5	5.0	71.6	4.6	18.2
Season 5	9240	1.1	7.2	11.6	60.2	3.5	16.4
2011–2015	43824	0.6	4.4	8.4	66.1	4.0	16.5

NOTE:
Definitions of five seasons refer to Table B.2.



NOTE:
Definitions of five seasons refer to Table B.2

Figure B.12 Frequency of Predicted Seasonal PG Stability Class at the Project Site (2011 to 2015)

B.8 CALMET MODEL OPTIONS

The model developer provided the CALMET user with numerous options to address a range of user needs. The parameters for the CALMET control file used in this assessment are provided in Table B.9 to Table B.14.

The default values recommended by the US EPA (US EPA, 1998) are presented for comparative purposes. In most cases, these default values are used. The Guidelines (BC ENV, 2015) Section 9.4 also indicates some specific values in CALMET Input Group 5 that are to be used instead of the default values. Some of the recommendations are mandatory (indicated by orange shading in Table B.13 and others are left to professional judgment (indicated by green shading in Table B.13).

Table B.9 CALMET Model Options Groups 0 and 1

Parameter	Default	Project	Comment
Input Group 0: Input and Output File Names			
NUSTA	-	0	Number of upper air stations
NOWSTA	-	0	Number of overwater met stations
MM3D	-	60	Number of CALWRF 3D.DAT files (one for each month)
NIGF	-	0	Number of IGF-CALMET.DAT files
Input Group 1: General run control parameters			
IBYR	-	2011	Starting year
IBMO	-	1	Starting month
IBDY	-	1	Starting day
IBHR	-	0	Starting hour
IBSEC	-	0	Starting second
IEYR	-	2016	Ending year
IEMO	-	1	Ending month
IEDY	-	1	Ending day
IEHR	-	0	Ending hour
IESEC	-	0	Ending second
ABTZ	-	UTC-0800	UTC time zone
NSECDT	3,600	3600	Length of modeling time-step (seconds)
IRTYPE	1	1	Run type
LCALGRD	T	T	Special data fields
ITEST	2	2	Flag to stop run after SETUP phase

Table B.10 CALMET Model Options Group 2: Grid Control Parameters

Parameter	Default	Project	Comment
PMAP	UTM	UTM	Map projection
IUTMZN	-	9	UTM Zone
UTMHEM	N	N	Hemisphere for UTM projection
DATUM	WGS-84	NAR-C	Datum-region for output coordinate
NX	-	200	No. X grid cells
NY	-	200	No. Y grid cells
DGRIDKM	-	0.25	Grid spacing (km)
XORIGKM	-	398.880	Reference coordinate of SW corner of grid cell (1,1) -X coordinate (km)
YORIGKM	-	6073.360	Reference coordinate of SW corner of grid cell (1,1) -Y coordinate (km)
NZ	-	12	Vertical grid definition: Number of vertical layers
ZFACE	-	0, 20, 40, 80, 120, 280, 520, 880, 1320, 1820, 2380, 3000 and 4000	Vertical grid definition: Cell face heights in arbitrary vertical grid (m)

Table B.11 CALMET Model Options Group 3: Output Options

Parameter	Default	Project	Comment
Disk Output:			
LSAVE	T	T	Save met. fields in the unformatted output files
IFORMO	1	1	Type of unformatted output file
Line Printer Output:			
LPRINT	F	F	Print meteorological fields
IPRINF	1	1	Print intervals (hrs)
IUVOUT (NZ)	0	12*0	Specify which layers of U,V wind component to print
IWOUT (NZ)	0	12*0	Specify which level of the w wind component to print
ITOUT (NZ)	0	12*0	Specify which levels of the 3-D temperature field to print
Meteorological fields to print:			
Variable		Print? 0 = no print 1 = print	Comment
STABILITY		0	PGT stability
USTAR		0	Friction velocity
MONIN		0	Monin-Obukhov length
MIXHT		0	Mixing height

Table B.11 CALMET Model Options Group 3: Output Options

Parameter	Default	Project	Comment
WSTAR		0	Convective velocity scale
PRECIP		0	Precipitation rate
SENSHEAT		0	Sensible heat flux
CONVZI		0	Convective mixing height
Testing and debug print options for micrometeorological module:			
LDB	F	F	Print input meteorological data and internal variables
NN1	1	1	First time step for which debug data are printed
NN2	1	1	Last time step for which debug data are printed
LDBCST	F	F	Print distance to land internal variables
Testing and debug print options for wind field module:			
IOUTD	0	0	Control variable for writing the test/debug wind fields to disk files
NZPRN2	1	1	Number of levels, starting at surface, to print
IPR0	0	0	Print the interpolated wind components
IPR1	0	0	Print the terrain adjusted surface wind components
IPR2	0	0	Print the smoothed wind components and the initial divergence fields
IPR3	0	0	Print the final wind speed and direction
IPR4	0	0	Print the final divergence fields
IPR5	0	0	Print the winds after kinematic effects are added
IPR6	0	0	Print the winds after the Froude number adjustment is made
IPR7	0	0	Print the winds after slope flows are added
IPR8	0	0	Print the final wind field components

Table B.12 CALMET Model Options Group 4: Meteorological Data Options

Parameter	Default	Project	Comment
NOOBS	0	2	No surface, overwater, or upper air observations Use WRF/3D for surface, overwater, and upper air data
Number of Surface & Precipitation Meteorological Stations:			
NSSTA	-	Not applicable	Number of surface stations
NPSTA	-	Not applicable	Number of precipitation stations
Cloud Data Options:			
MCLOUD	0	4	Gridded cloud cover from prognostic relative humidity at all levels
File Formats:			
IFORMS	2	Not applicable	Surface meteorological data file format
IFORMP	2	Not applicable	Precipitation data file format
IFORMC	2	Not applicable	Cloud data file format

Table B.13 CALMET Model Option Group 5: Wind Field Options and Parameters

Parameter	Default	Project	Comment
Wind Field Model Options:			
IWFCOD	1	1	Model selection variables
IFRADJ	1	1	Compute Froude number adjustment
IKINE	0	0	Compute kinematic effects
IOBR	0	0	Use O'Brien procedure for adjustment of the vertical velocity
ISLOPE	1	1	Compute slope flow effects
IEXTRP	1	1	no extrapolation is done
ICALM	0 or 1	0	Extrapolate surface winds even if calm
BIAS	0	12*0	Layer-dependent biases modifying the weights of surface and upper air stations
RMIN2	4	Not applicable	Minimum distance from nearest upper air station to surface station for which extrapolation of surface winds at surface station will be allowed
IPROG	2,4 or 14	14	Use gridded prognostic wind field model output fields as input to the diagnostic wind field model (from WRF 3D.DAT)
ISTEPPGS	3600	3600	Time step (seconds) of the prognostic model input data
IGFMET	0	0	Use coarse CALMET fields as initial guess fields

Table B.13 CALMET Model Option Group 5: Wind Field Options and Parameters

Parameter	Default	Project	Comment
Radius of Influence Parameters:			
LVARY	F	F	Use varying radius of influence
RMAX1	-	Not applicable	Maximum radius of influence over land in the surface layer (km)
RMAX2	-	Not applicable	Maximum radius of influence over land aloft (km)
RMAX3	-	Not applicable	Maximum radius of influence over water
Other Wind Field Input Parameters:			
RMIN	0.1	0.1	Minimum radius of influence used in the wind field interpolation (km)
TERRAD	-	5	Radius of influence of terrain features (km)
R1	-	Not applicable	Relative weighting of the first guess field and observations in the surface layer (km)
R2	-	Not applicable	Relative weighting of the first guess field and observations in the layers aloft (km)
RPROG	-	0	Relative weighting parameter of the prognostic wind field data (km)
DIVLIM	5.0E-6	5.0E-6	Maximum acceptable divergence in the divergence minimization procedure
NITER	50	50	Maximum number of iterations in the divergence minimization procedure
NSMTH (NZ)	2,(mxnz-1)*4	2,11*4	Number of passes in the smoothing procedure
NINTR2	99	12*99	Maximum number of stations used in each layer for the interpolation of data to a grid point
CRITFN	1.0	1.0	Critical Froude number
ALPHA	0.1	0.1	Empirical factor controlling the influence of kinematic effects
FEXTR2(NZ)	0.0	12*0	Multiplicative scaling factor for extrapolation of surface observations to upper layers
Barrier Information:			
NBAR	0	0	Number of barriers to interpolation of the wind fields
KBAR	NZ	12	Level (1 to NZ) up to which barriers apply
XBBAR	-	0	X coordinate of beginning of each barrier
YBBAR	-	0	Y coordinate of beginning of each barrier
XEBAR	-	0	X coordinate of ending of each barrier
YEBAR	-	0	Y coordinate of ending of each barrier

Table B.13 CALMET Model Option Group 5: Wind Field Options and Parameters

Parameter	Default	Project	Comment
Diagnostic Module Data Input Options:			
IDIOPT1	0	0	Surface temperature (0 = compute internally from hourly surface observation)
ISURFT	-	-1	use 2-D spatially varying surface temperatures
IDIOPT2	0	0	Domain-averaged temperature lapse (0 = compute internally from hourly surface observation)
IUPT	-	Not applicable	Upper air station to use for the domain-scale lapse rate
ZUPT	200	Not applicable	Depth through which the domain-scale lapse rate is computed (m)
IDIOPT3	0	0	Domain-averaged wind components
IUPWND	-1	-1	Upper air station to use for the domain-scale winds (-1 indicating 3-D initial guess fields)
ZUPWND	1., 1000	1., 1000	Bottom and top of layer through which domain-scale winds are computed (m)
IDIOPT4	0	0	Observed surface wind components for wind field module
IDIOPT5	0	0	Observed upper air wind components for wind field module
Lake Breeze Information:			
LLBREZE	F	F	Use lake breeze module
NBOX	-	Not applicable	Number of lake breeze regions
XG1	-	Not applicable	X Grid line 1 defining the region of interest
XG2	-	Not applicable	X Grid line 2 defining the region of interest
YG1	-	Not applicable	Y Grid line 1 defining the region of interest
YG2	-	Not applicable	Y Grid line 2 defining the region of interest
XBCST	-	Not applicable	X Point defining the coastline in kilometres (Straight line)
YBCST	-	Not applicable	Y Point defining the coastline in kilometres (Straight line)
XECST	-	Not applicable	X Point defining the coastline in kilometres (Straight line)
YECST	-	Not applicable	Y Point defining the coastline in kilometres (Straight line)
NLB	-	Not applicable	Number of stations in the region
METBXID	-	Not applicable	Station ID’s in the region
NOTES: Orange shading = mandatory recommendations Green shading = left up to professional judgment			

Table B.14 CALMET Model Option Group 6: Mixing Height, Temperature and Precipitation Parameters

Parameter	Default	Project	Comment
Empirical Mixing Height Constants:			
CONSTB	1.41	1.41	Neutral, mechanical equation
CONSTE	0.15	0.15	Convective mixing height equation
CONSTN	2400	2400	Stable mixing height equation
CONSTW	0.16	0.16	Over water mixing height equation
FCORIO	1.0E-4	1.0E-04	Absolute value of Coriolis (l/s)
Spatial Averaging of Mixing Heights:			
IAVEZI	1	1	Conduct spatial averaging
MNMDAV	1	1	Maximum search radius in averaging (grid cells)
HAFANG	30	30	Half-angle of upwind looking cone for averaging
ILEVZI	1	1	Layer of winds used in upwind averaging
Convective Mixing Heights Options:			
IMIXH	1	1	Method to compute the convective mixing height (Maul-Carson)
THRESHL	0.05	0.05	Threshold buoyancy flux required to sustain convective mixing height growth overland (W/m^3)
THRESHW	0.05	0.05	Threshold buoyancy flux required to sustain convective mixing height growth overwater (W/m^3)
IZICRLX	1	1	Use convective mixing height relaxation to equilibrium value
TZICRLX	800	800	Relaxation time (seconds) of convective mixing height to equilibrium value
ITWPROG	0	0	Option for overwater lapse rates used in convective mixing height growth (1=use prognostic lapse rates)
ILUOC3D	16	16	Land use category ocean in 3D.DAT datasets
Other Mixing Height Variables:			
DPTMIN	0.001	0.001	Minimum potential temperature lapse rate in the stable 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 overwater mixing height (m)
ZIMAXW	3000	3000	Maximum overwater mixing height (m)

Table B.14 CALMET Model Option Group 6: Mixing Height, Temperature and Precipitation Parameters

Parameter	Default	Project	Comment
Overwater Surface Fluxes Method and Parameters:			
ICOARE	10	10	COARE with no wave parameterization
DSHELF	0	0	Coastal/Shallow water length scale (km)
IWARM	0	0	COARE warm layer computation
ICOOL	0	0	COARE cool skin layer computation
Relative Humidity Parameters:			
IRHPROG	0	0	3D relative humidity from observations
Temperature Parameters:			
ITPROG	-	1	Surface temperature from observations; Use WRF/3D for upper temperature data
IRAD	1	1	Interpolation type
TRADKM	500	500	Radius of influence for temperature interpolation (km)
NUMTS	-	Not applicable	Maximum number of stations to include in temperature interpolation
IAVET	1	1	Conduct spatial averaging of temperatures (1 = yes)
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 categories for temperature interpolation over water
JWAT2	-	999	Ending land use categories for temperature interpolation over water

B.9 REFERENCES

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APPENDIX C

CALPUFF

1 Appendix C CALPUFF

Appendix C CALPUFF

C.1 INTRODUCTION

This section discusses the application of the primary dispersion model that was used for the air quality assessment for the proposed Ksi Lisims LNG Project. The dispersion modelling was conducted following the British Columbia (BC) Air Quality Dispersion Modelling Guideline (the Guideline) (BC ENV, 2022a).

C.2 CALPUFF MODEL

C.2.1 Model Description

The CALPUFF model (Scire et al. 2000) is a multi-layer, multi-species, non-steady state puff dispersion model that can simulate the effects of time and space-varying meteorological conditions on substance transport, transformation, and removal. CALPUFF contains algorithms for near-source effects such as building downwash, transitional plume rise, partial plume penetration, as well as longer-range effects such as chemical transformation, and pollutant removal (wet scavenging and dry deposition). It can accommodate arbitrarily varying point source and area source emissions. Most of the algorithms contain options to treat physical processes at differing levels of detail depending on the requirements for the particular model application:

- **Atmospheric Dispersion:** Several options are provided in CALPUFF for the computation of dispersion coefficients:
  - similarity theory to estimate sigma v (or σv) and sigma w (or σw) from surface heat and momentum fluxes provided by CALMET
  - Pasquill-Gifford (PG) or McElroy-Pooler (MP) dispersion coefficients
  - dispersion equations based on the Complex Terrain Dispersion Model (CTDM)
  - hourly values of direct turbulence measurements (σv and σw)
- **Chemical Transformation:** CALPUFF includes options to parameterize chemical transformation effects using the five species scheme (SO_2, SO_4^{2-}, NO_X, nitric acid [HNO_3], and NO_3^-) used in the MESOPUFF II model; a modified six-species scheme (SO_2, SO_4^{2-}, nitric oxide [NO], NO_2, HNO_3, and NO_3^-) adapted from the RIVAD/ARM3 (Regional Impact in Visibility and Acid Deposition/Acid Rain Mountain Mesoscale Model) method; updated RIVAD with ISORROPPIA inorganic aerosol thermodynamic equilibrium model; or a set of user specified, diurnally-varying transformation rates.

- **Dry Deposition:** A full resistance model is provided to calculate dry deposition rates of gases and particulate matter as a function of geophysical parameters, meteorological conditions and substance properties. 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 bypass 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 versus liquid precipitation).

The following section describes the application of the CALPUFF model specific to the Project assessment. The most recently available version of the CALPUFF model was selected (i.e., Version 7.2.1 [Level 150618]).

C.2.2 Model Application

C.2.2.1 CALPUFF Study Area

The CALPUFF model requires the user to define a domain where the emissions sources are identified and quantified, the meteorological conditions are characterized, and the locations where the air quality changes are to be predicted. It was determined that a 40 km x 40 km area centered on the Project is sufficient to determine the effect of Project emissions on air quality. The study area boundaries enclose the concentration contours attributable to the Project that are greater than 10% of the applicable regulatory criteria in accordance with the Guideline (BC ENV, 2022a). Table C.1 identifies the CALPUFF study area coordinates for this assessment.

Table C.1 CALPUFF Study Area Coordinates

Domain Corner	Location (UTM NAD 83, Zone 9)	
	East (m)	North (m)
Northwest	403886	6118716
Southwest	403886	6078716
Southeast	443886	6078716
Northeast	443886	6118716

C.2.2.2 Meteorological Data

For this assessment, CALMET model was run in hybrid mode by using surface observations and WRF 4 km gridded data (BC ENV, 2021) for the period of January 1, 2011 to December 31, 2015. There are no surface and upper air station located within the CALMET domain. For this application, CALMET model was run in no-observation mode.

C.2.2.3 Emissions and Source Characteristics

CALPUFF was used to simulate the transport and dispersion of emissions from the proposed Ksi Lisims LNG project. Appendix A of the Technical Report provides emission source characteristics and emission rates for the proposed Ksi Lisims LNG project sources used for this assessment.

C.2.2.4 Receptor Locations

Two types of receptors within the domain are defined: nested Cartesian grid points and discrete (sensitive and distance) locations.

Gridded Cartesian Receptors

Predictions of ground-level air concentrations on and outside the plant boundary were produced according to the Guideline (BC ENV, 2022a), using a series of nested Cartesian grids with increasing receptor density with proximity to the site. The receptor grids and their corresponding spacing are as follows:

- 20 m receptor spacing along the plant boundary (as defined in Section 7.3 in the Guideline [ENV 2022a])
- 50 m spacing within 2 km x 2 km of the Project Sources
- 250 m spacing within 6 km x 6 km of the Project Sources
- 250 m spacing within 3 km x 3 km over Ginglox
- 500 m spacing within the 10 km by 10 km of the Project Sources
- 1,000 m spacing within the 40 km by 40 km CALPUFF study area

The described grid comprises 10,002 receptor locations. Figure C.1 shows the receptor grid used within the CALPUFF modelling domain

Discrete Receptors

For the CALPUFF model the proposed sensitive receptors is provided in the Dispersion Modelling Plan (Appendix A: Table 1 and shown in Figure 3). These receptors were derived following Section 7.4 in the Guideline (ENV 2022a).

The sensitive receptors were broadly grouped as follows:

- 11 lakes, creeks, and rivers selected for the aquatics assessment
- 25 schools, daycares, health care facilities and residential areas selected for the human health risk assessment



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Site
Gingolx
International Boundary
Watercourse
Waterbody
Ground Elevation (m)
High : 1652
Low : 0

Ksi Lisims LNG Plant Boundary
Model Receptor

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

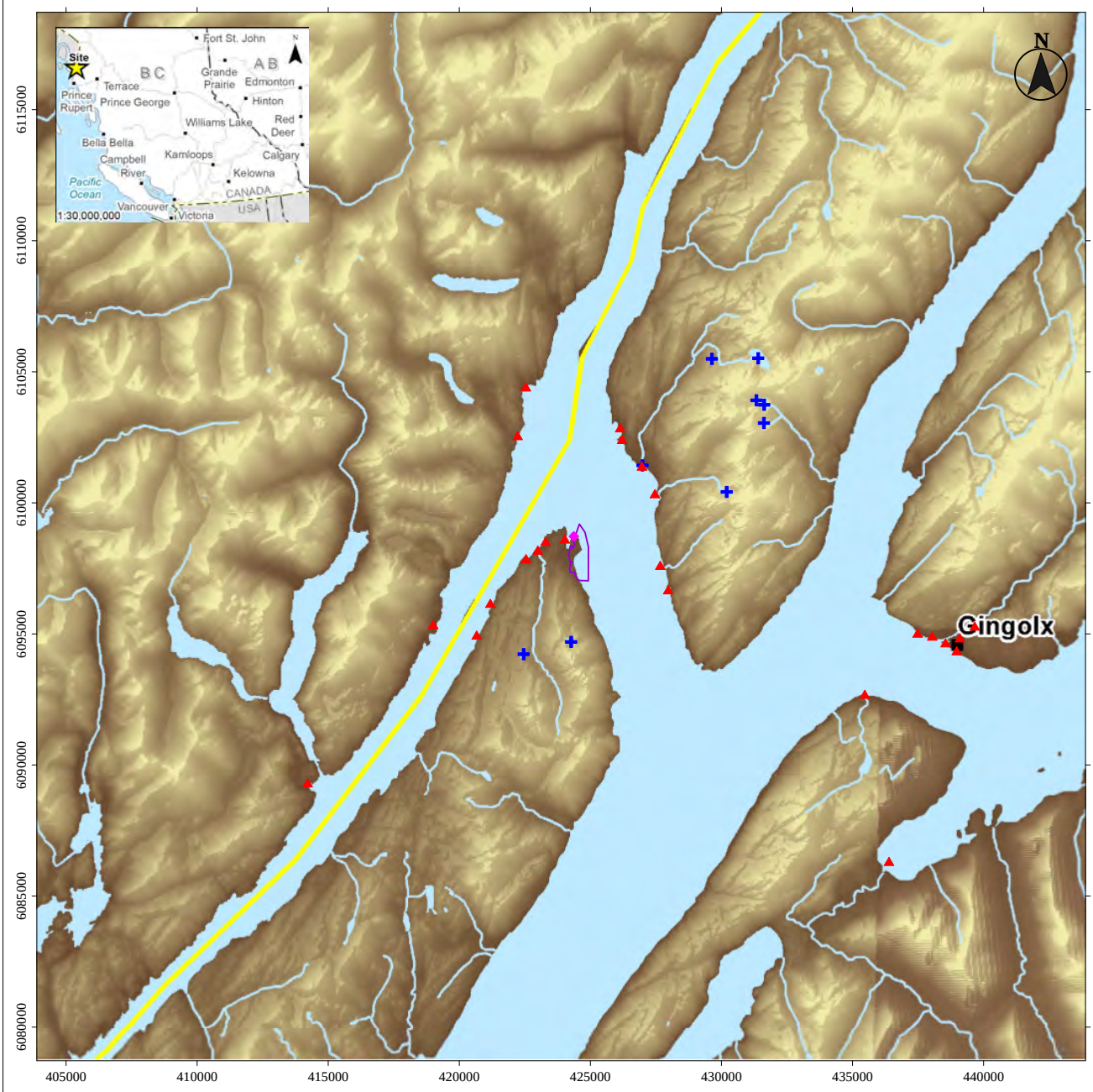
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
C.1

Title
Receptor Grid in the Modelling Domain

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Site
Gingolx
International Boundary
Watercourse
Waterbody
Ground Elevation (m)
High : 1652
Low : 0

Ksi Lisims LNG Plant Boundary

Sensitive Receptors for Human Health Assessment

Sensitive Receptors for Aquatics Assessment

Sensitive Receptor for Noise Assessment

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
C.2

Title
Sensitive Receptors in the Modelling Domain

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C.2.2.5 Building Downwash

Buildings or other solid structures may affect the flow of air near a source and cause building downwash effects (e.g., eddies on the downwind side), which have potential to reduce plume rise and affect dispersion. For dispersion modelling purposes, building downwash effects were considered for the Project sources with the Plume Rise Model Enhancement (PRIME) downwash routine (MBDW=2) suggested in the Guideline (BC ENV, 2022a). For the building and structure dimensions considered in dispersion modelling, see Appendix A.

C.2.2.6 Terrain Effects

The CALPUFF model was used to estimate concentrations, for each species considered, at each receptor location. 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 was used to modify the height of the plume.

The Partial Plume Path Adjustment Method employs a plume path coefficient (PPC) to adjust the height of the plume above the ground. PPC default values of 0.50, 0.50, 0.50, 0.50, 0.35 and 0.35 for PG stability classes A, B, C, D, E, and F, respectively, were used.

C.2.2.7 Dispersion Coefficients

Fundamental parameters controlling plume dispersion in a Gaussian model such as CALPUFF are the dispersion coefficients. These values, which must be specified for both the horizontal and the vertical directions, can be estimated in CALPUFF using several different methods. For this application, dispersion coefficients were internally computed from turbulence estimates based on micrometeorological data from CALMET (MDISP = 2). This selected method is based on BC ENV recommendations (i.e., Table 7.1 in the Guideline [BC ENV, 2022a]).

C.2.2.8 Chemical Transformation

The updated RIVAD(Regional Impact in Visibility and Acid Deposition Model) chemical scheme with ISORROPIA equilibrium is selected (MCHEM = 6) to be consistent with the Guideline. The updated RIVAD chemical scheme calculates transformation of SO_2 to SO_4 and NO/NO_2 to HNO_3 and NO_3 with ISORROPIA model for inorganic gas-particle equilibrium (TRC Environmental Corporation 2010). The selected chemical transformation scheme was applied relative to the prediction of sulphate and nitrate compounds and the associated deposition.

The chemical transformation scheme requires NO and NO_2 emissions rates. Typically, only the NO_X emission rate is known, and this rate is expressed in terms of NO_2 mass equivalent. Based on the NO_X emission rate, the individual NO and NO_2 emission rates were calculated as follows:

- 90% NO and 10% NO_2 on a volume basis
- NO mass emission = 0.9*(30/46)*(NO_X mass emission)
- NO_2 mass emission = 0.1 *(46/46)*(NO_X mass emission)

These assumptions result in 85% NO and 15% NO_2 emissions on a mass basis. The 90% NO and 10% NO_2 volume ratio is consistent with the ozone limiting method (OLM).

Counter to the Guideline (BC ENV, 2022a), the aqueous phase chemistry flag (MAQCHEM) and Liquid Water Content flag (MLWC) will be turned off. Stantec has conducted extensive model performance analysis of deposition using MAQCHEM in Kitimat and has found, due to the high precipitation rates and relative humidity on the north coast, CALPUFF significantly overpredicts the wet deposition of SO2 while model predictions demonstrated conservative, but realistic predictions without use of this model option (i.e, MAQCHEM=0). Recent modelling by Rio Tinto (ESSA Technologies, et al. 2020) also did not employee the aqueous phase chemistry option.

C.2.2.9 NOx to NO_2 Chemistry

The Guideline identifies several NOx to NO_2 conversion approaches: the total conversion method (TCM) that assumes all NOx is converted to NO_2; the ambient ratio method (ARM); the ozone limiting method (OLM) using representative ozone measurements; and the CALPUFF predictions based on the RIVAD/ISORROPIA approach. For the methods that use representative ozone data, it is desirable to adopt ozone concentrations that match the time period that match the meteorological data (i.e., hourly values for the 2012).

NO to NO_2 conversion will be carried out using the ambient ratio method 2 (ARM2) consistent with Section 3.2.1.2 and Appendix A of the Guidance for NO_2 Dispersion Modelling in British Columbia (NO_2 Guidance) (ENV 2022b). Existing air quality in the assessment area is considered pristine and there is no monitoring data available, on this basis, the Coastal Sites ARM2 curve will be used to convert NO to NO_2, as provided in the NO_2 Guidance (BC ENV, 2022b).

C.2.2.10 NH_3 Concentrations

The Interagency Workshop of Air Quality Modeling Phase 2 report (IWAQM 1998) recommends background ammonia (NH_3) concentration of 10 ppb for grassland and 0.5 ppb for forest land. Considering the majority of the area surrounding Kitimat is forest land, a constant value of 0.5 ppb was selected as monthly background NH3 for this assessment.

C.2.2.11 Secondary Particular Formation

The CALPUFF model was used to predict secondary $PM_{2.5}$ formation due to precursor SO_2 and NO_X emissions. The model predicts particulate nitrate NO_3^-, which can exist as an aerosol (i.e., dissolved in a water droplet) or as a particle (e.g., NH_4NO_3). Similarly, sulphate SO_4^{2-} can also exist as an aerosol (i.e., dissolved in a water droplet) or as a particle (e.g., ammonium sulphate $[(NH_4)_2SO_4]$. NO_3^- and SO_4^{2-} are assumed to react with ambient NH_3 to produce NH_4NO_3 and $(NH_4)_2SO_4$, respectively; the predicted sulphate and nitrate are multiplied by the factors indicated in Table C.2.

Table C.2 $PM_{2.5}$ Multipliers for SO_4^{2-} and NO_3^-

Predicted Parameter	SO_4^{2-}	NO_3^-
Molecular mass	96	62
End product	$(NH_4)_2SO_4$	NH_4NO_3
Molecular mass	132	80
Multiplier	1.375	1.290
NOTE: Multiplier = (Molecular Mass of End Product)/(Molecular Mass of Predicted Parameter)		

The $PM_{2.5}$ predictions derived from the CALPUFF model include the primary $PM_{2.5}$ contribution plus the secondary sulphate contribution and the secondary nitrate contribution.

C.2.2.12 Deposition Calculation Approach

Deposition Parameters

Deposition is comprised of dry and wet removal mechanisms. The dry and wet deposition rates depend on the phase of the compound being deposited (e.g., vapour or particle), and other physical and chemical properties of the compound. For this assessment, deposition of nitrogen and sulphur compounds is required to predict as these compounds can have potential acidification or eutrophication effects on terrestrial and aquatic systems.

For dry deposition, the compound groups are discussed in terms of the deposition options that are available in the CALPUFF model:

- For SO_2, NO, NO_2, and HNO_3, dry deposition is calculated using the CALPUFF internal vapour-phase resistance sub-model. The **default** resistance model input parameters are listed in Table C.8.
- For SO_4^{-2} and NO_3^-, dry deposition is calculated using the CALPUFF internal particle-phase resistance sub-model. The **default** geometric mass mean diameters and standard deviations of 0.48 µm and 2 µm (respectively) based on the CALPUFF manual (Scire et al. 2000) were adopted.

The calculation of wet deposition requires wet scavenging coefficients that vary with phase and form of the precipitation (i.e., liquid (rain) or solid (snow)). The CALPUFF model assumes the scavenging coefficient approach for both gases and particles. For the nitrogen and sulphur compounds, the **default** wet scavenging coefficients listed in Table C.10 are used; and these are based on the CALPUFF manual (Scire et al. 2000) and CALPUFF GUI species library.

Sulphur and Nitrogen Compound Depositions

The project will be a source of acid forming emissions (SO_2 and NO_X contributions). The CALPUFF model predicts SO_2, SO_4^{2-}, NO, NO_2, HNO_3 and NO_3^- deposition as annual averages attributable to emission sources located in the model domain.

Sulphur Deposition

The total sulphur deposition (S) was calculated as follows:

$$S = \frac{96}{64}[SO_2] + [SO_4^{2-}]$$

where S is expressed in kg SO_4^{2-}/ha/a and the values in the square brackets represent the sum of the predicted wet and dry deposition values in kg SO_4^{2-}/ha/a. The multiplication coefficients account for molecular mass differences for the individual species.

Nitrogen Deposition

The total nitrogen deposition (N) was calculated as follows:

$$N = \frac{14}{30}[NO] + \frac{14}{46}[NO_2] + \frac{14}{63}[HNO_3] + \frac{14}{62}[NO_3^-]$$

where the N is expressed in kg N/ha/a and the values in the square brackets represent the sum of the predicted wet and dry deposition values in kg/ha/a. The multiplication coefficients account for molecular mass differences for the individual species.

Sulphur and Nitrogen Depositions

The total sulphur and nitrogen depositions (S + N) was calculated as follows:

$$S + N = \left(\frac{2}{64}[\mathrm{so_2}] + \frac{2}{96}[\mathrm{so_4^{2-}}] + \frac{1}{30}[NO] + \frac{1}{46}[NO_2] + \frac{1}{63}[HNO_3] + \frac{1}{62}[NO_3^-]\right) * 1000$$

where the (S + N) is expressed in eq/ha/a and the values in the square brackets represent the sum of the predicted wet and dry deposition values in kg/ha/a. The multiplication coefficients account for valance and molecular mass differences for the individual species.

C.2.3 Model Options

The input parameters for the CALPUFF control file used in the modelling assessment are provided in Table C.1 to Table C.13. The input groups that are applicable to this assessment are indicated by grey shading in Table C.1. Section 7.8 and Section 10.7 of the Guideline indicate the key CALPUFF model options. Although not specified in the Guideline, it is assumed that the default values are those defined in the CALPUFF user manual (Scire et al. 2000). In most cases, these default values are used. Table 7.1 of the Guideline (BC ENV, 2022a) also indicates specific values to be used instead of the default values. Some of the recommendations are mandatory (indicated by orange shading) and others are left to professional judgment (indicated by green shading).

Table C.3 Input Groups in the CALPUFF Control

Input Group	Description	Applicable to Project?
0	Input and output file names	Yes
1	General run control parameters	Yes
2	Technical options	Yes
3	Species list	Yes
4	Grid control parameters	Yes
5	Output options	Yes
6	Sub grid scale complex terrain inputs	No
7	Dry deposition parameters for gases	Yes
8	Dry deposition parameters for particles	Yes
9	Miscellaneous dry deposition for parameters	No
10	Wet deposition parameters	Yes
11	Chemistry parameters	Yes
12	Diffusion and computational parameters	Yes
13	Point source parameters	Yes
14	Area source parameters	No
15	Line source parameters	No
16	Volume source parameters	No
17	FLARE source control parameters	No
18	Road Emissions parameters	No
19	Emission rate scale-factor tables	No
20	Non-gridded (discrete) receptor information	Yes

Table C.4 Input Group 1: General Run Control Parameters

Parameter	Default	Project	Comments
METRUN	0	0	All model periods in met file(s) will be run
IBYR	-	2011	Starting year
IBMO	-	1	Starting month
IBDY	-	1	Starting day
IBHR	-	0	Starting hour
IEYR	-	2016	Ending year
IEMO	-	1	Ending month
IEDY	-	1	Ending day
IEHR	-	0	Ending hour
ABTZ		UTC-0800	Base time zone
NSPEC	-	11	Number of chemical species
NSE	-	8	Number of chemical species to be emitted
ITEST	2	2	Program is executed after SETUP phase
MRESTART	0	0	Do not read or write a restart file during run
NRESPD	0	0	File updated every 24 periods
METFM	1	1	CALMET binary file (CALMET.MET)
AVET	60	60	Averaging time in minutes
PGTIME	60	60	PG Averaging time in minutes
IOUTU	1	1	Output units for binary concentration and flux files written in Dataset v2.2 or later formats. 1 = mass - g/m^3 (conc) or $g/m^2/s$ (dep)

Table C.5 Input Group 2: Technical Options

Parameter	Default	Project	Comments
MGAUSS	1	1	Gaussian distribution used in near field
MCTADJ	3	3	Partial plume path terrain adjustment
MCTSG	0	0	Scale-scale complex terrain not modelled
MSLUG	0	0	Near-field puffs not modelled as elongated
MTRANS	1	1	Transitional plume rise modelled
MTIP	1	1	Stack tip downwash used
MRISE	1	1	Method used to compute plume rise for point sources not subject to building downwash. 1 = Briggs plume rise
MBDW	1 or 2	2	PRIME Method is used to simulate building downwash
MSHEAR	0	0	Vertical wind shear is not modelled
MSPLIT	0	0	Puff splitting not used
MCHEM	6	6	Transformation rates computed internally (Updated RIVAD scheme with ISORROPIA equilibrium)
MAQCHEM	1	0	Transformation rates and wet scavenging coefficients adjusted for in-cloud aqueous phase reactions
MLWC	1	1	Gridded cloud water data read from CALMET water content output files
MWET	1	1	Wet removal modelled
MDRY	1	1	Dry deposition modelled
MTILT	0	0	Gravitational settling (plume tilt) is not modelled
MDISP	2 or 3	2	Dispersion coefficients from internally calculated sigma v, sigma w using micrometeorological variables (u*, w*, L, etc.) *per BC ENV* Guideline
MTURBVW	3	Not applicable	Used only if MDISP = 1or 5.
MDISP2	3	Not applicable	Used only if MDISP = 1or 5.
MTAULY	0	0	Draxler default 617.284 (s)
MTAUADV	0	0	No turbulence advection
MCTURB	1	1	Standard CALPUFF subroutines
MROUGH	0	0	PG σ_y and σ_z is not adjusted for roughness
MPARTL	1	1	Partial plume penetration of elevated inversion
MPARTLBA	1	1	Partial plume penetration of elevated inversion modelled for the buoyant area sources
MTINV	0	0	Strength of temperature inversion computed from default gradients
MPDF	0 or 1	1	Yes if MDISP = 2 (turbulence based dispersion coefficients).
MSGTIBL	0	0	Sub-grid TIBL module not used for shoreline
MBCON	0	0	Boundary concentration conditions not modelled

Table C.5 Input Group 2: Technical Options

Parameter	Default	Project	Comments
MSOURCE	0	0	Individual source contributions not saved
MFOG	0	0	Do not configure for FOG model output
MREG	1	0	Do not test options specified to see if they conform to regulatory values
NOTES: Mandatory or recommendations by the Guideline Section 7.8. Professional judgement required per the Guideline Section 7.8.			

Table C.6 Input Group 3: Species List

CSPEC	Modelled[1]	Emitted[2]	Dry Deposition[3]	Output Group Number
SO_2	1	1	1	0
SO4	1	0	2	0
NO	1	1	1	0
NO2	1	1	1	0
HNO3	1	0	1	0
NO3	1	0	2	0
$PM_{2.5}$	1	1	2	0
CO	1	1	0	0
NO_x	1	1	0	0
H2S	1	1	0	0
VOC	1	1	0	0

NOTES:
[1] 0 = no, 1 = yes
[2] 0 = no, 1 = yes
[3] 0 = none, 1 = computed-gas, 2 = computed particle, 3 = user-specified

Table C.7 Input Group 4: Map Projection and Grid Control Parameters

Parameter	Default	Project	Comments
PMAP	UTM	UTM	Universal Transverse Mercator
FEAST	0	0	False Easting (km) at the projection origin
FNORTH	0	0	False Northing (km) at the projection origin
IUTMZN	-	9	UTM zone
UTMHEM	N	N	Northern Hemisphere for UTM projection
DATUM	WGS-84	NAR-C	NAR-C is applicable for this assessment. WGS-84 is just the datum for TRC demo case along with the CALPUFF release.
NX	-	200	Number of X grid cells in meteorological grid
NY		200	Number of Y grid cells in meteorological grid
NZ	-	12	Vertical grid definition: Number of vertical layers
DGRIDKM	-	0.25	Grid spacing (km) to match CALMET (see Attachment C)
ZFACE	-	0, 20, 40, 80, 120, 280, 520, 880, 1320, 1820, 2380, 3000 and 4000	Vertical grid definition: Cell face heights (m). Selected to match CALMET (Attachment C).
XORIGKM	-	398.880	Reference X coordinate for SW corner of grid cell (1,1) of meteorological grid (km)
YORIGKM	-	6073.360	Reference Y coordinate for SW corner of grid cell (1,1) of meteorological grid (km)
IBCOMP	-	1	X index of lower left corner of the computational grid
JBCOMP	-	1	Y index of lower left corner of the computational grids
IECOMP	-	200	X index of the upper right corner of the computational grid
JECOMP	-	200	Y index of the upper right corner of the computational grid
LSAMP	T	F	Sampling grid is not used
IBSAMP	-	Not applicable	X index of lower left corner of the sampling grid
JBSAMP	-	Not applicable	Y index of lower left corner of the sampling grid
IESAMP	-	Not applicable	X index of upper right corner of the sampling grid
JESAMP	-	Not applicable	Y index of upper right corner of the sampling grid
MESHDN	1	1	Nesting factor of the sampling grid

Table C.8 Input Group 5: Output Options

Parameter	Default	Project	Comments
ICON	1	1	Output file CONC.DAT containing concentrations is created
IDRY	1	1	Output file DFLX.DAT containing dry fluxes is created
IWET	1	1	Output file WFLX.DAT containing wet fluxes is created
IT2D	0	0	2D Temperature
IRHO	0	0	Density
IVIS	1	0	Output file containing relative humidity data is not created
LCOMPRS	T	T	Perform data compression in output file
IQAPLOT	1	1	Create a standard series of output files (e.g., locations of sources, receptors, grids ...) suitable for plotting
IMFLX	0	0	Do not calculate mass fluxes across specific boundaries
INRISE	0	0	Do not create a file with plume properties for each rise increment, for each model timestep
IMBAL	0	0	Mass balances for each species are not reported hourly
ICPRT	0	1	Print concentration fields to the output list file
IDPRT	0	0	Do not print dry flux fields to the output list file
IWPRT	0	0	Do not print wet flux fields to the output list file
ICFRQ	1	1	Concentration fields are printed to output list file every 24-hour
IDFRQ	1	1	Dry flux fields are printed to output list file every 24-hour
IWFRQ	1	1	Wet flux fields are printed to output list file every 24-hour
IPRTU	1	3	Units for line printer output are in $\mu g/m^3$ for concentration and $\mu g/m^2/s$ for deposition
IMESG	2	2	Messages tracking the progress of run are written on screen
LDEBUG	F	F	Logical value for debug output
IPFDEB	1	1	First puff to track
NPFDEB	1	1	Number of puffs to track
NN1	1	1	Meteorological period to start output
NN2	10	10	Meteorological period to end output

Table C.8 Input Group 5: Output Options

Species	Concentrations Printed (0 = no, 1 = yes)		Dry Fluxes Printed (0 = no, 1 = yes)		Wet Fluxes Printed (0 = no, 1 = yes)		Mass Flux	
	Printed	Saved to Disk	Printed	Saved to Disk	Printed	Saved to Disk	Printed	Saved to Disk
SO_2	0	1	0	1	0	1	0	0
SO_4	0	1	0	1	0	1	0	0
NO	0	1	0	1	0	1	0	0
NO_2	0	1	0	1	0	1	0	0
HNO_3	0	1	0	1	0	1	0	0
NO_3	0	1	0	1	0	1	0	0
$PM_{2.5}$	0	1	0	1	0	1	0	0
CO	0	1	0	1	0	1	0	0
NO_x	0	1	0	1	0	1	0	0
H2S	0	1	0	1	0	1	0	0
VOC	0	1	0	1	0	1	0	0

Table C.9 Input Group 6: Sub-Grid Scale Complex Terrain Inputs

Parameter	Default	Project	Comments
NHILL	0	0	Number of terrain features (not applicable)
NCTREC	0	0	Number of special complex terrain receptors (not applicable)
MHILL	-	2	Hill data created by OPTHILL & input below in Subgroup (6b); Receptor data in Subgroup (6c) (not applicable)
XHILL2M	1	1	Conversion factor for changing horizontal dimensions to metres (not applicable)
ZHILL2M	1	1	Conversion factor for changing vertical dimensions to metres (not applicable)
XCTDMKM	-	0	X origin of CTDM system relative to CALPUFF coordinate system (km) (not applicable)
YCTDMKM	-	0	Y origin of CTDM system relative to CALPUFF coordinate system (km) (not applicable)

Table C.10 Input Group 7: Dry Deposition Parameters for Gases

Parameter	Default	Project	Comments
SO_2	0.1509	0.1509	Diffusivity
	1000	1000	Alpha star
	8.0	8.0	Reactivity
	0.0	0.0	Mesophyll resistance
	0.04	0.04	Henry's Law coefficient
NO	0.1345	0.1345	Diffusivity
	1.0	1.0	Alpha star
	2.0	2.0	Reactivity
	25	25	Mesophyll resistance
	18	18	Henry's Law coefficient
NO_2	0.1656	0.1656	Diffusivity
	1.0	1.0	Alpha star
	8.0	8.0	Reactivity
	5.0	5.0	Mesophyll resistance
	3.5	3.5	Henry's Law coefficient
HNO_3	0.1628	0.1628	Diffusivity
	1.0	1.0	Alpha star
	18.0	18.0	Reactivity
	0.0	0.0	Mesophyll resistance
	0.00000008	0.00000008	Henry's Law coefficient
NO_X	0.1656	0.1656	Diffusivity
	1.0	1.0	Alpha star
	8.0	8.0	Reactivity
	5.0	5.0	Mesophyll resistance
	3.5	3.5	Henry's Law coefficient
CO	0.186	0.186	Diffusivity
	1.0	1.0	Alpha star
	2.0	2.0	Reactivity
	61.0	61.0	Mesophyll resistance
	44.0	44.0	Henry's Law coefficient

Table C.11 CALPUFF Model Option Groups 8, 9 and 10

Species	Default	Project	Comments
Input Group 8: Dry Deposition Parameters for Particles			
SO_4^{2-}	0.48	0.48	Geometric mass mean diameter of SO_4^{2-} [µm]
SO_4^{2-}	2.0	2.0	Geometric standard deviation of SO_4^{2-} [µm]
NO_3^-	0.48	0.48	Geometric mass mean diameter of NO_3^-[µm]
NO_3^-	2.0	2.0	Geometric standard deviation of NO_3^- [µm]
$PM_{2.5}$	0.48	0.48	Geometric mass mean diameter of PM [µm]
$PM_{2.5}$	1.5	1.5	Geometric standard deviation of PM [µm]
Input Group 9: Miscellaneous Dry Deposition Parameters			
RCUTR	30	30	Reference cuticle resistance (s/cm)
RGR	10	10	Reference ground resistance (s/cm)
REACTR	8	8	Reference pollutant reactivity
NINT	9	9	Number of particle size intervals for effective particle deposition velocity
IVEG	1	1	Vegetation in non-irrigated areas is active and unstressed
Input Group 10: Wet Deposition Parameters			
SO_2	3.0E-05	3.0E-05	Scavenging coefficient for liquid precipitation [s^{-1}]
	0.0	0.0	Scavenging coefficient for frozen precipitation [s^{-1}]
SO_4^{2-}	1.0E-04	1.0E-04	Scavenging coefficient for liquid precipitation [s^{-1}]
	3.0E-05	3.0E-05	Scavenging coefficient for frozen precipitation [s^{-1}]
NO	2.9E-05	2.9E-05	Scavenging coefficient for liquid precipitation [s^{-1}]
	0.0	0.0	Scavenging coefficient for frozen precipitation [s^{-1}]
NO_2	5.1E-05	5.1E-05	Scavenging coefficient for liquid precipitation [s^{-1}]
	0.0	0.0	Scavenging coefficient for frozen precipitation [s^{-1}]
HNO_3	6.0E-05	6.0E-05	Scavenging coefficient for liquid precipitation [s^{-1}]
	0.0	0.0	Scavenging coefficient for frozen precipitation [s^{-1}]
NO_3^-	1.0E-04	1.0E-04	Scavenging coefficient for liquid precipitation [s^{-1}]
	3.0E-05	3.0E-05	Scavenging coefficient for frozen precipitation [s^{-1}]
$PM_{2.5}$	1.0E-04	1.0E-04	Scavenging coefficient for liquid precipitation [s^{-1}]
	3.0E-05	3.0E-05	Scavenging coefficient for frozen precipitation [s^{-1}]

Table C.12 Input Group 11: Chemistry Parameters

Parameters	Default	Project	Comments
MOZ	1	1	Read hourly ozone concentrations from OZONE.DAT data file (2011-2015 hourly file generated by Whitesail station 288 ozone values)
BCKO3	12*80	Not used	Background ozone concentration (ppb)
MNH3	0	0	Used only if MCHEM =6 or 7. MNH3 =0, means using monthly background ammonia values (BCKNH3) - no vertical variation
MAVGNH3	1	Not used	Ammonia vertical averaging option. Used only if MCHEM = 6 or 7, and MNH3 = 1
BCKNH3	12*10	12*0.5	Constant background concentration in ppb
RNITE1	0.2	0.2	Night-time NO_2 loss rate in percent/hour
RNITE2	2	2	Night-time NO_X loss rate in percent/hour
RNITE3	2	2	Night-time HNO_3 loss rate in percent/hour
MH2O2	1	0	Use a monthly background H_2O_2 value
BCKH2O2	12*1	12*1	Monthly background H_2O_2 concentrations (used for aqueous phase transformations, not applicable)
RH_ISRP	50	50	Used only if MCHEM=6 or 7. Minimum relative humidity used in ISORROPIA computations
SO4_ISRP	0.4	0.4	Used only if MCHEM=6 or 7. Minimum SO4 used in ISORROPIA computations
BCKPMF	-	Not used	Fine particulate concentration for secondary organic aerosol option, used only for MESOPUFF II scheme for OH (MCHEM =4) and Updated RIVAD scheme with ISORROPIA equilibrium and CalTech SOA (MCHEM =7)
OFRAC	-	Not used	Organic fraction of fine particulate for secondary organic aerosol option, used only for MESOPUFF II scheme for OH (MCHEM =4) and Updated RIVAD scheme with ISORROPIA equilibrium and CalTech SOA (MCHEM =7)
VCNX	-	Not used	VOC/NO_X ratio for secondary organic aerosol option, used only for MESOPUFF II scheme for OH

NOTES:
"-" means not available.
Mandatory or recommendations by the Guideline Section 7.8.
Professional judgement required per the Guideline Section 7.8.
User specified per the Guideline Section 10.7.

Table C.13 Input Group 12: Misc. Dispersion and Computational Parameters

Parameters	Default	Project	Comments
SYTDEP	550	550	Horizontal size of a puff in metres beyond which the time dependant dispersion equation of Heffter (1965) is used
MHFTSZ	0	0	Do not use Heffter formulas for σ_z
JSUP	5	5	Stability class used to calc dispersion rates for puffs above boundary layer
CONK1	0.01	0.01	Vertical dispersion constant for stable conditions
CONK2	0.1	0.1	Vertical dispersion constant for neutral or stable conditions
TBD	0.5	0.5	Use ISC transition point for determining the transition point between the Schulman-Scire (Schulman et al. 2000) to Huber-Snyder Building Downwash scheme
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	20	Land use category for RSA
ZOIN	0.25	0.25	Roughness length in meters for domain
XLAIIN	3	3	Leaf area index for domain
ELEVIN	0	0	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	Sigma-v is read for lateral turbulence data
IMIXCTDM	0	0	Predicted mixing heights are used
XMXLEN	1	1	Maximum length of emitted slug in meteorological grid units
XSAMLEN	1	1	Maximum travel distance of slug or puff in meteorological grid units during one sampling unit
MXNEW	99	99	Max number of puffs released from one source during one time step
MXSAM	99	99	Maximum number of sampling steps during one time step for a puff or slug
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 or slug
SZMIN	1	1	Minimum sigma z in metres for a new puff or slug
SZCAP_M	5.0E06	5.0E06	Maximum sigma z in metres to avoid numerical problem in calculating time or distance

Table C.13 Input Group 12: Misc. Dispersion and Computational Parameters

Stability Class	Parameter			
	SVMIN (Project)		SWMIN (Project)	
	Minimum turbulence (σ_v) (m/s)		Minimum turbulence (σ_w) (m/s)	
	Land	Water	Land	Water
A	0.2	0.2	0.2	0.2
B	0.2	0.2	0.12	0.12
C	0.2	0.2	0.08	0.08
D	0.2	0.2	0.06	0.06
E	0.2	0.2	0.03	0.03
F	0.2	0.2	0.016	0.016

Parameters	Default	Project	Comments
CDIV	0.0, 0.0	0.0, 0.0	Divergence criteria for dw/dz in met cells
NLUTBIL	4	4	Search radius for nearest land and water cells used in the subgrid TIBL module
WSCALM	0.5	0.5	Minimum wind speed allowed for non-calm conditions (m/s)
XMAXZI	3000	3000	Maximum mixing height in metres
XMINZI	50	50	Minimum mixing height in metres
WSCAT	1.54	1.54	wind speed category 1 [m/s]
	3.09	3.09	wind speed category 2 [m/s]
	5.14	5.14	wind speed category 3 [m/s]
	8.23	8.23	wind speed category 4 [m/s]
	10.80	10.80	wind speed category 5 [m/s]
PLX0	0.07	0.07	Wind Speed Power Law Exponent (Stability class A)
	0.07	0.07	Wind Speed Power Law Exponent (Stability class B)
	0.10	0.10	Wind Speed Power Law Exponent (Stability class C)
	0.15	0.15	Wind Speed Power Law Exponent (Stability class D)
	0.35	0.35	Wind Speed Power Law Exponent (Stability class E)
	0.55	0.55	Wind Speed Power Law Exponent (Stability class F)
PTG0	0.020	0.020	Potential temperature gradient for Stability Class E stability (degK/m)
	0.035	0.035	Potential temperature gradient for Stability Class F (degK/m)

Table C.13 Input Group 12: Misc. Dispersion and Computational Parameters

Parameters	Default	Project	Comments
PPC	0.50	0.50	Plume Path Coefficient (Stability class A)
	0.50	0.50	Plume Path Coefficient (Stability class B)
	0.50	0.50	Plume Path Coefficient (Stability class C)
	0.50	0.50	Plume Path Coefficient (Stability class D)
	0.35	0.35	Plume Path Coefficient (Stability class E)
	0.35	0.35	Plume Path Coefficient (Stability class 5)
SL2PF	10	10	Slug-to-puff transition criterion factor equal to sigma y/length of slug
NSPLIT	3	3	Number of puffs that result every time a puff is split
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	Time(s) of day when split puffs are eligible to be split once again
ZISPLIT	100	100	Minimum allowable last hour's mixing height for puff splitting
ROLDMAX	0.25	0.25	Maximum allowable ratio of last hour's mixing height and maximum mixing height experienced by the puff for puff splitting
NSPLITH	5	5	Number of puffs that result every time a puff is horizontally split
SYSPLITH	1	1	Minimum sigma-y of puff before it may be horizontally split
SHSPLITH	2	2	Minimum puff elongation rate due to wind shear before it may be horizontally split
CNSPLITH	1.0E-7	1.0E-7	Minimum concentration of each species in puff before it may be horizontally split
EPSSLUG	1.00E-04	1.00E-04	Fractional convergence criterion for numerical SLUG sampling iteration
EPSAREA	1.00E-06	1.00E-06	Fractional convergence criterion for numerical AREA sampling iteration
DRISE	1.0	1.0	Trajectory step length for numerical rise
HTMINBC	500	500	Minimum height (m) to which BC puffs are mixed as they are emitted (MBCON=2 ONLY)
RSAMPBC	10	10	Search radius (km) about a receptor for sampling nearest BC puff.
MDEPBC	1	1	Concentration is adjusted for depletion
NOTE: Mandatory or recommendations by the Guideline Section 7.8.			

Table C.14 CALPUFF Model Option Groups 13

Parameters	Default	Project	Comments
Input Group 13: Point Source Parameters			
NPT1	-	Varies by scenario	Number of point sources with constant stack parameters
IPTU	1	1	Units for point source emission rates are g/s
NSPT1	0	0	Number of source-species combinations with variable emissions scaling factors
NPT2	-	0	Number of point sources with variable emission parameters provided in external file
NOTES: Point source (i.e. stacks) parameters are given in Appendix A. "-" means not applicable.			

Table C.15 CALPUFF Model Option Groups 20

Parameters	Default	Project	Comments
Input Group 20: Non-gridded Receptor Information			
NREC	-	10,038	Number of non-gridded receptors
NOTES: Discrete receptors are identified on Figure C.2. "-" means not applicable.			

C.3 REFERENCES

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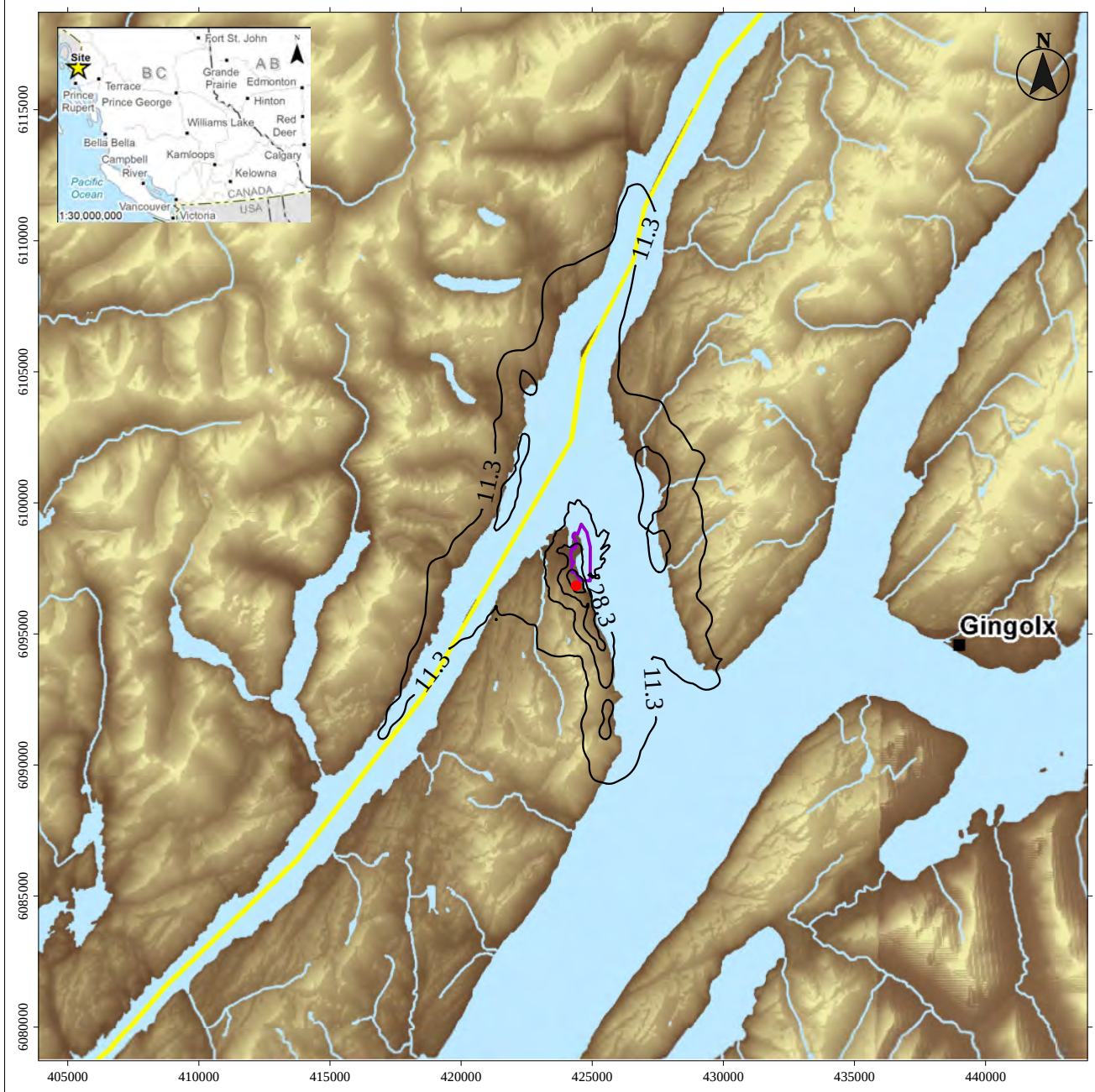
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APPENDIX D

Isopleth Maps

Appendix D ISOPLETH MAPS



Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Maximum 1-hour Average 98th Daily Maximum NO_2 Concentration: 84.1 µg/m³

1-hour NO_2 BC AQO: 113 µg/m³

Contour Levels: 11.3, 28.3, 56.5, 79, 84.8, 113 µg/m³

Baseline: not added

Metres

0 5000 10000

KSI LISIMS LNG

Stantec

Notes

1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Project Location
Pearse Island, BC

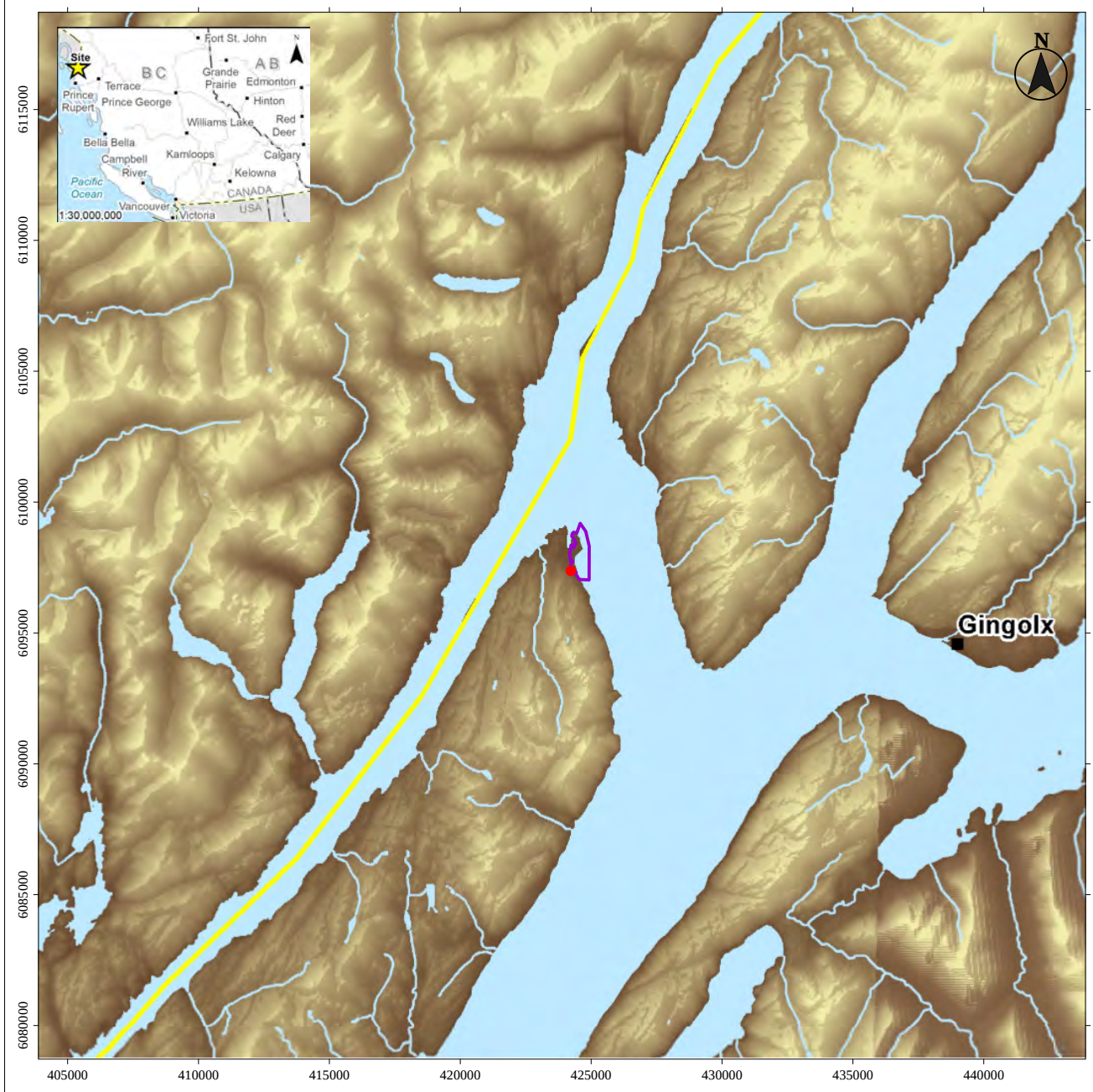
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-1

Title
Project-Alone Case 1 (BC Hydro)
Predicted Ground-Level 98th Percentile
of 1-hour Daily Maximum NO_2 Concentrations (µg/m³)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Maximum Annual Average NO_2 Concentration: 8.5 µg/m³

Annual NO_2 BC AQO: 32 µg/m³

Contour Levels: 8, 16, 24, 32 µg/m³

Baseline: not added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

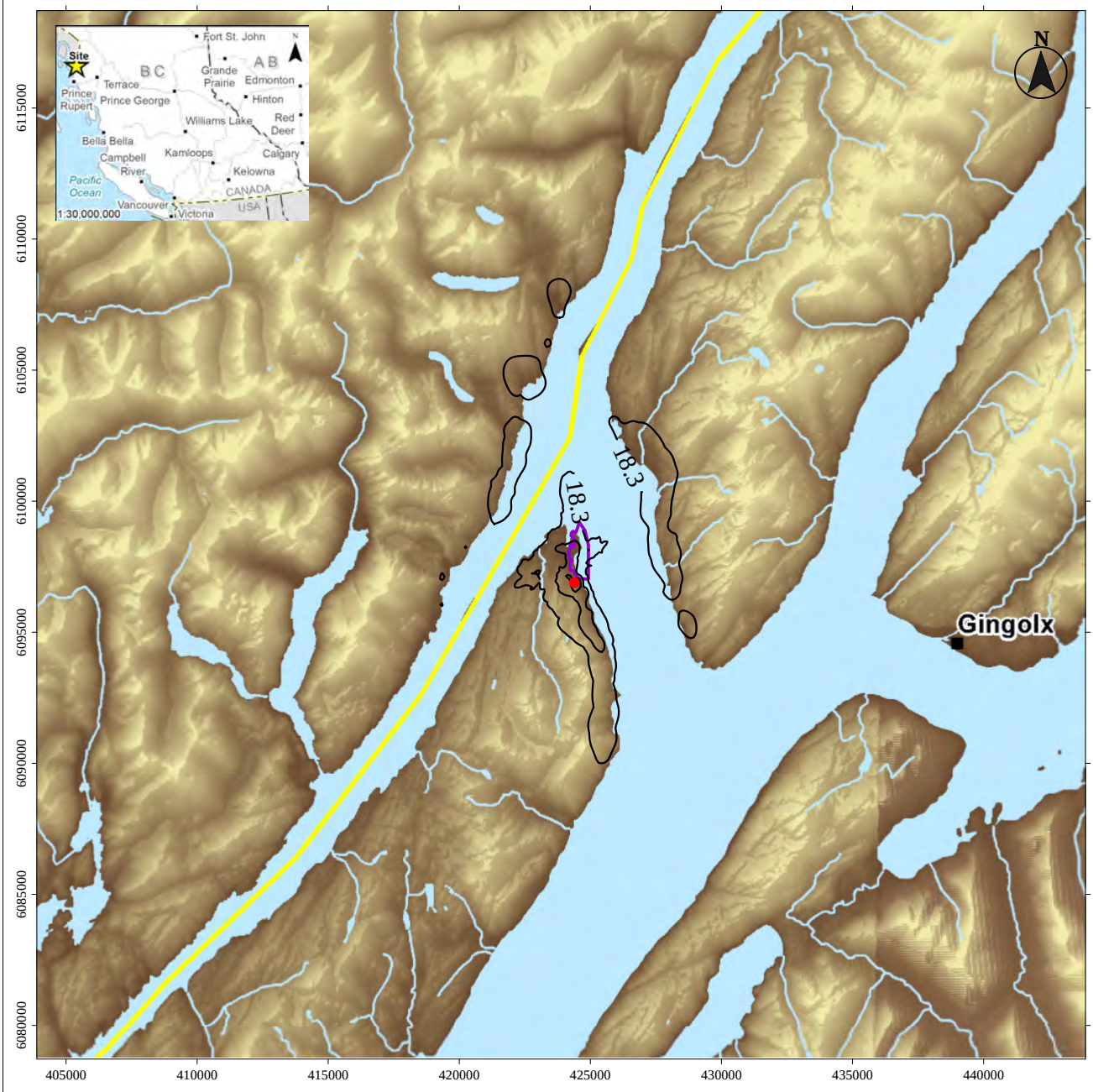
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-2

Title
Project-Alone Case 1 (BC Hydro)
Predicted Ground-Level Annual Average
NO_2 Concentrations (µg/m³)

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Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Maximum 1-hour Average 99th Daily Maximum SO_2 Concentration: 156 µg/m3

1-hour SO_2 BC AQO: 183 µg/m3

Contour Levels: 18.3, 45.8, 91.5, 137.3, 170, 183 µg/m3

Baseline: not added

Metres

0 5000 10000

KSI LISIMS LNG

Stantec

Notes

1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Project Location
Pearse Island, BC

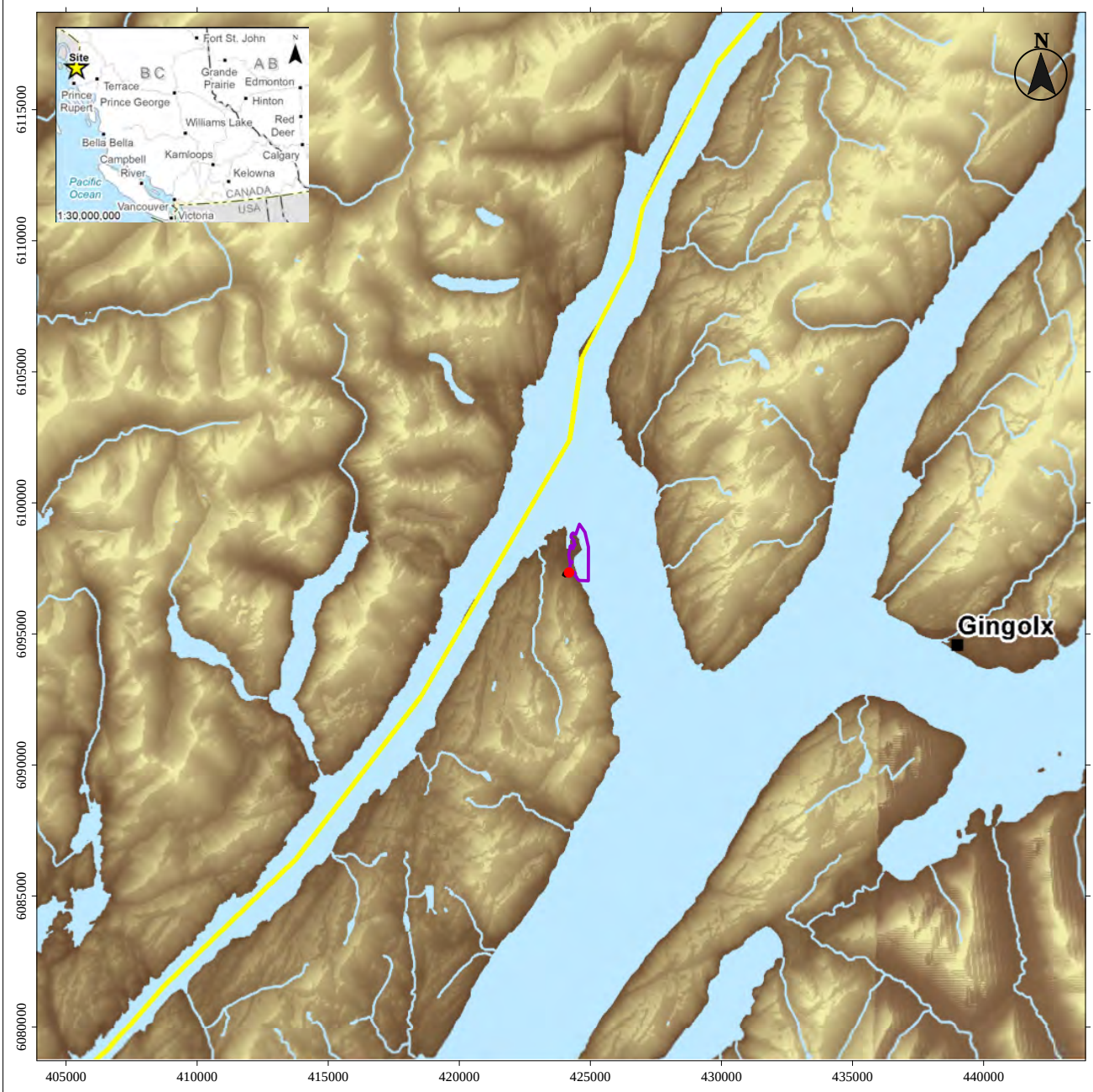
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-3

Title
Project-Alone Case 1 (BC Hydro)
Predicted Ground-Level 99th Percentile
of 1-hour Daily Maximum SO_2 Concentrations (µg/m3)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Maximum Annual Average SO_2 Concentration: 4.9 µg/m³

Annual SO_2 BC AQO: 13 µg/m³

Contour Levels: 3.3, 6.5, 9.8, 13 µg/m³

Baseline: not added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

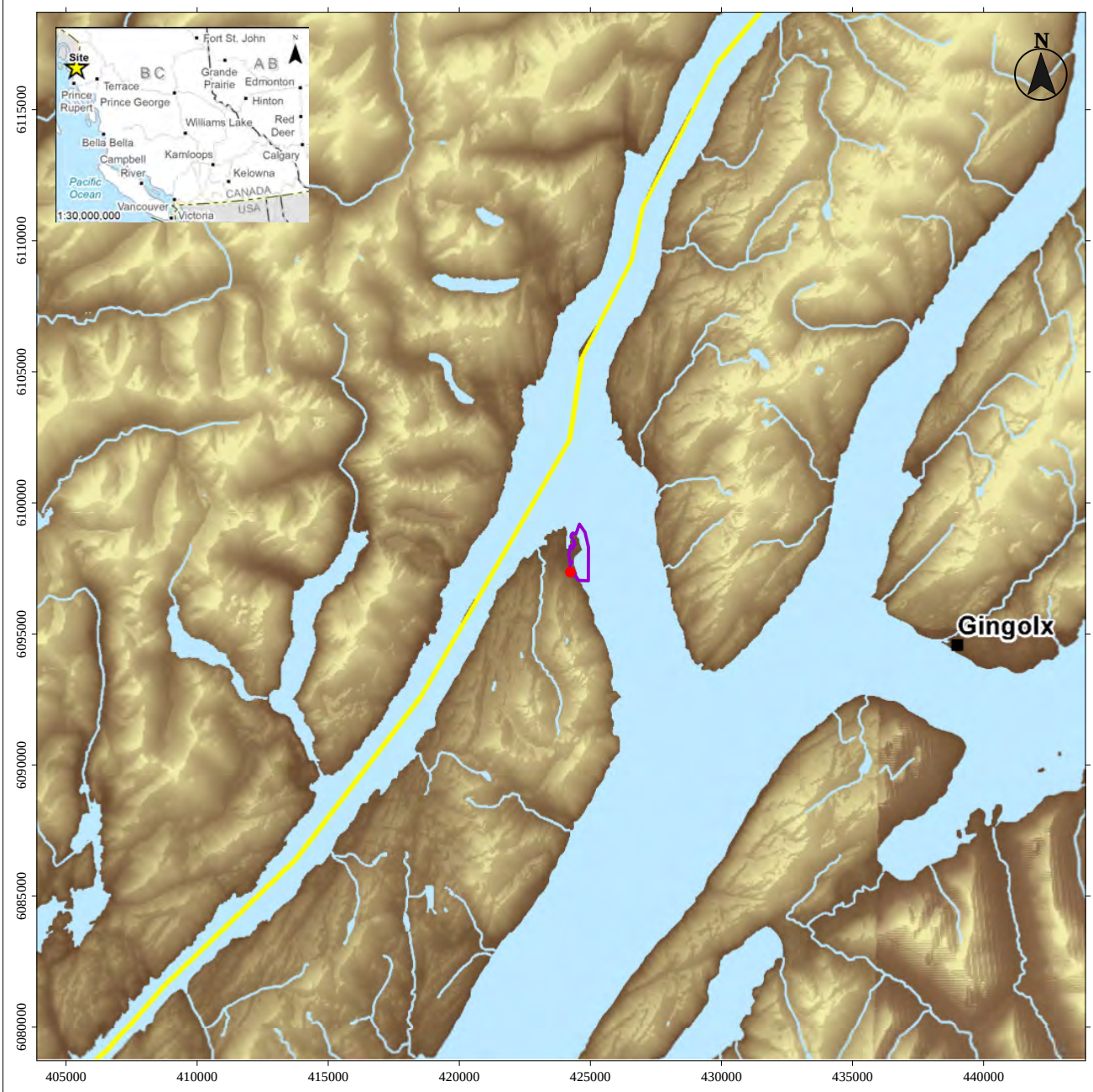
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-4

Title
Project-Alone Case 1 (BC Hydro)
Predicted Ground-Level Annual Average
SO_2 Concentrations (µg/m³)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Maximum 24-Hour Average 98th $PM_{2.5}$ Concentration: 1.5 µg/m³

24-hour $PM_{2.5}$ BC AQO: 25 µg/m³

Contour Levels: 6.3, 12.5, 18.8, 25 µg/m³

Baseline: not added

Metres

0 5000 10000

Stantec

Project Location
Pearse Island, BC

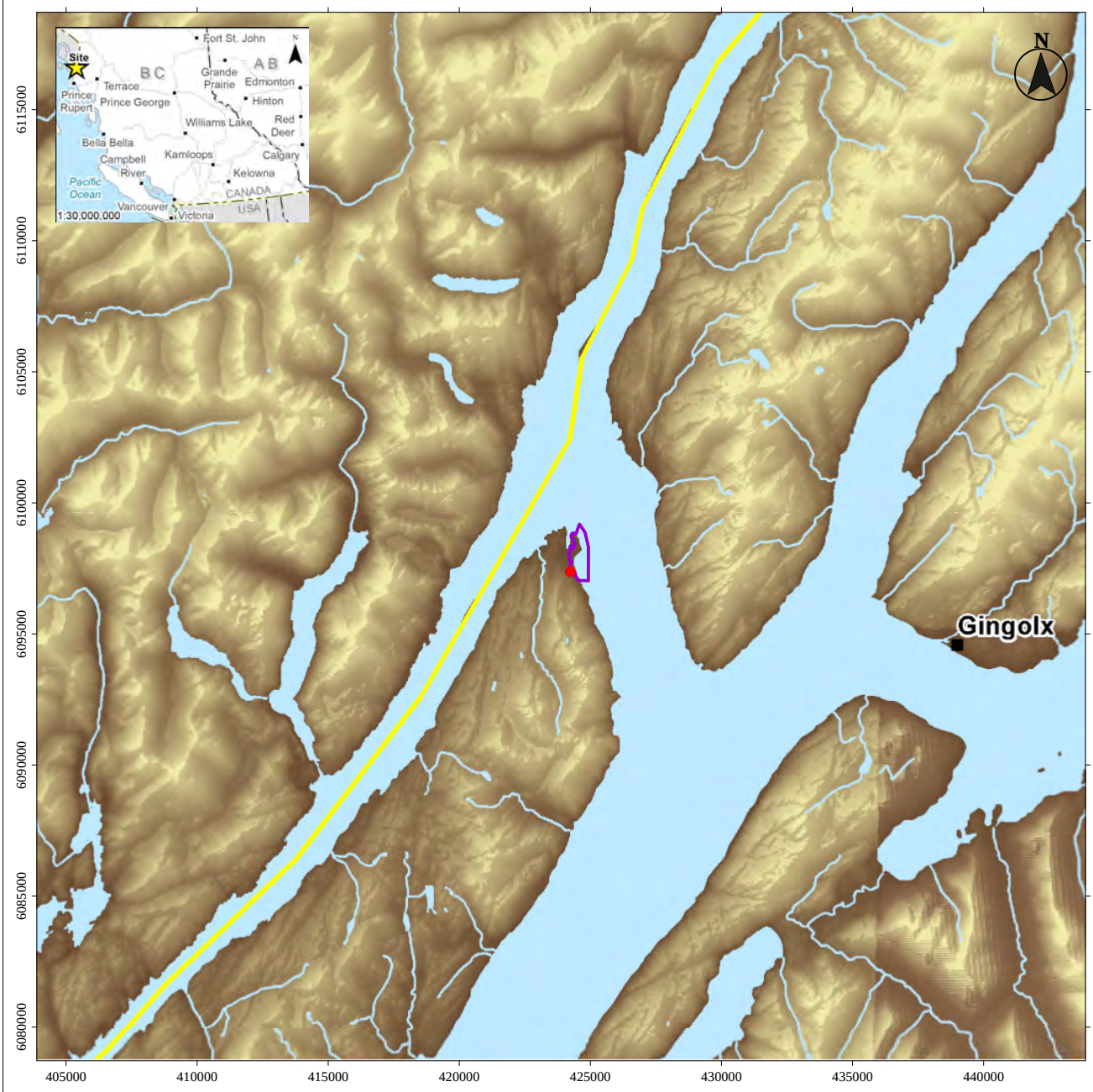
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-5

Title
Project-Alone Case 1 (BC Hydro)
Predicted Ground-Level 98th Percentile 24-hour Average $PM_{2.5}$ Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Maximum Annual Average $PM_{2.5}$ Concentration: 0.2 µg/m³

Annual $PM_{2.5}$ BC AQO: 8 µg/m³

Contour Levels: 2, 4, 6, 8 µg/m³

Baseline: not added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

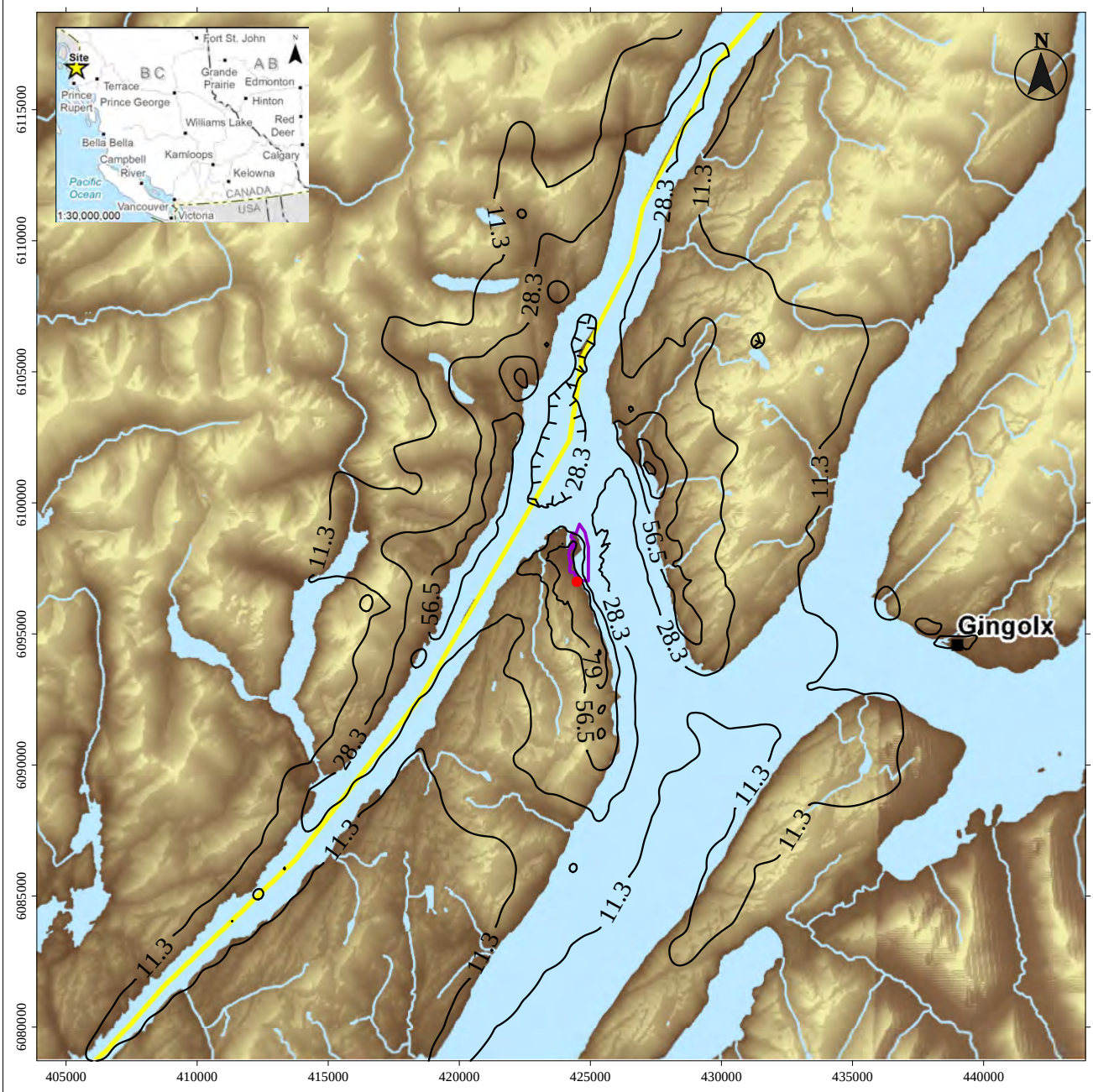
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-6

Title
Project-Alone Case 1 (BC Hydro)
Predicted Ground-Level Annual Average
$PM_{2.5}$ Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Maximum 1-hour Average 98th Daily Maximum NO_2 Concentration: 84.2 µg/m³

1-hour NO_2 BC AQO: 113 µg/m³

Contour Levels: 11.3, 28.3, 56.5, 79, 84.8, 113 µg/m³

Baseline: not added

Metres

0 5000 10000

KSI LISIMS LNG

Stantec

Notes

1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Project Location
Pearse Island, BC

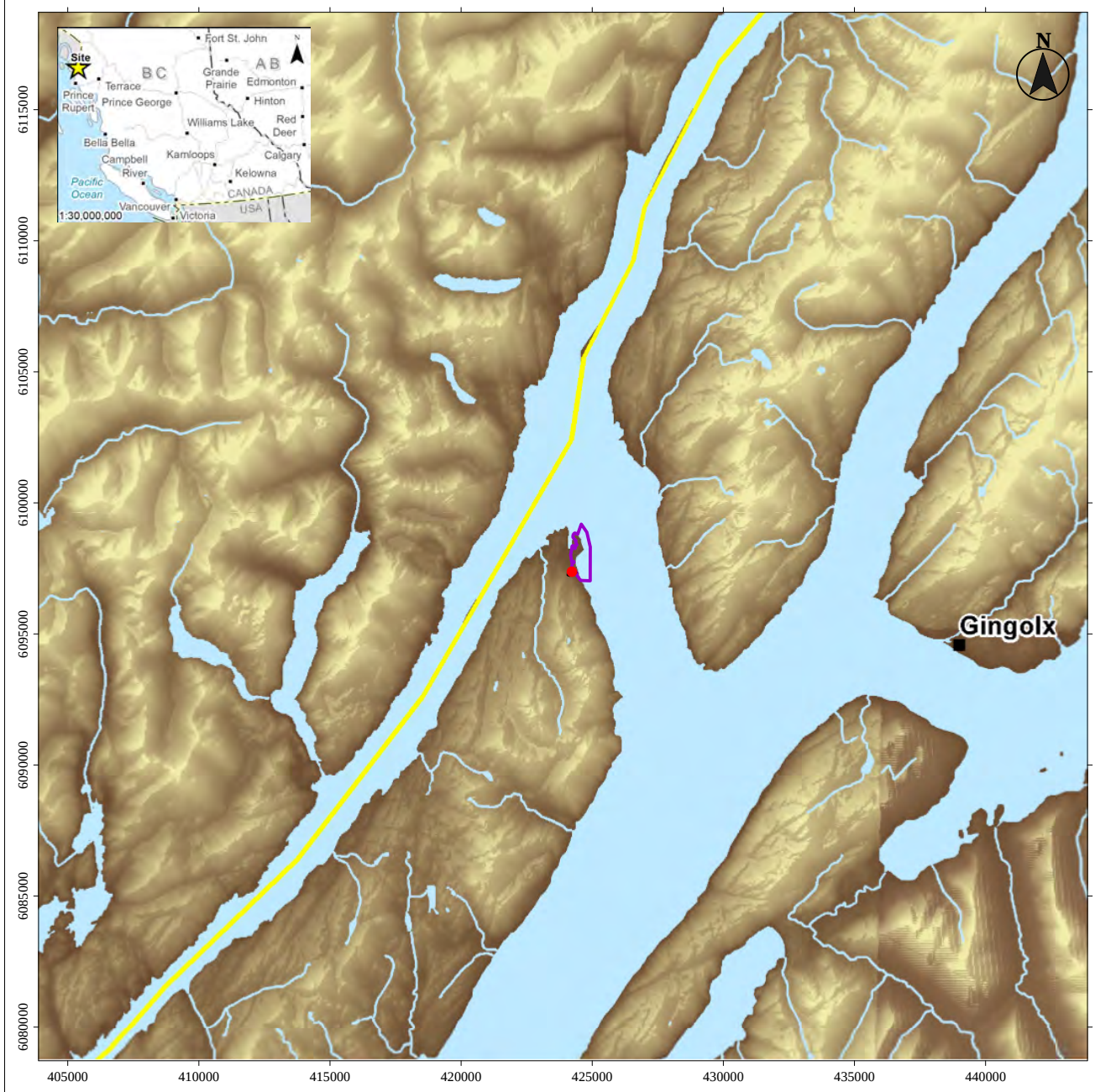
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-7

Title
Project-Alone Case 2 (Site-power)
Predicted Ground-Level 98th Percentile
of 1-hour Daily Maximum NO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Maximum Annual Average NO_2 Concentration: 9.9 µg/m³

Annual NO_2 BC AQO: 32 µg/m³

Contour Levels: 8, 16, 24, 32 µg/m³

Baseline: not added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

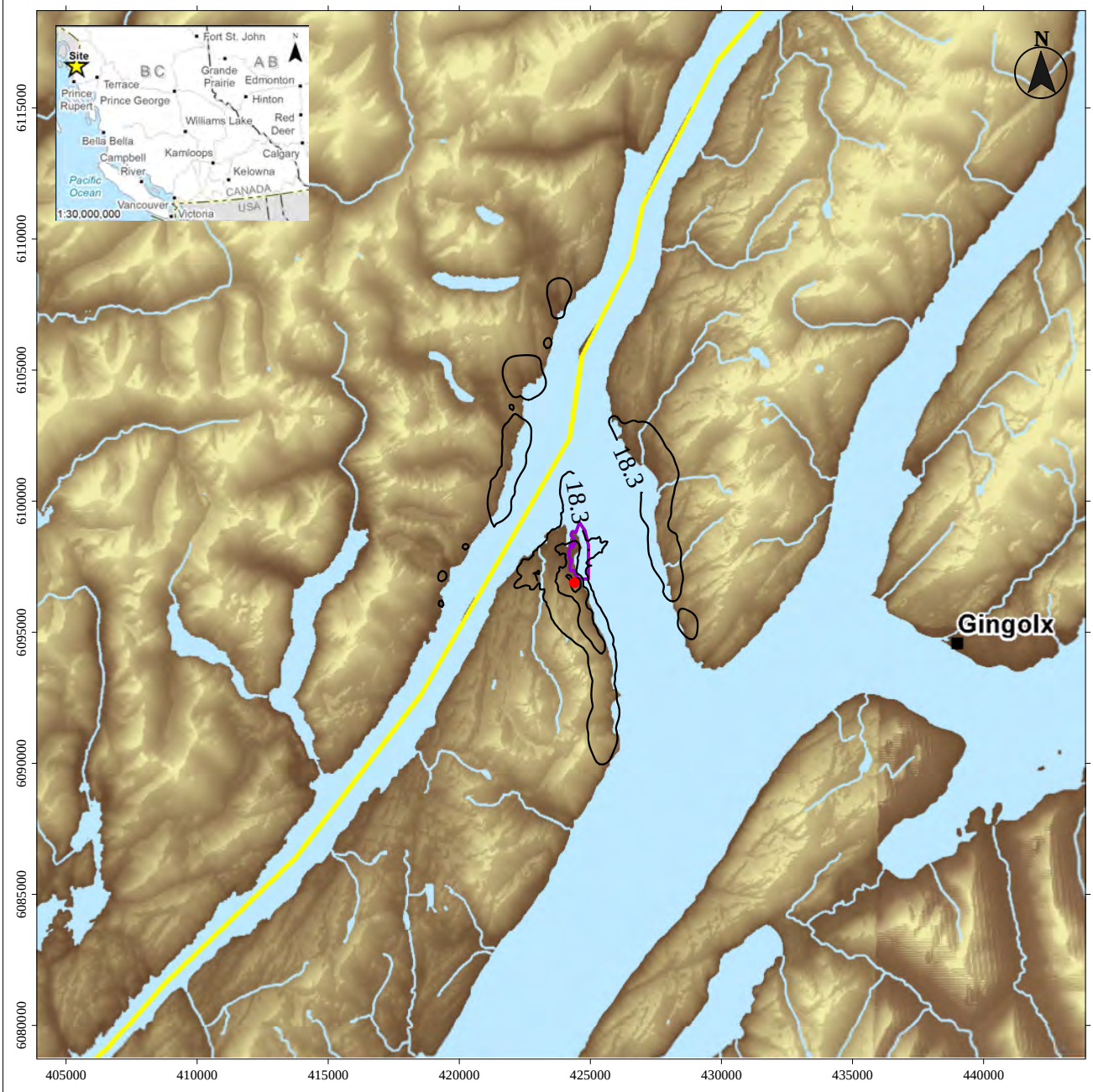
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-8

Title
Project-Alone Case 2 (Site-power)
Predicted Ground-Level Annual Average
NO_2 Concentrations (µg/m³)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Maximum 1-hour Average 99th Daily Maximum SO_2 Concentration: 156 µg/m3

1-hour SO_2 BC AQO: 183 µg/m3

Contour Levels: 18.3, 45.8, 91.5, 137.3, 170, 183 µg/m3

Baseline: not added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

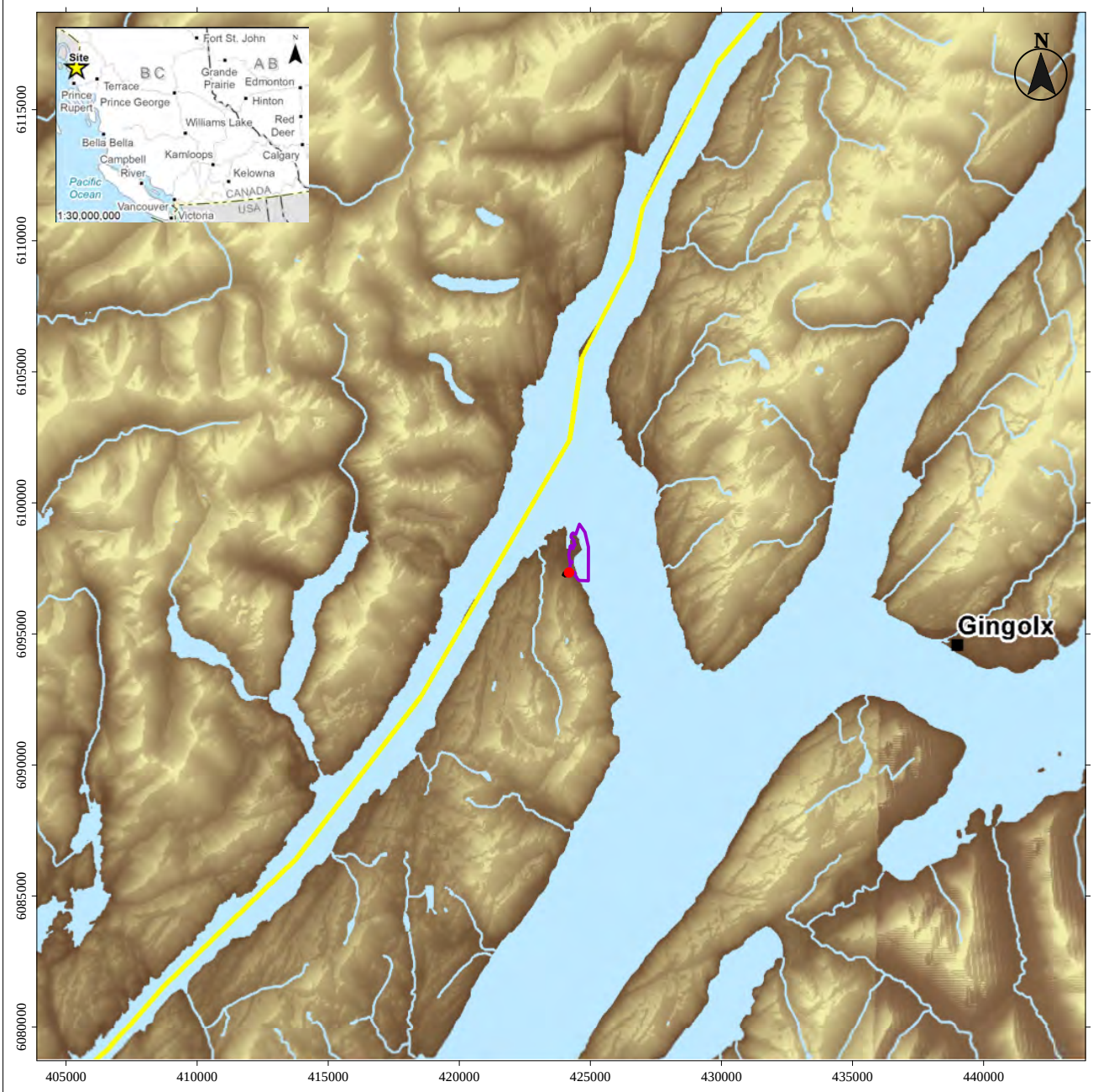
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-9

Title
Project-Alone Case 2 (Site-power)
Predicted Ground-Level 99th Percentile
of 1-hour Daily Maximum SO_2 Concentrations (µg/m3)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Maximum Annual Average SO_2 Concentration: 5.0 µg/m³

Annual SO_2 BC AQO: 13 µg/m³

Contour Levels: 3.3, 6.5, 9.8, 13 µg/m³

Baseline: not added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

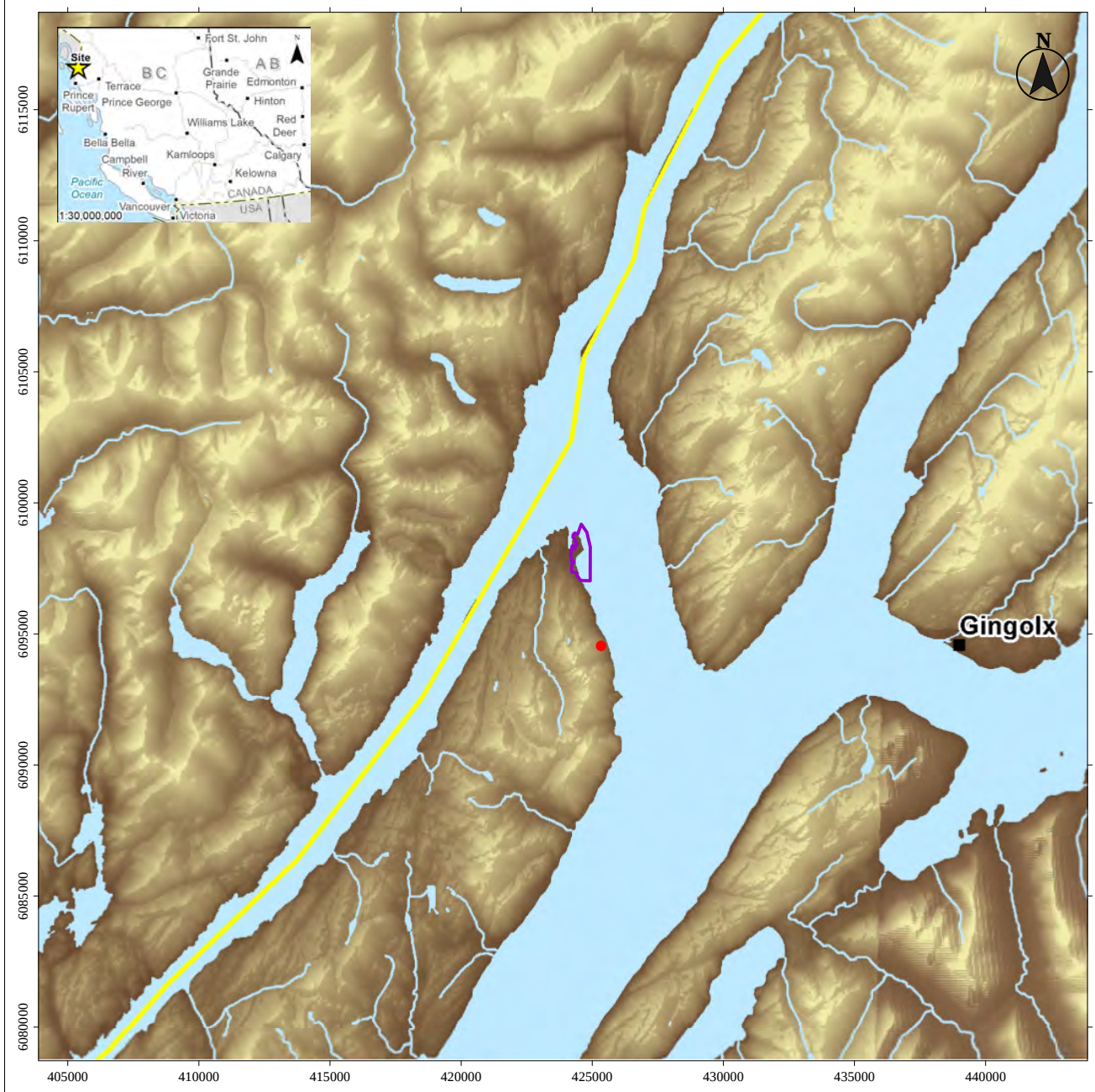
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-10

Title
Project-Alone Case 2 (Site-power)
Predicted Ground-Level Annual Average
SO_2 Concentrations (µg/m³)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Maximum 24-Hour Average 98th $PM_{2.5}$ Concentration: 4.0 µg/m³

24-hour $PM_{2.5}$ BC AQO: 25 µg/m³

Contour Levels: 6.3, 12.5, 18.8, 25 µg/m³

Baseline: not added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

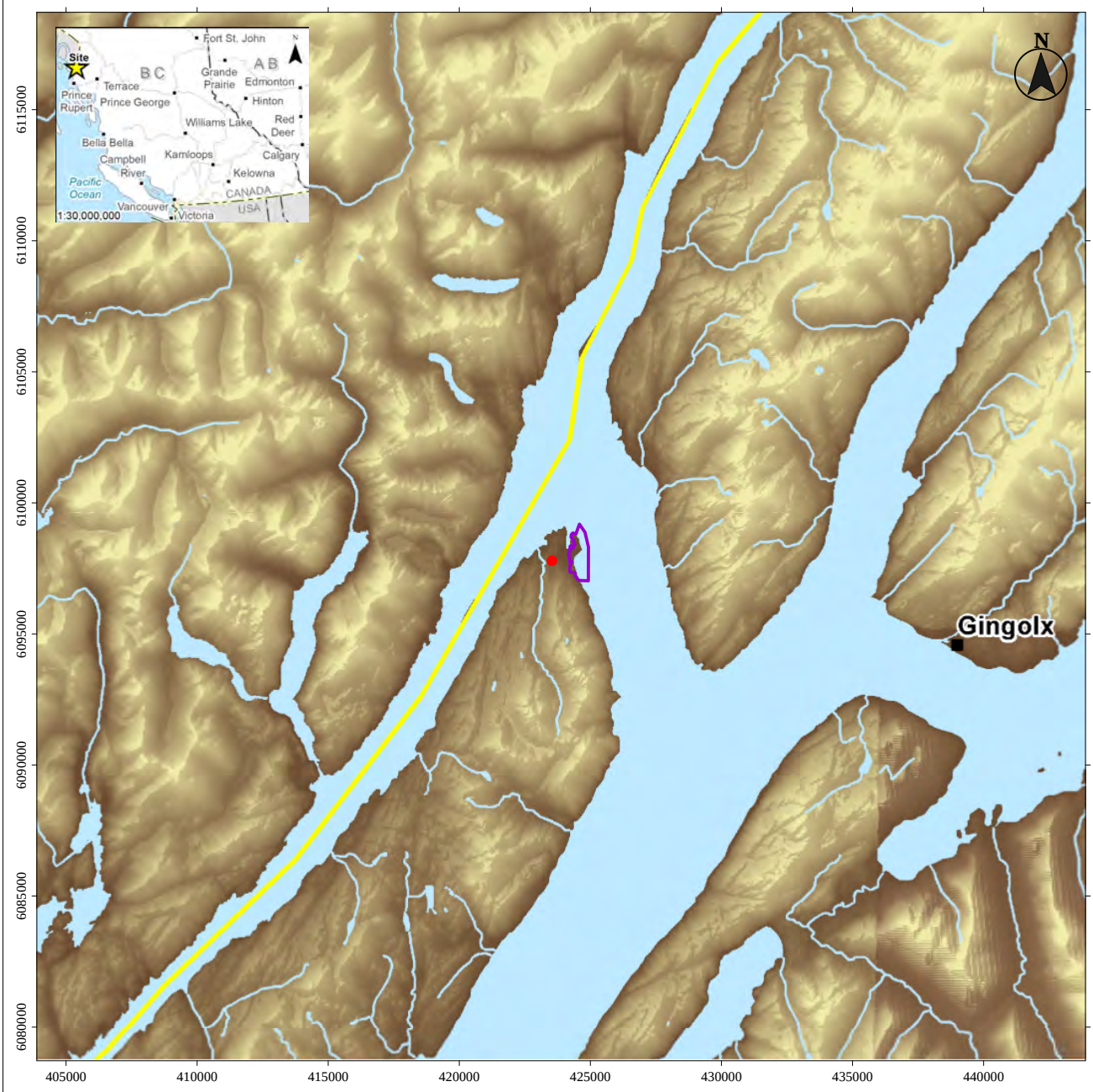
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-11

Title
Project-Alone Case 2 (Site-power)
Predicted Ground-Level 98th Percentile 24-hour Average $PM_{2.5}$ Concentrations (µg/m³)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Maximum Annual Average $PM_{2.5}$ Concentration: 0.4 µg/m³

Annual $PM_{2.5}$ BC AQO: 8 µg/m³

Contour Levels: 2, 4, 6, 8 µg/m³

Baseline: not added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

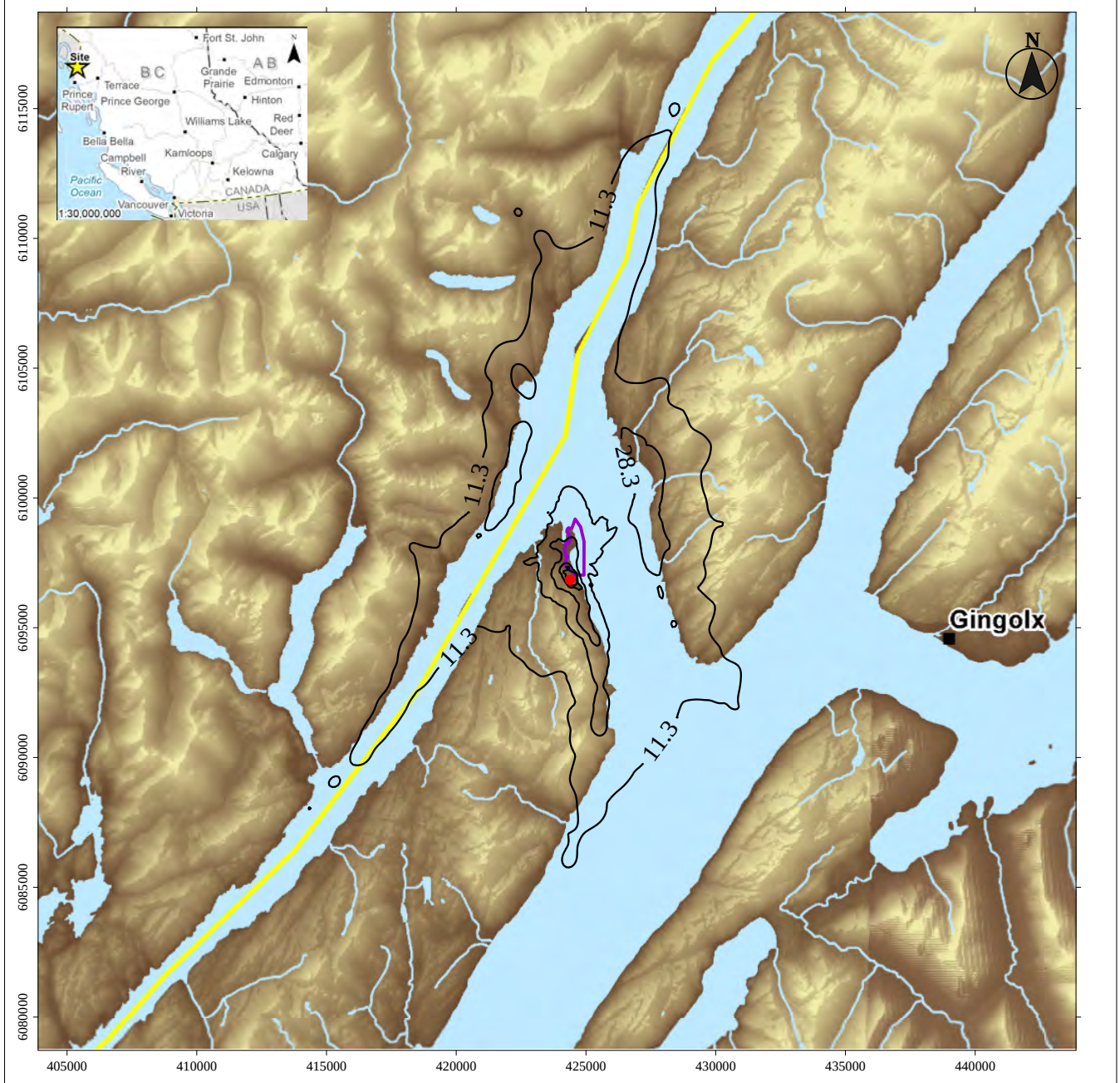
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-12

Title
Project-Alone Case 2 (Site-power)
Predicted Ground-Level Annual Average
$PM_{2.5}$ Concentrations (µg/m³)

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Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Maximum 1-hour Average 98th Daily Maximum NO_2 Concentration: 86.7 µg/m³

1-hour NO_2 BC AQO: 113 µg/m³

Contour Levels: 11.3, 28.3, 56.5, 79, 84.8, 113 µg/m³

Baseline: 2.6 µg/m³ added

Metres

0 5000 10000

KSI LISIMS LNG

Stantec

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Project Location
Pearse Island, BC

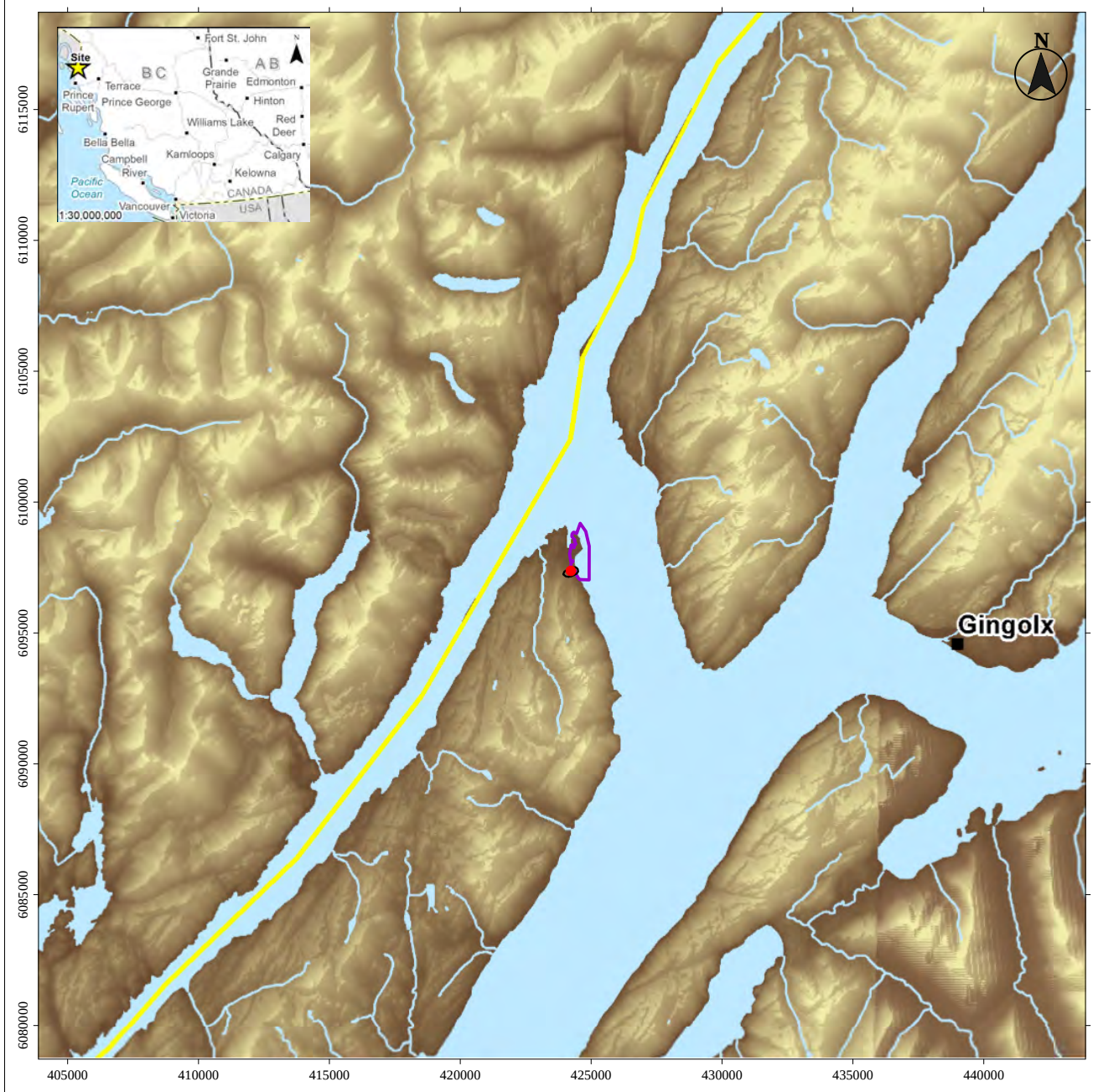
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-13

Title
Application Case 1 (BC Hydro)
Predicted Ground-Level 98th Percentile
of 1-hour Daily Maximum NO_2 Concentrations (µg/m³)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Maximum Annual Average NO_2 Concentration: 11.1 µg/m³

Annual NO_2 BC AQO: 32 µg/m³

Contour Levels: 8, 16, 24, 32 µg/m³

Baseline: 2.6 µg/m³ added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

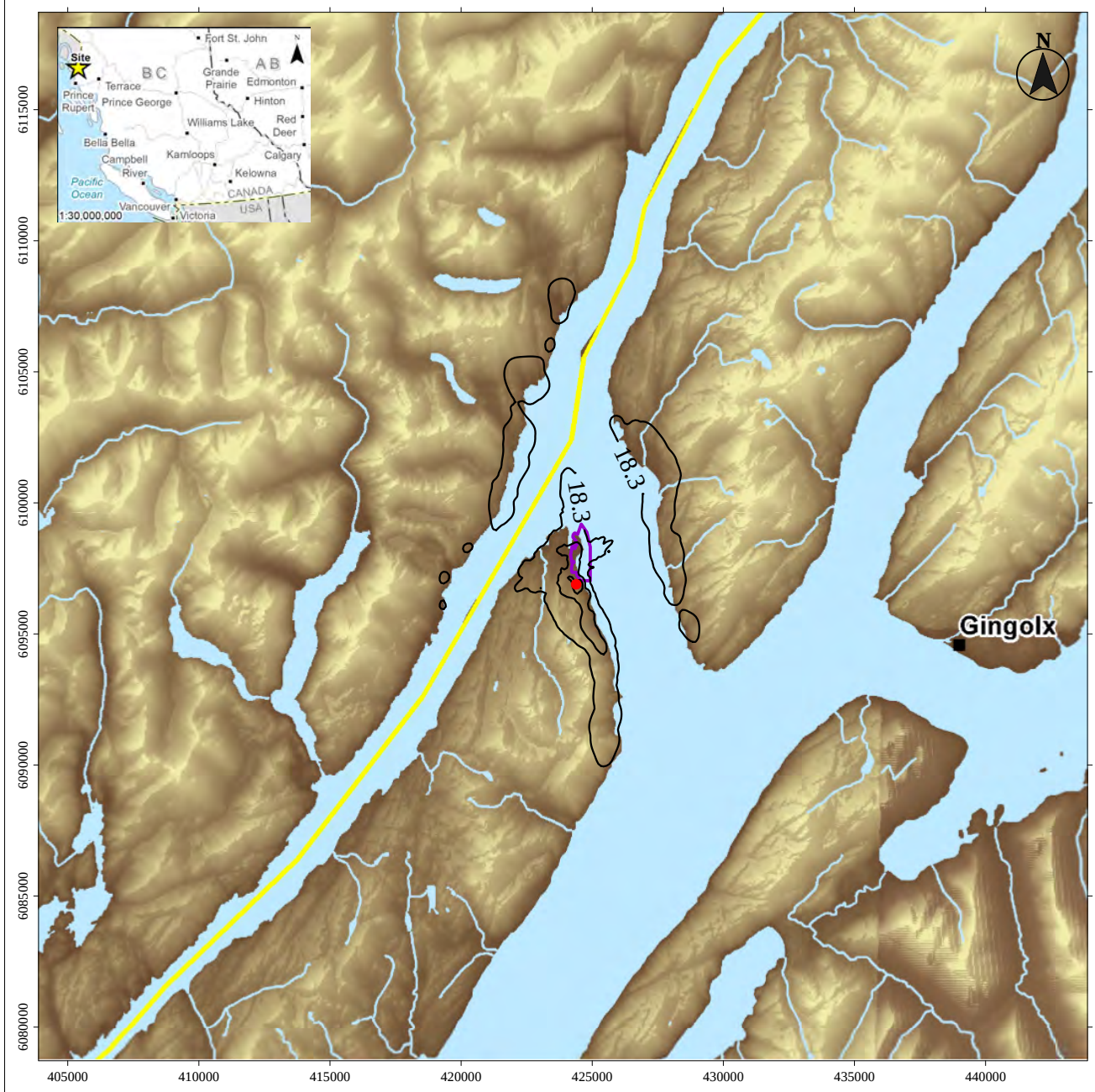
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-14

Title
Application Case 1 (BC Hydro)
Predicted Ground-Level Annual Average
NO_2 Concentrations (µg/m³)

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Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Maximum 1-hour Average 99th Daily Maximum SO_2 Concentration: 157 µg/m³

1-hour SO_2 BC AQO: 183 µg/m³

Contour Levels: 18.3, 45.8, 91.5, 137.3, 170, 183 µg/m³

Baseline: 0.8 µg/m³ added

Metres

0 5000 10000

KSI LISIMS LNG

Stantec

Notes

1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Project Location
Pearse Island, BC

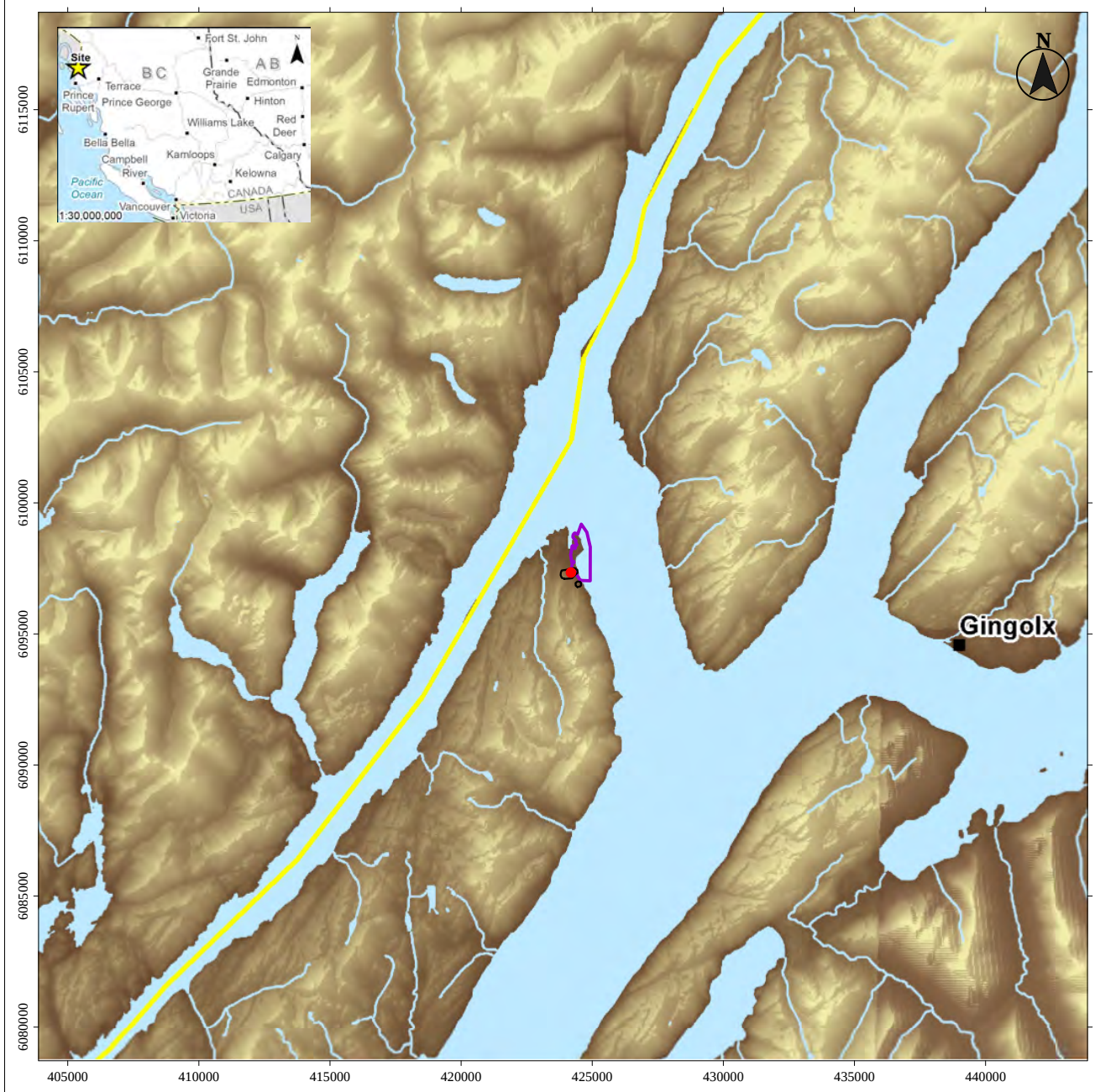
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-15

Title
Application Case 1 (BC Hydro)
Predicted Ground-Level 99th Percentile
of 1-hour Daily Maximum SO_2 Concentrations (µg/m³)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Maximum Annual Average SO_2 Concentration: 5.7 µg/m³

Annual SO_2 BC AQO: 13 µg/m³

Contour Levels: 3.3, 6.5, 9.8, 13 µg/m³

Baseline: 0.8 µg/m³ added

Metres

0 5000 10000

Stantec

Project Location
Pearse Island, BC

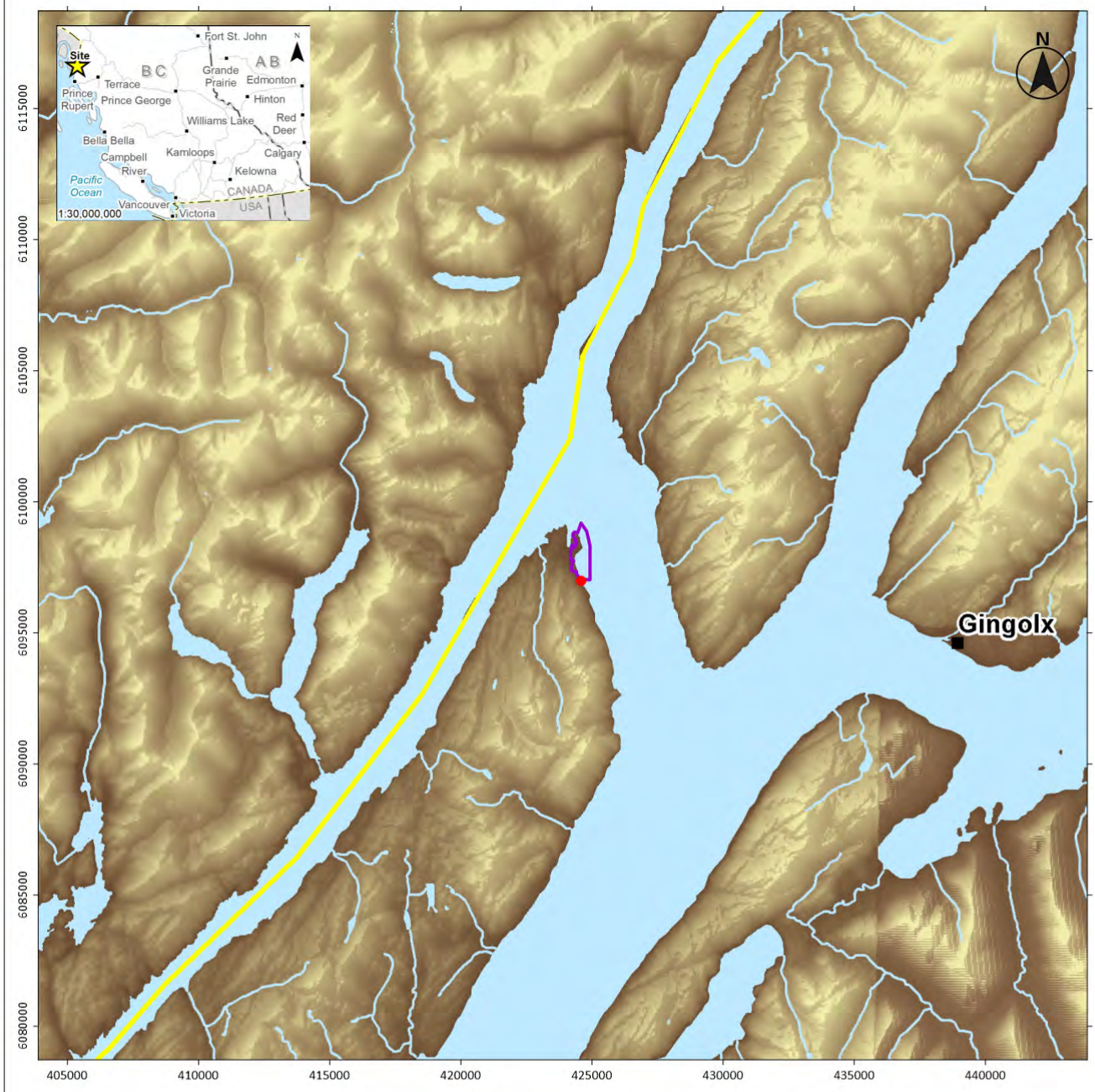
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-16

Title
Application Case 1 (BC Hydro)
Predicted Ground-Level Annual Average
SO_2 Concentrations (µg/m³)

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KSI LISIMS LNG

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Maximum 24-Hour Average 98th $PM_{2.5}$ Concentration: 10.0 µg/m³

24-hour $PM_{2.5}$ BC AQO: 25 µg/m³

Contour Levels: 6.3, 12.5, 18.8, 25 µg/m³

Baseline: 8.5 µg/m³ added

Metres

0 5000 10000

Notes

1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-17

Title
Application Case 1 (BC Hydro)
Predicted Ground-Level 98th Percentile 24-hour Average $PM_{2.5}$ Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Maximum Annual Average $PM_{2.5}$ Concentration: 3.7 µg/m³

Annual $PM_{2.5}$ BC AQO: 8 µg/m³

Contour Levels: 2, 4, 6, 8 µg/m³

Baseline: 3.5 µg/m³ added

Metres

0 5000 10000

Notes

1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia, Natural Resources Canada, Stantec, Rockies LNG, Maxar

Stantec

Project Location
Pearse Island, BC

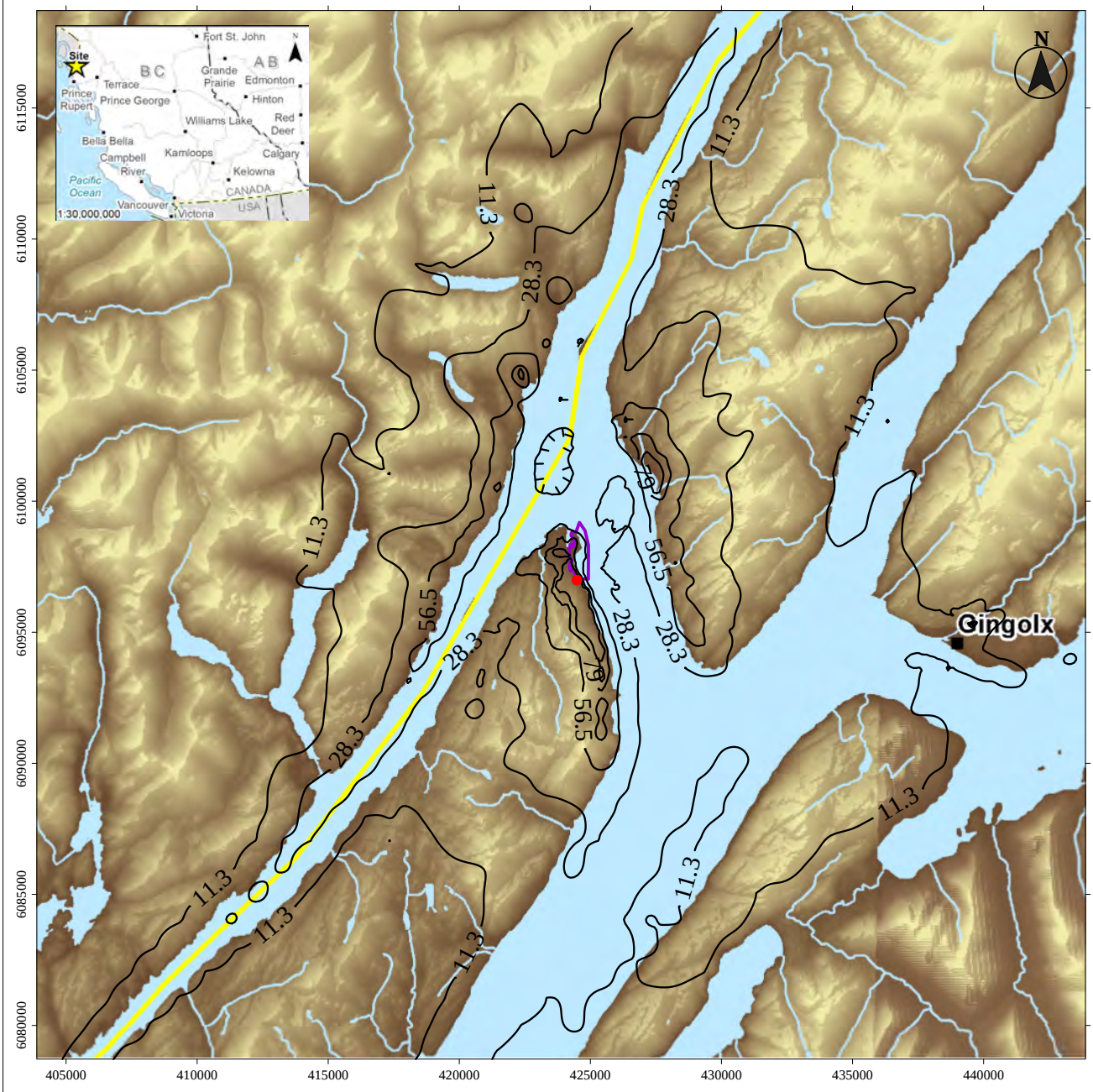
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-18

Title
Application Case 1 (BC Hydro)
Predicted Ground-Level Annual Average $PM_{2.5}$ Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Maximum 1-hour Average 98th Daily Maximum NO_2 Concentration: 86.8 µg/m3

1-hour NO_2 BC AQO: 113 µg/m3

Contour Levels: 11.3, 28.3, 56.5, 79, 84.8, 113 µg/m3

Baseline: 2.6 µg/m³ added

Metres

0 5000 10000

KSI LISIMS LNG

Stantec

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Project Location
Pearse Island, BC

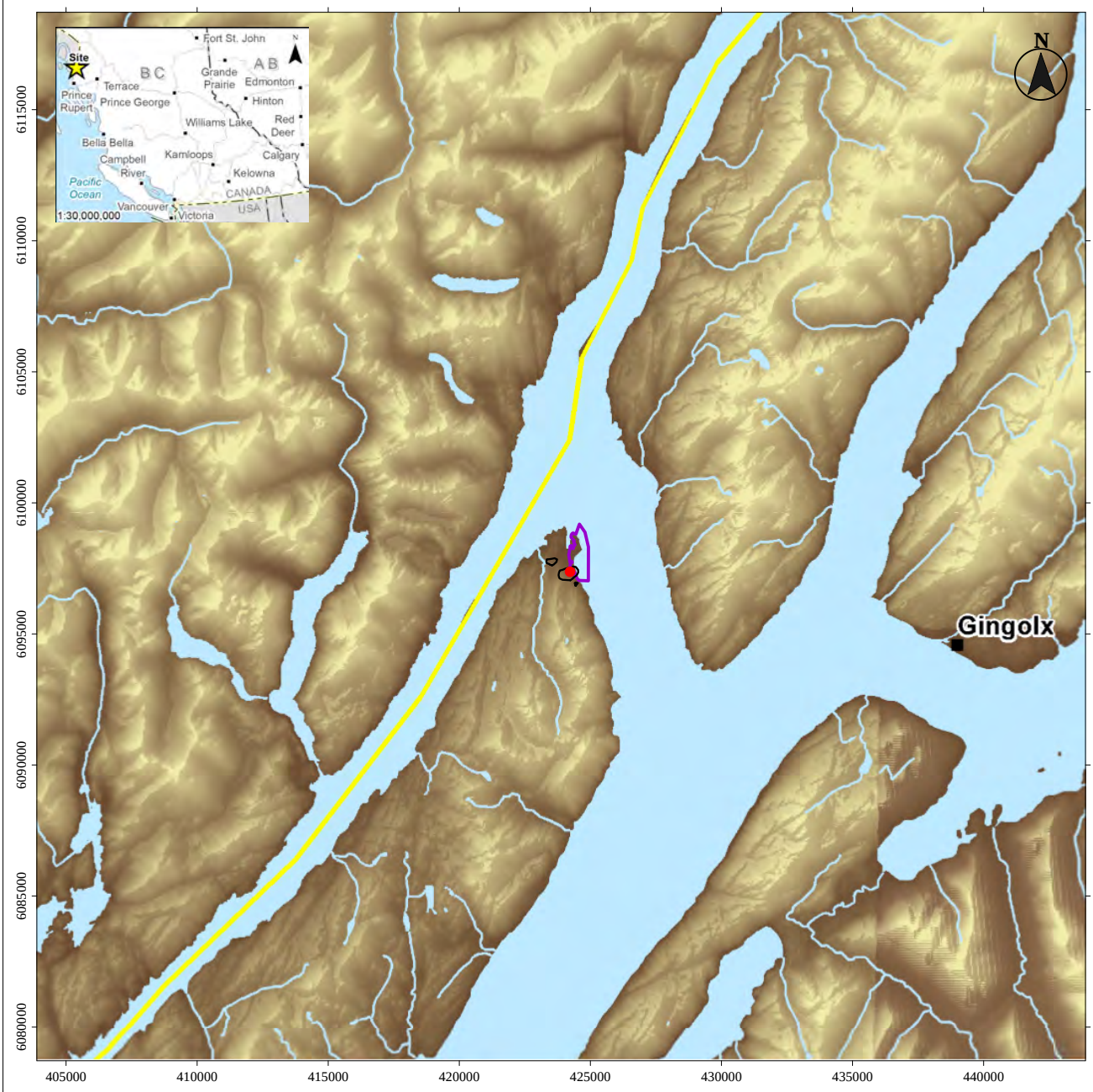
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-19

Title
Application Case 2 (Site-power)
Predicted Ground-Level 98th Percentile
of 1-hour Daily Maximum NO_2 Concentrations (µg/m3)

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Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Maximum Annual Average NO_2 Concentration: 12.5 µg/m³

Annual NO_2 BC AQO: 32 µg/m³

Contour Levels: 8, 16, 24, 32 µg/m³

Baseline: 2.6 µg/m³ added

Metres

0 5000 10000

KSI LISIMS LNG

Stantec

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Project Location
Pearse Island, BC

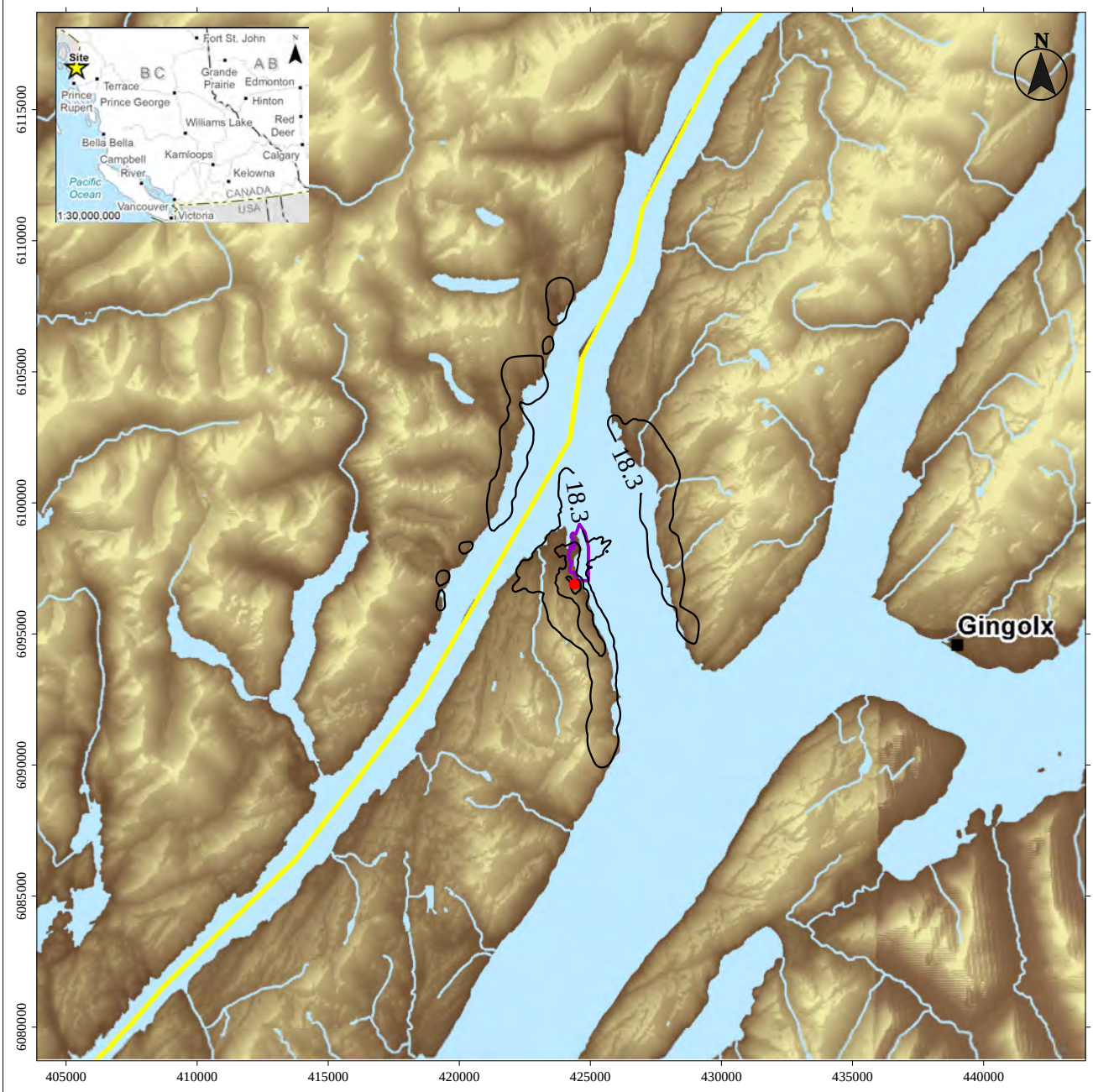
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-20

Title
Application Case 2 (Site-power)
Predicted Ground-Level Annual Average
NO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Maximum 1-hour Average 99th Daily Maximum SO_2 Concentration: 157 µg/m³

1-hour SO_2 BC AQO: 183 µg/m³

Contour Levels: 18.3, 45.8, 91.5, 137.3, 170, 183 µg/m³

Baseline: 0.8 µg/m³ added

Metres

0 5000 10000

Stantec

Project Location
Pearse Island, BC

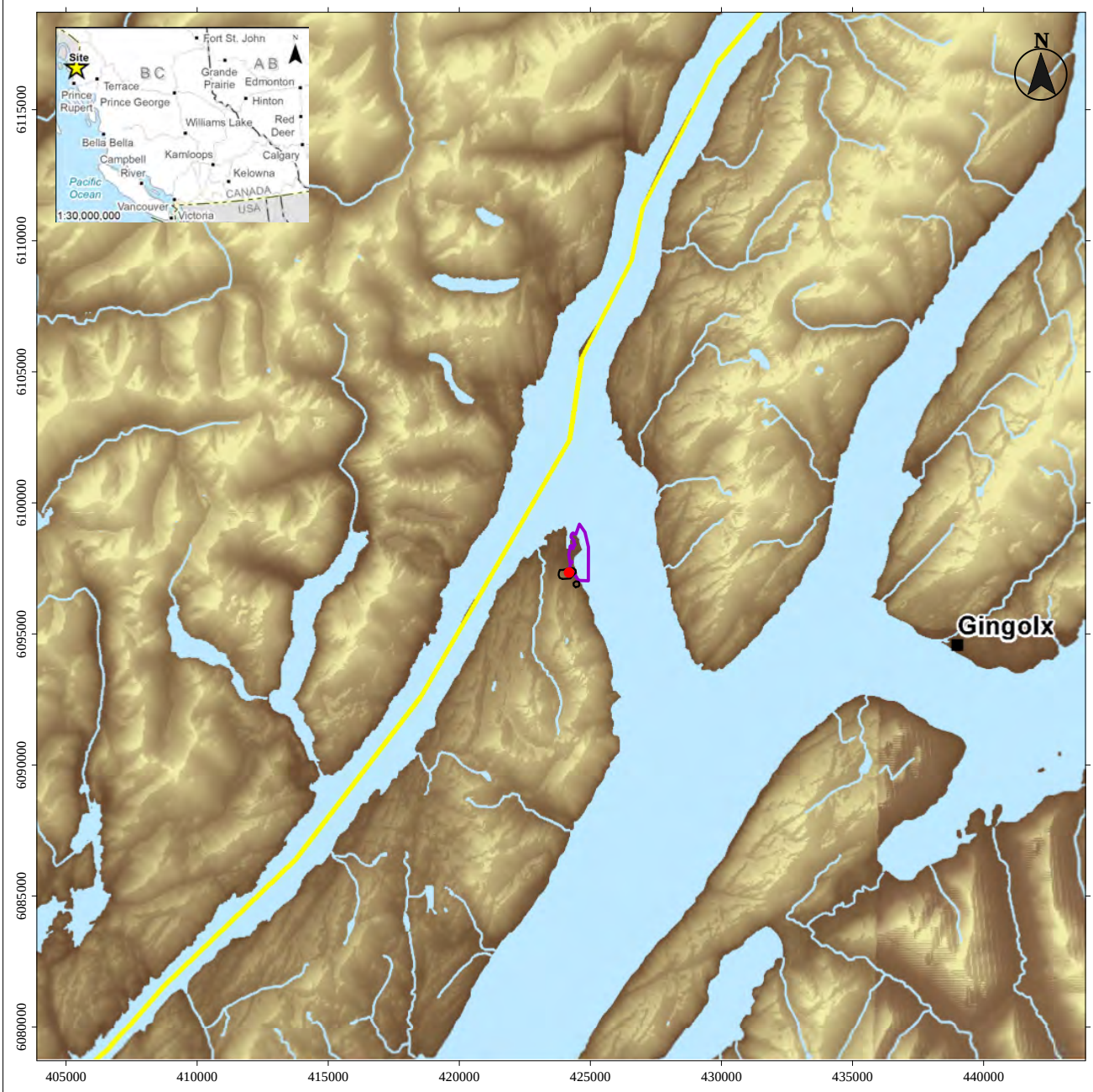
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-21

Title
Application Case 2 (Site-power)
Predicted Ground-Level 99th Percentile
of 1-hour Daily Maximum SO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Maximum Annual Average SO_2 Concentration: 5.8 µg/m³

Annual SO_2 BC AQO: 13 µg/m³

Contour Levels: 3.3, 6.5, 9.8, 13 µg/m³

Baseline: 0.8 µg/m³ added

Metres

0 5000 10000

Stantec

Project Location
Pearse Island, BC

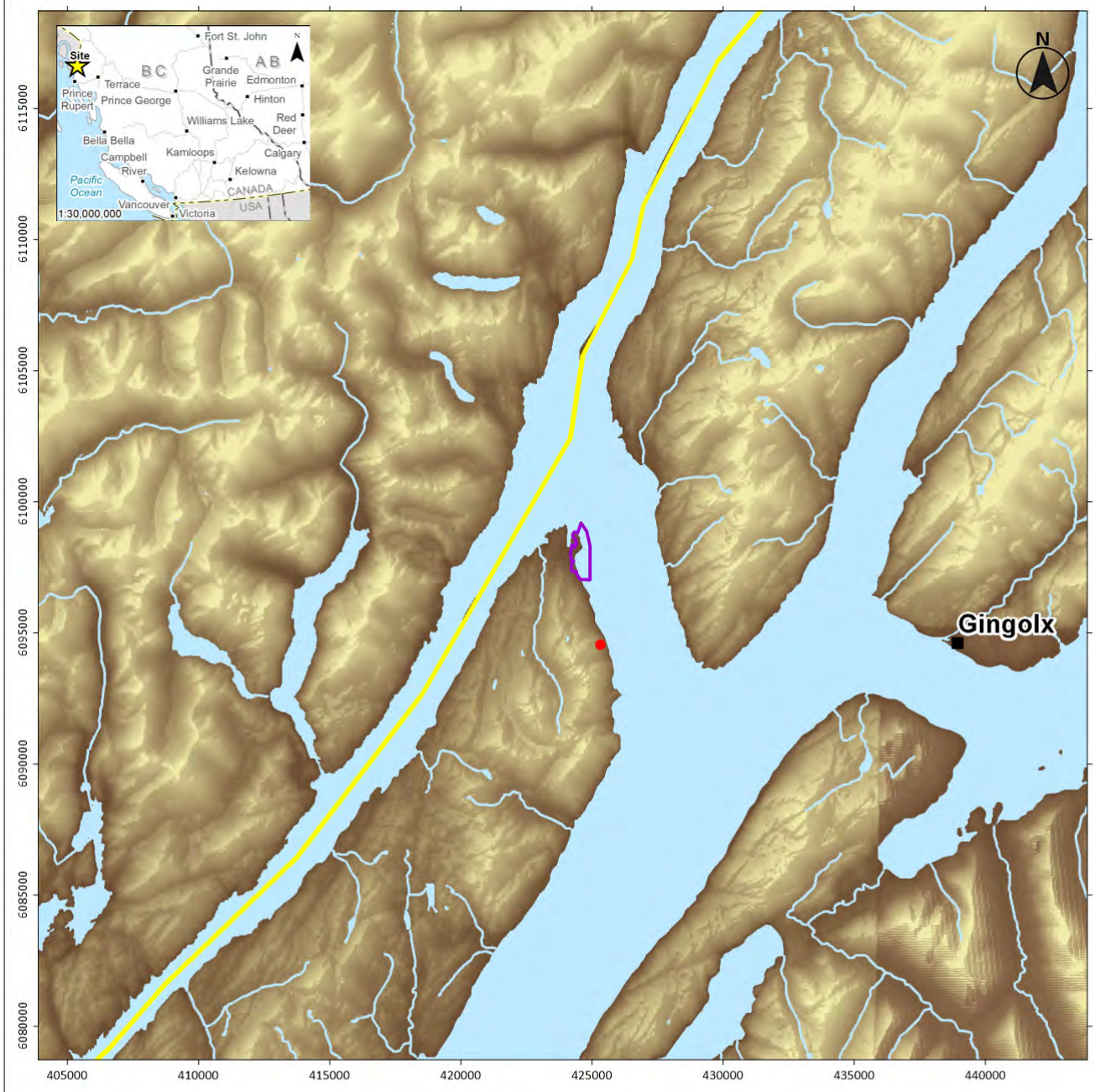
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-22

Title
Application Case 2 (Site-power)
Predicted Ground-Level Annual Average
SO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Maximum 24-Hour Average 98th $PM_{2.5}$ Concentration: 12.5 µg/m³

24-hour $PM_{2.5}$ BC AQO: 25 µg/m³

Contour Levels: 6.3, 12.5, 18.8, 25 µg/m³

Baseline: 8.5 µg/m³ added

Metres

0 5000 10000

Notes

1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-23

Title
Application Case 2 (Site-power)
Predicted Ground-Level 98th Percentile 24-hour Average $PM_{2.5}$ Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia, Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Maximum Annual Average $PM_{2.5}$ Concentration: 3.9 µg/m³

Annual $PM_{2.5}$ BC AQO: 8 µg/m³

Contour Levels: 2, 4, 6, 8 µg/m³

Baseline: 3.5 µg/m³ added

Metres

0 5000 10000

Stantec

Project Location
Pearse Island, BC

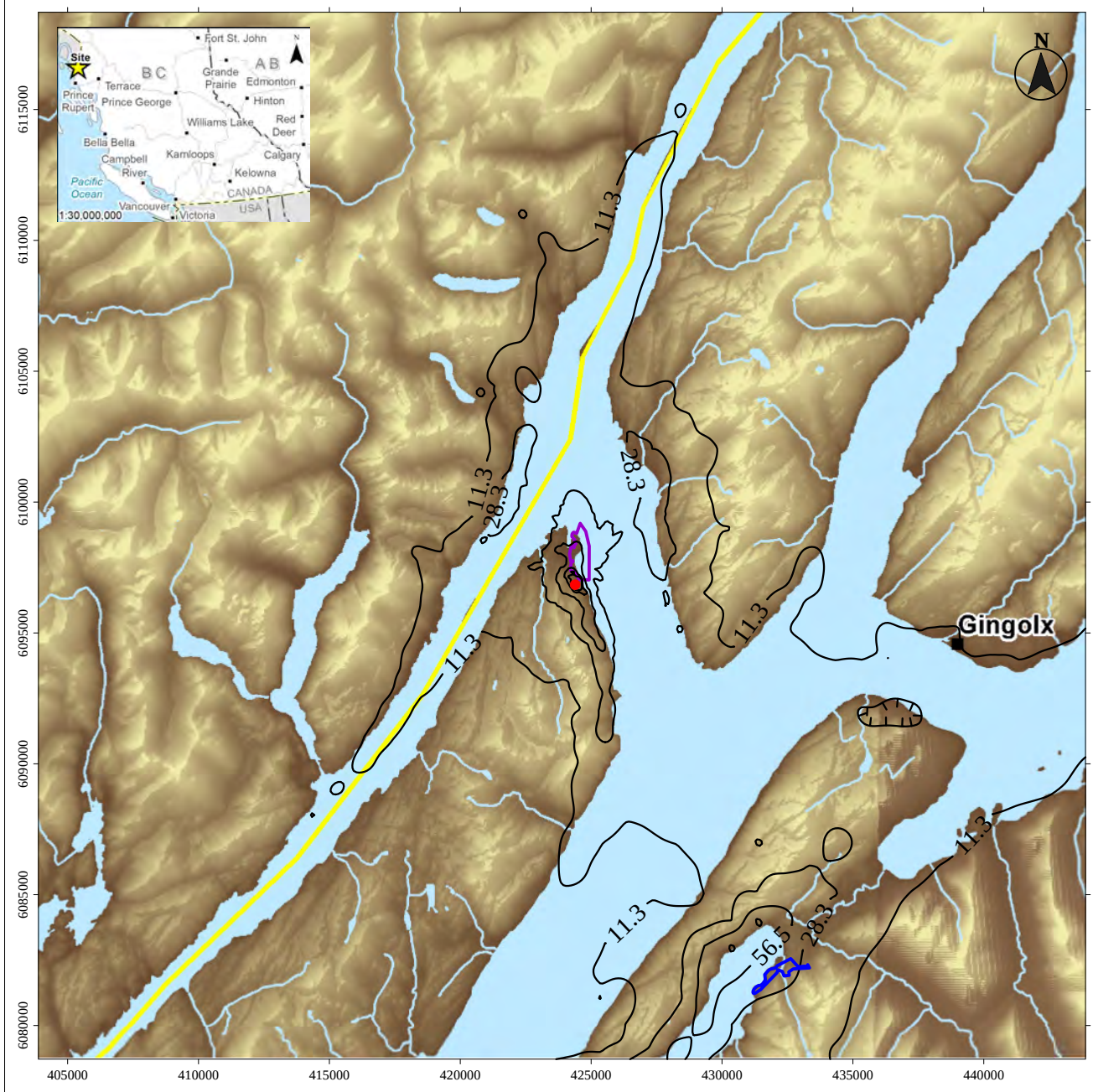
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-24

Title
Application Case 2 (Site-power)
Predicted Ground-Level Annual Average
$PM_{2.5}$ Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Enbridge Nasoga Compressor Station

Maximum 1-hour Average 98th Daily Maximum NO_2 Concentration: 86.7 µg/m³

1-hour NO_2 BC AQO: 113 µg/m³

Contour Levels: 11.3, 28.3, 56.5, 79, 84.8, 113 µg/m³

Baseline: 2.6 µg/m³ added

Metres

0 5000 10000

KSI LISIMS LNG

Stantec

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Project Location
Pearse Island, BC

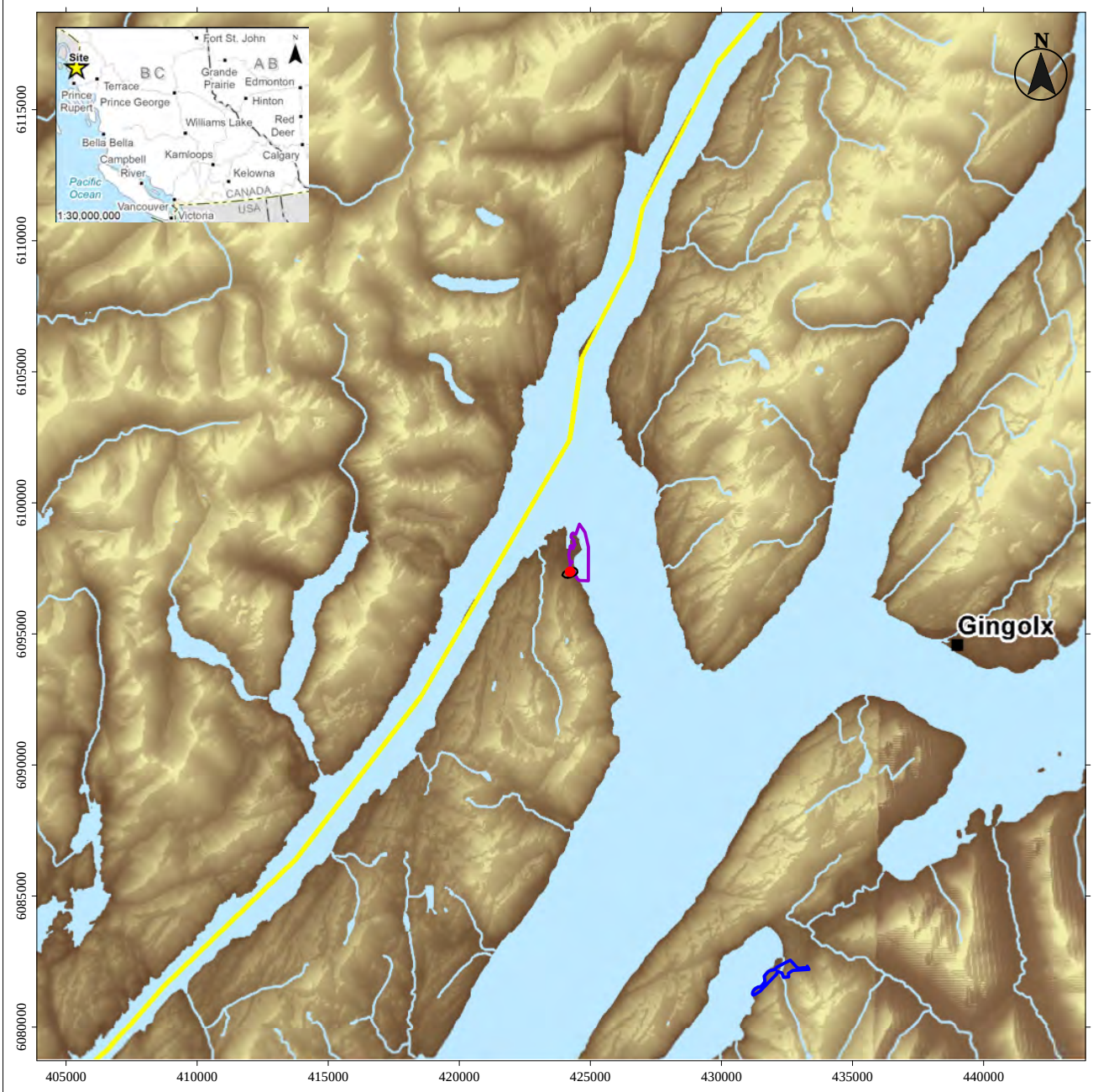
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-25

Title
Cumulative Case 1 (BC Hydro)
Predicted Ground-Level 98th Percentile
of 1-hour Daily Maximum NO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site
Gingolx
International Boundary
Watercourse
Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Enbridge Nasoga Compressor Station

Maximum Annual Average NO_2 Concentration: 11.2 µg/m³

Annual NO_2 BC AQO: 32 µg/m³

Contour Levels: 8, 16, 24, 32 µg/m³

Baseline: 2.6 µg/m³ added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

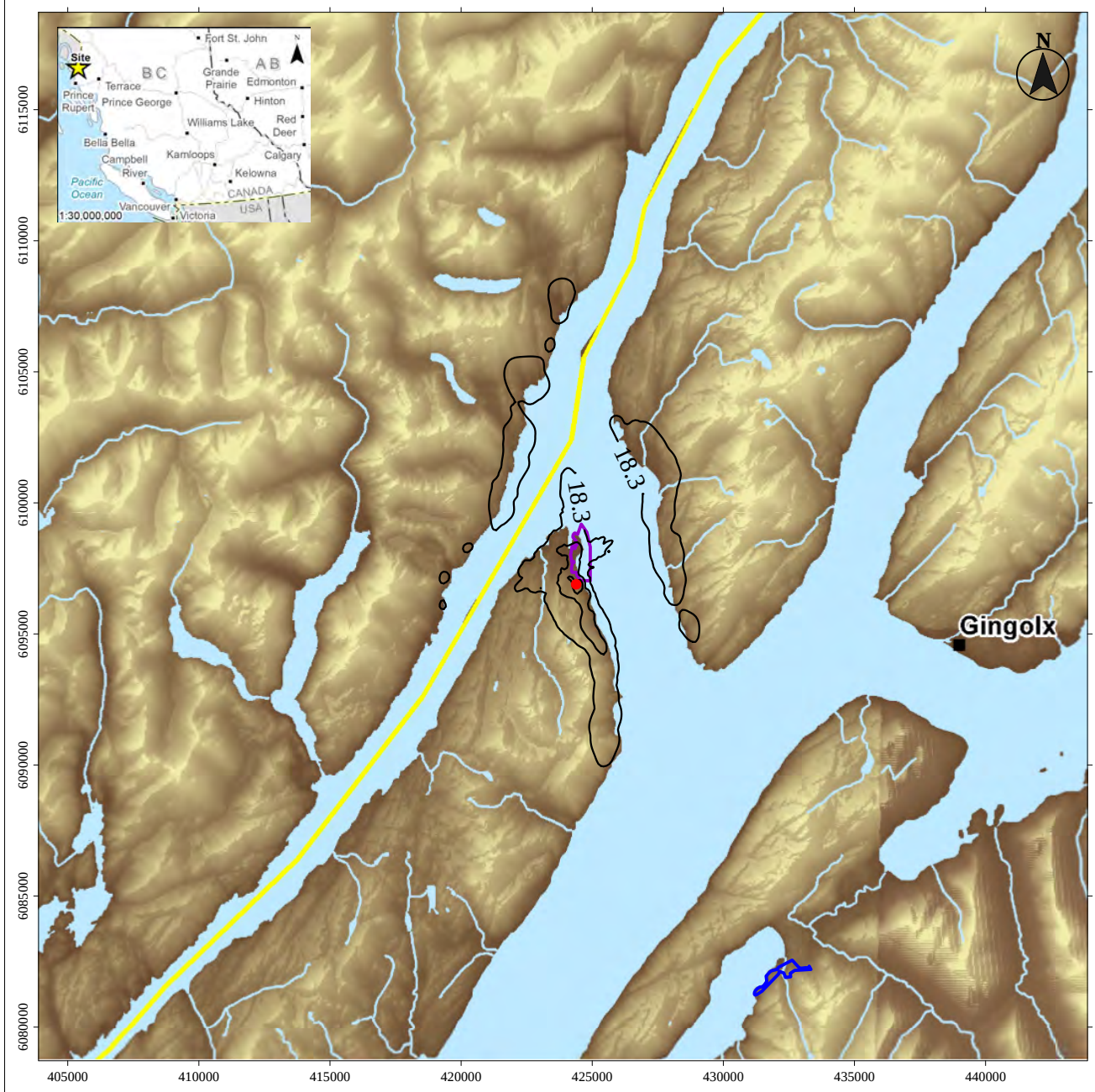
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-26

Title
Cumulative Case 1 (BC Hydro)
Predicted Ground-Level Annual Average
NO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Enbridge Nasoga Compressor Station

Maximum 1-hour Average 99th Daily Maximum SO_2 Concentration: 157 µg/m³

1-hour SO_2 BC AQO: 183 µg/m³

Contour Levels: 18.3, 45.8, 91.5, 137.3, 170, 183 µg/m³

Baseline: 0.8 µg/m³ added

Metres

0 5000 10000

Stantec

Project Location
Pearse Island, BC

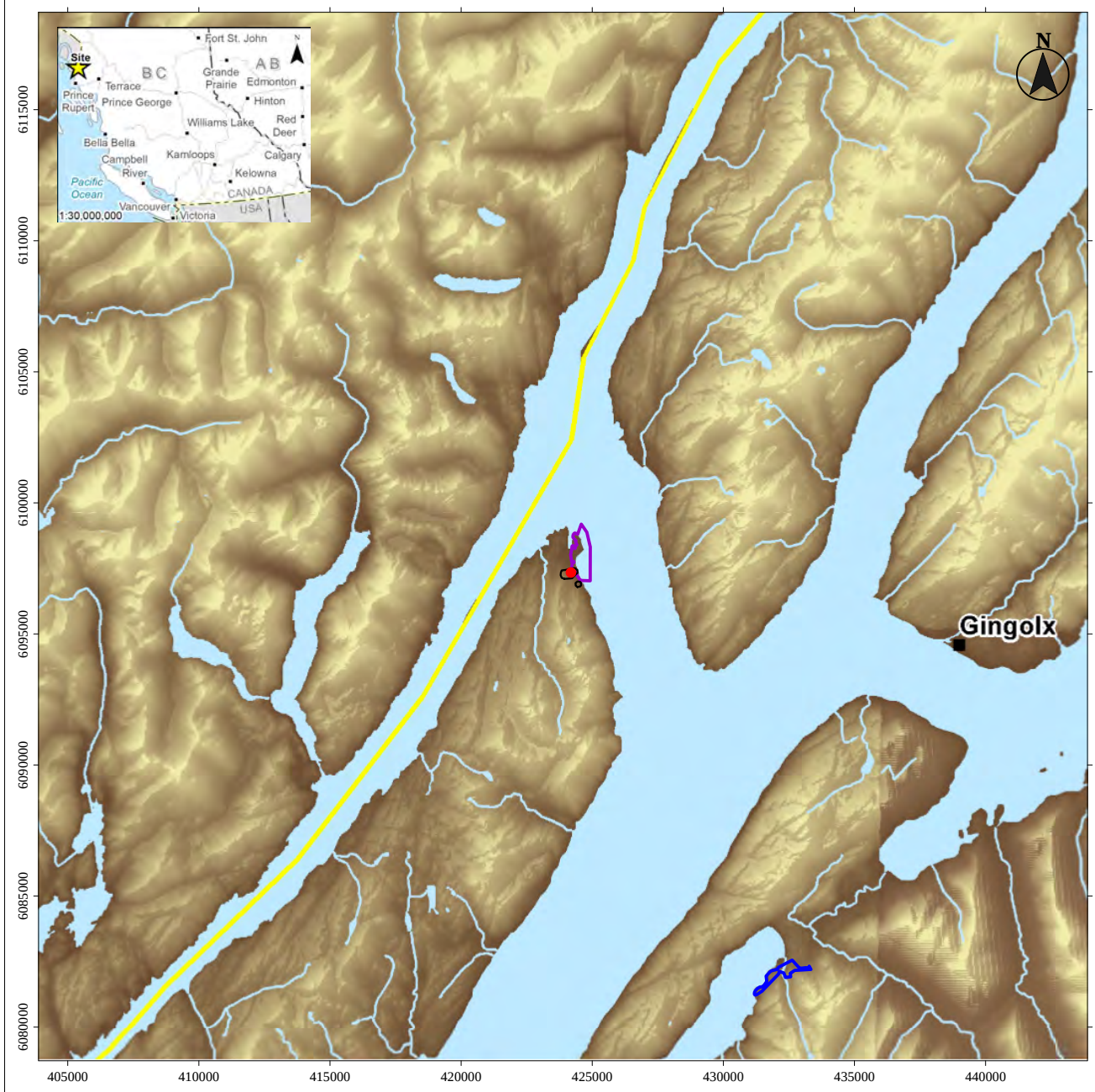
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-27

Title
Cumulative Case 1 (BC Hydro)
Predicted Ground-Level 99th Percentile
of 1-hour Daily Maximum SO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Enbridge Nasoga Compressor Station

Maximum Annual Average SO_2 Concentration: 5.7 µg/m³

Annual SO_2 BC AQO: 13 µg/m³

Contour Levels: 3.3, 6.5, 9.8, 13 µg/m³

Baseline: 0.8 µg/m³ added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

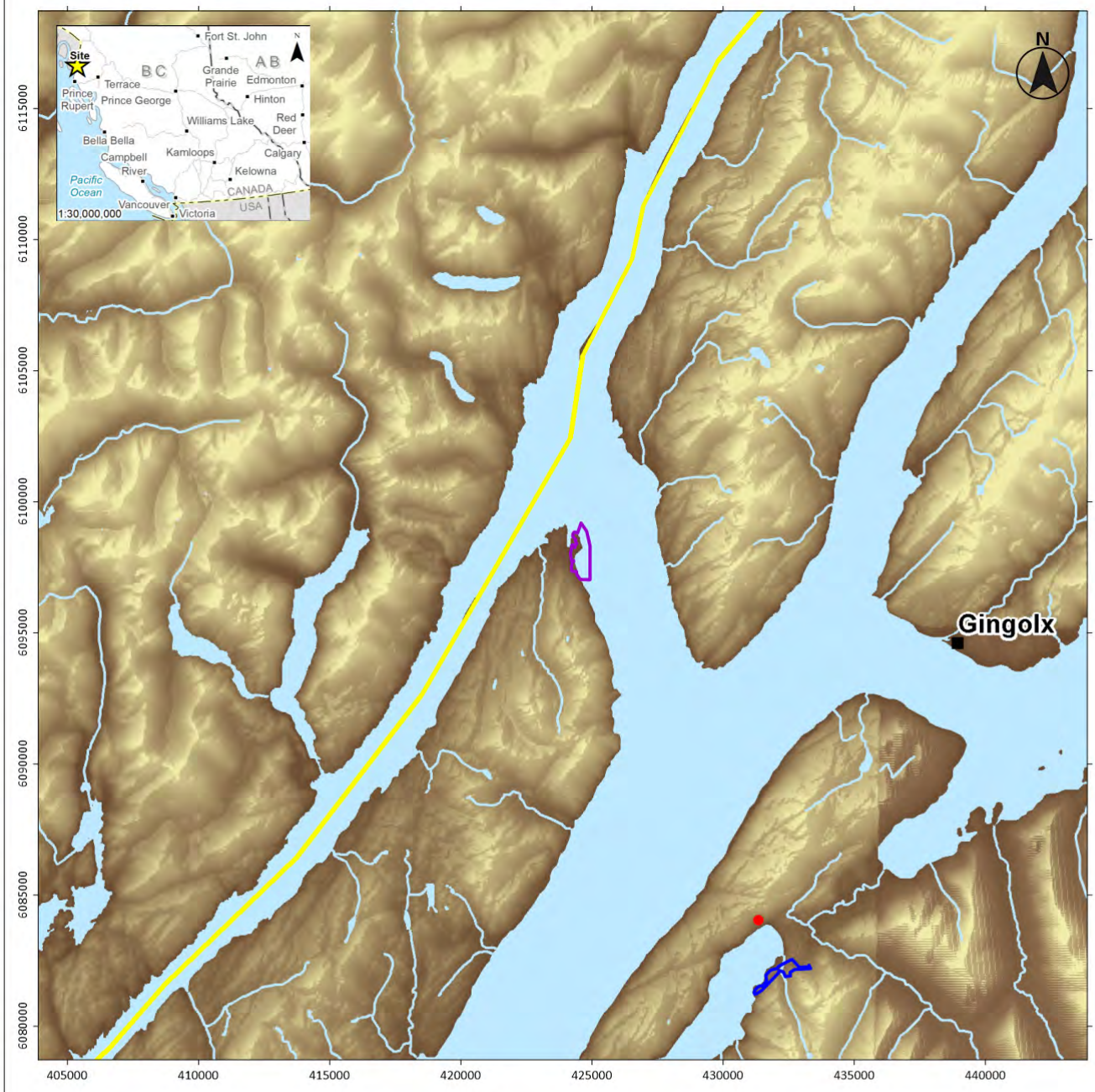
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-28

Title
Cumulative Case 1 (BC Hydro)
Predicted Ground-Level Annual Average
SO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Enbridge Nasoga Compressor Station

Maximum 24-Hour Average 98th $PM_{2.5}$ Concentration: 10.3 µg/m³

24-hour $PM_{2.5}$ BC AQO: 25 µg/m³

Contour Levels: 6.3, 12.5, 18.8, 25 µg/m³

Baseline: 8.5 µg/m³ added

Metres

0 5000 10000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-29

Title
Cumulative Case 1 (BC Hydro)
Predicted Ground-Level 98th Percentile 24-hour Average $PM_{2.5}$ Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Enbridge Nasoga Compressor Station

Maximum Annual Average $PM_{2.5}$ Concentration: 3.7 µg/m³

Annual $PM_{2.5}$ BC AQO: 8 µg/m³

Contour Levels: 2, 4, 6, 8 µg/m³

Baseline: 3.5 µg/m³ added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

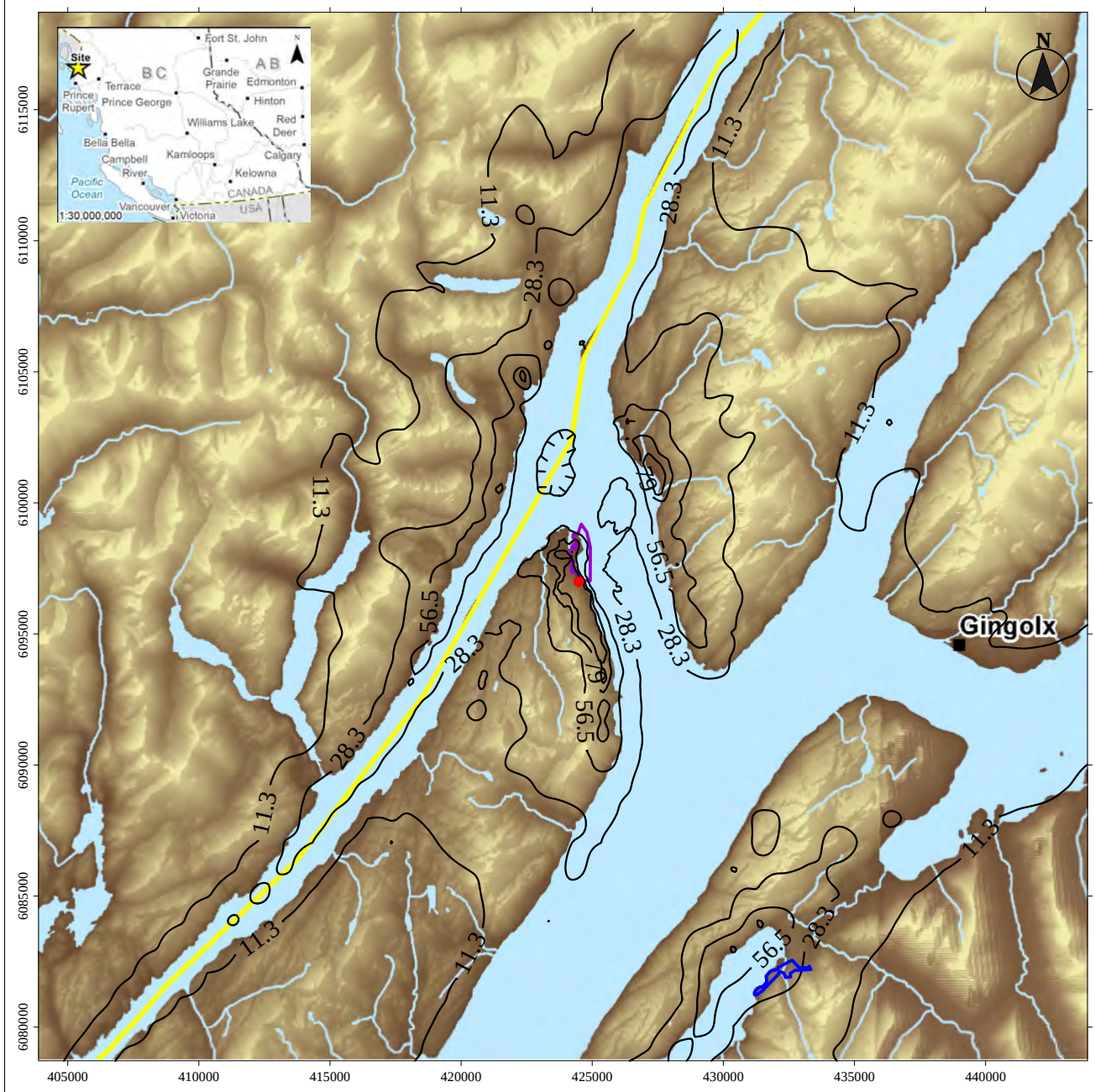
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-30

Title
Cumulative Case 1 (BC Hydro)
Predicted Ground-Level Annual Average
$PM_{2.5}$ Concentrations (µg/m³)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site
Gingolx
International Boundary
Watercourse
Waterbody
Ground Elevation (m)
High : 1652
Low : 0

Enbridge Nasoga Compressor Station

Maximum 1-hour Average 98th Daily Maximum NO_2 Concentration: 86.8 µg/m³

1-hour NO_2 BC AQO: 113 µg/m³

Contour Levels: 11.3, 28.3, 56.5, 79, 84.8, 113 µg/m3

Baseline: 2.6 µg/m³ added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

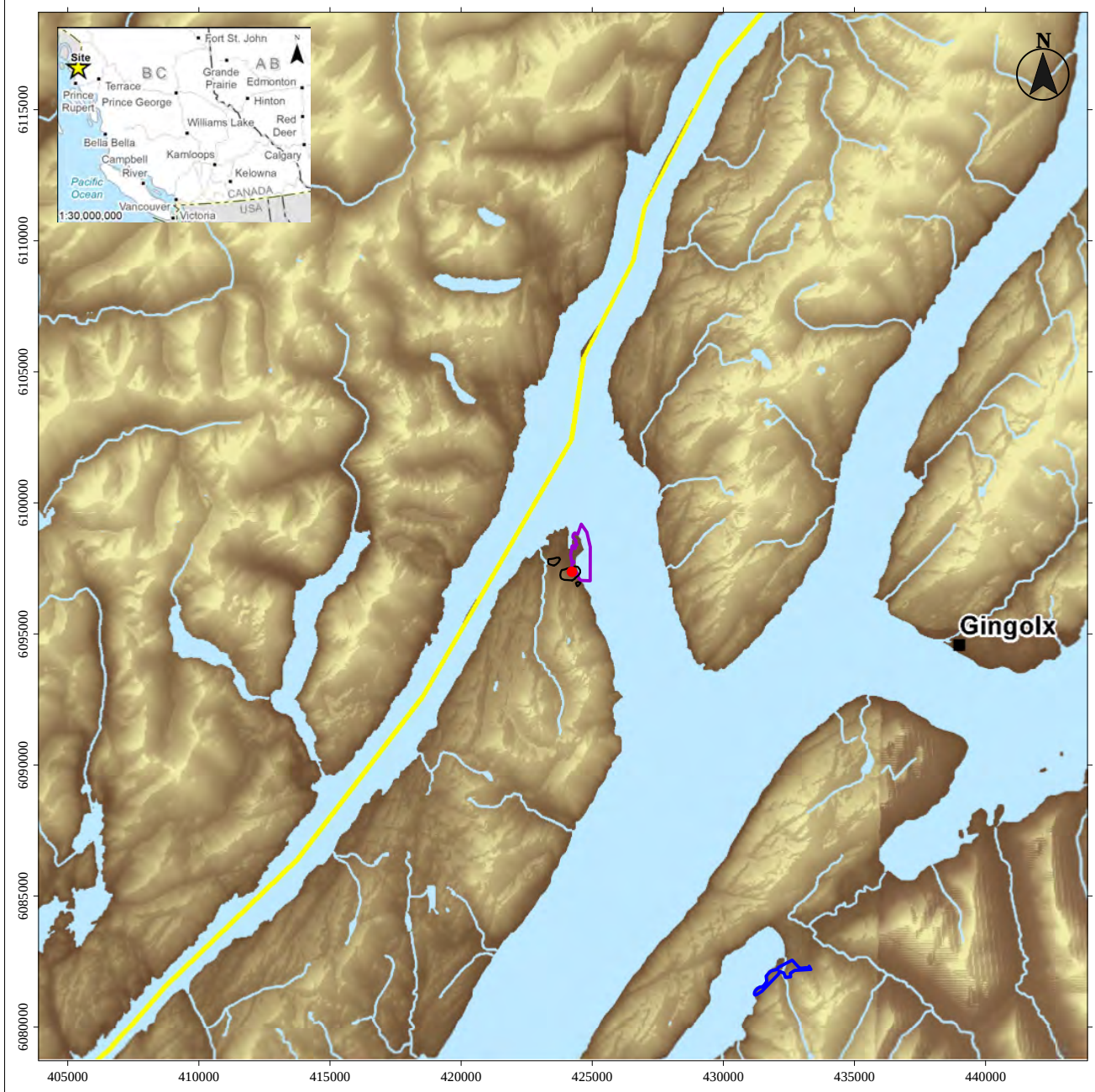
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-31

Title
Cumulative Case 2 (Site-power)
Predicted Ground-Level 98th Percentile
of 1-hour Daily Maximum NO_2 Concentrations (µg/m3)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Enbridge Nasoga Compressor Station

Maximum Annual Average NO_2 Concentration: 12.5 µg/m³

Annual NO_2 BC AQO: 32 µg/m³

Contour Levels: 8, 16, 24, 32 µg/m³

Baseline: 2.6 µg/m³ added

Metres

0 5000 10000

Stantec

Project Location
Pearse Island, BC

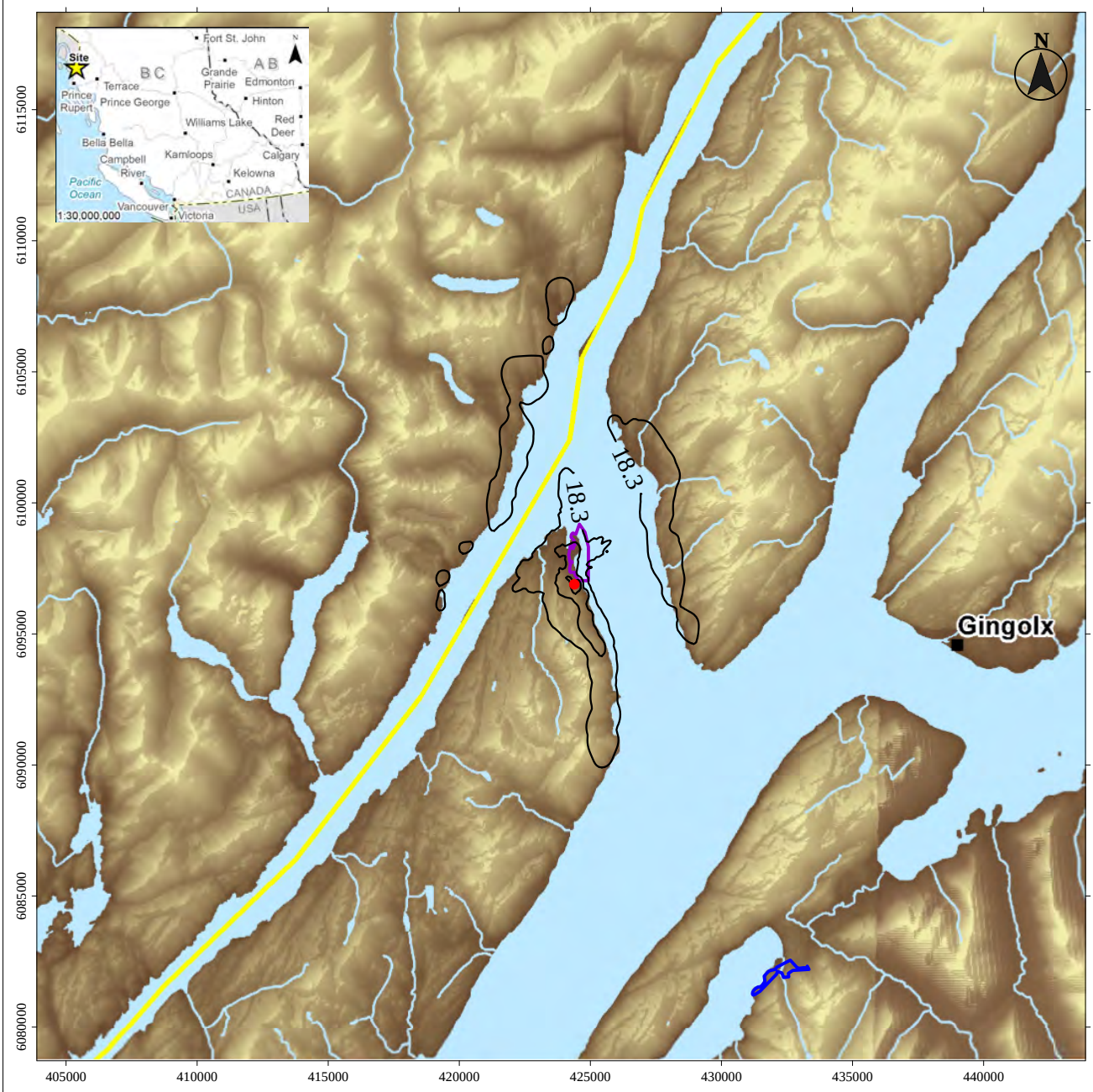
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-32

Title
Cumulative Case 2 (Site-power)
Predicted Ground-Level Annual Average
NO_2 Concentrations (µg/m³)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site
Gingolx
International Boundary
Watercourse
Waterbody
Ground Elevation (m)
High : 1652
Low : 0

Enbridge Nasoga Compressor Station

Maximum 1-hour Average 99th Daily Maximum SO_2 Concentration: 157 µg/m³

1-hour SO_2 BC AQO: 183 µg/m³

Contour Levels: 18.3, 45.8, 91.5, 137.3, 170, 183 µg/m³

Baseline: 0.8 µg/m³ added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-33

Title
Cumulative Case 2 (Site-power)
Predicted Ground-Level 99th Percentile
of 1-hour Daily Maximum SO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)
High : 1652
Low : 0

Enbridge Nasoga Compressor Station

Maximum Annual Average SO_2 Concentration: 5.8 µg/m³

Annual SO_2 BC AQO: 13 µg/m³

Contour Levels: 3.3, 6.5, 9.8, 13 µg/m³

Baseline: 0.8 µg/m³ added

Metres
0 5000 10000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-34

Title
Cumulative Case 2 (Site-power)
Predicted Ground-Level Annual Average
SO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Enbridge Nasoga Compressor Station

Maximum 24-Hour Average 98th $PM_{2.5}$ Concentration: 12.5 µg/m³

24-hour $PM_{2.5}$ BC AQO: 25 µg/m³

Contour Levels: 6.3, 12.5, 18.8, 25 µg/m³

Baseline: 8.5 µg/m³ added

Metres

0 5000 10000

Notes

1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-35

Title
Cumulative Case 2 (Site-power)
Predicted Ground-Level 98th Percentile 24-hour Average $PM_{2.5}$ Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Ksi Lisims LNG Plant Boundary

Site

Gingolx

International Boundary

Watercourse

Waterbody

Ground Elevation (m)

High : 1652

Low : 0

Enbridge Nasoga Compressor Station

Maximum Annual Average $PM_{2.5}$ Concentration: 3.9 µg/m³

Annual $PM_{2.5}$ BC AQO: 8 µg/m³

Contour Levels: 2, 4, 6, 8 µg/m³

Baseline: 3.5 µg/m³ added

Metres

0 5000 10000

Notes

1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

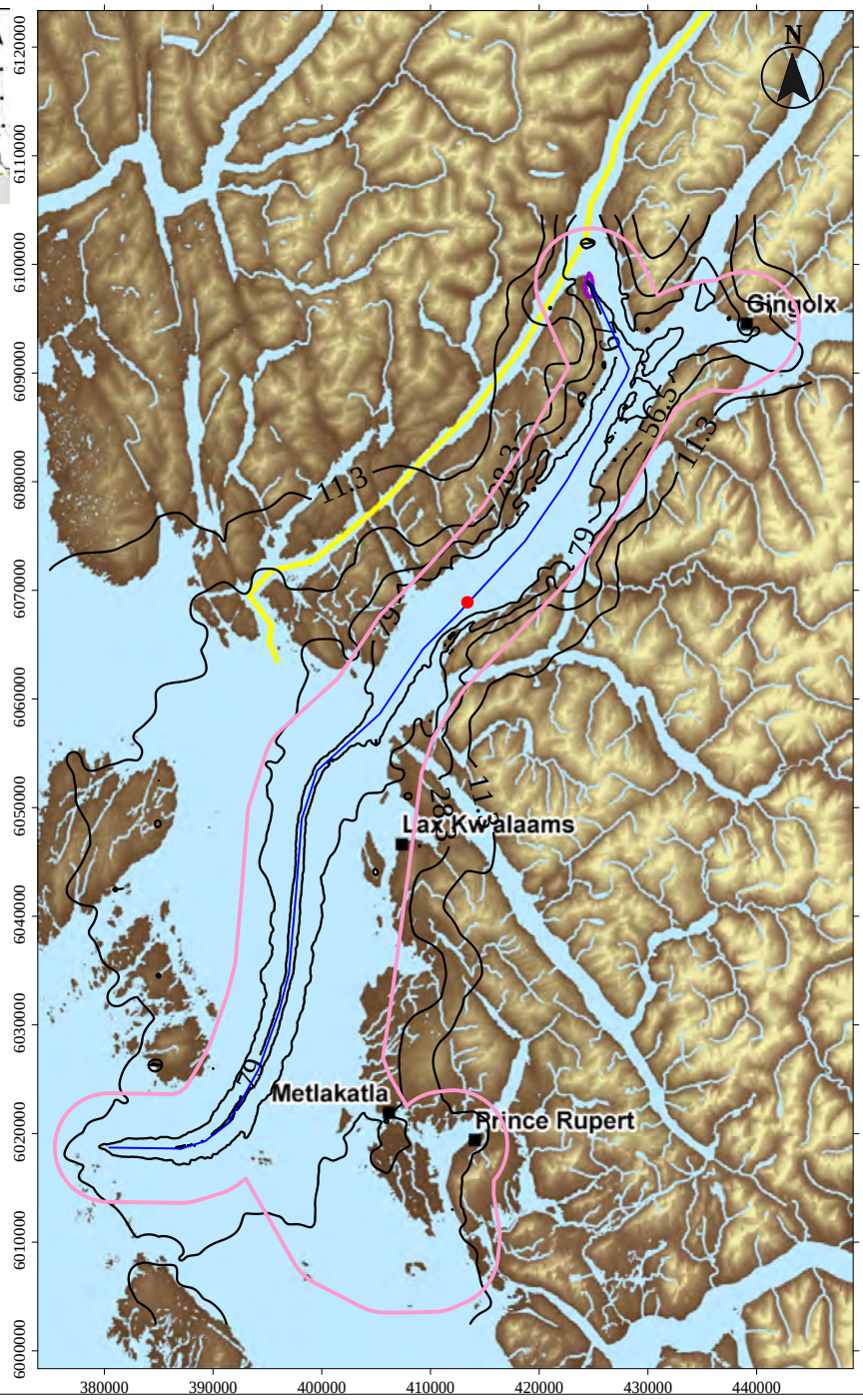
Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-36

Title
Cumulative Case 2 (Site-power)
Predicted Ground-Level Annual Average
$PM_{2.5}$ Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.





KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Shipping Boundary
Shipping Route

Maximum 1-hour Average 98th Daily Maximum NO_2 Concentration: 84.1 µg/m³

1-hour NO_2 BC AQO: 113 µg/m³

Contour Levels: 11.3, 28.3, 56.5, 79, 84.8, 113 µg/m³

Baseline: not added

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

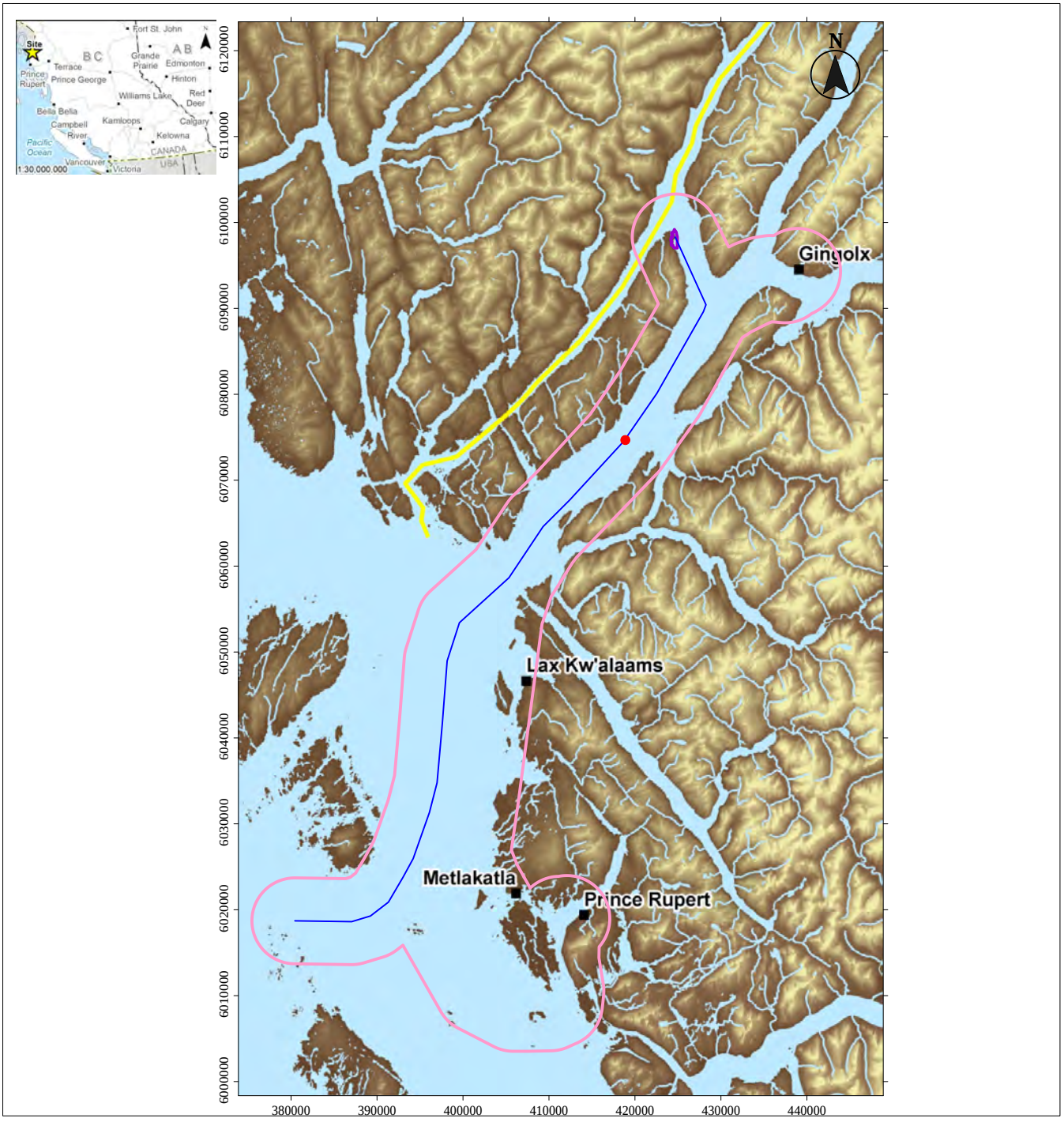
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-37

Title
Operations Shipping Route Project-Alone Case
Predicted Ground-Level 98th Percentile
of 1-hour Daily Maximum NO_2 Concentrations (µg/m³)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Shipping Boundary
Shipping Route

Maximum Annual Average NO_2 Concentration: 7.1 µg/m³

Annual NO_2 BC AQO: 32 µg/m³

Contour Levels: 8, 16, 24, 32 µg/m³

Baseline: not added

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

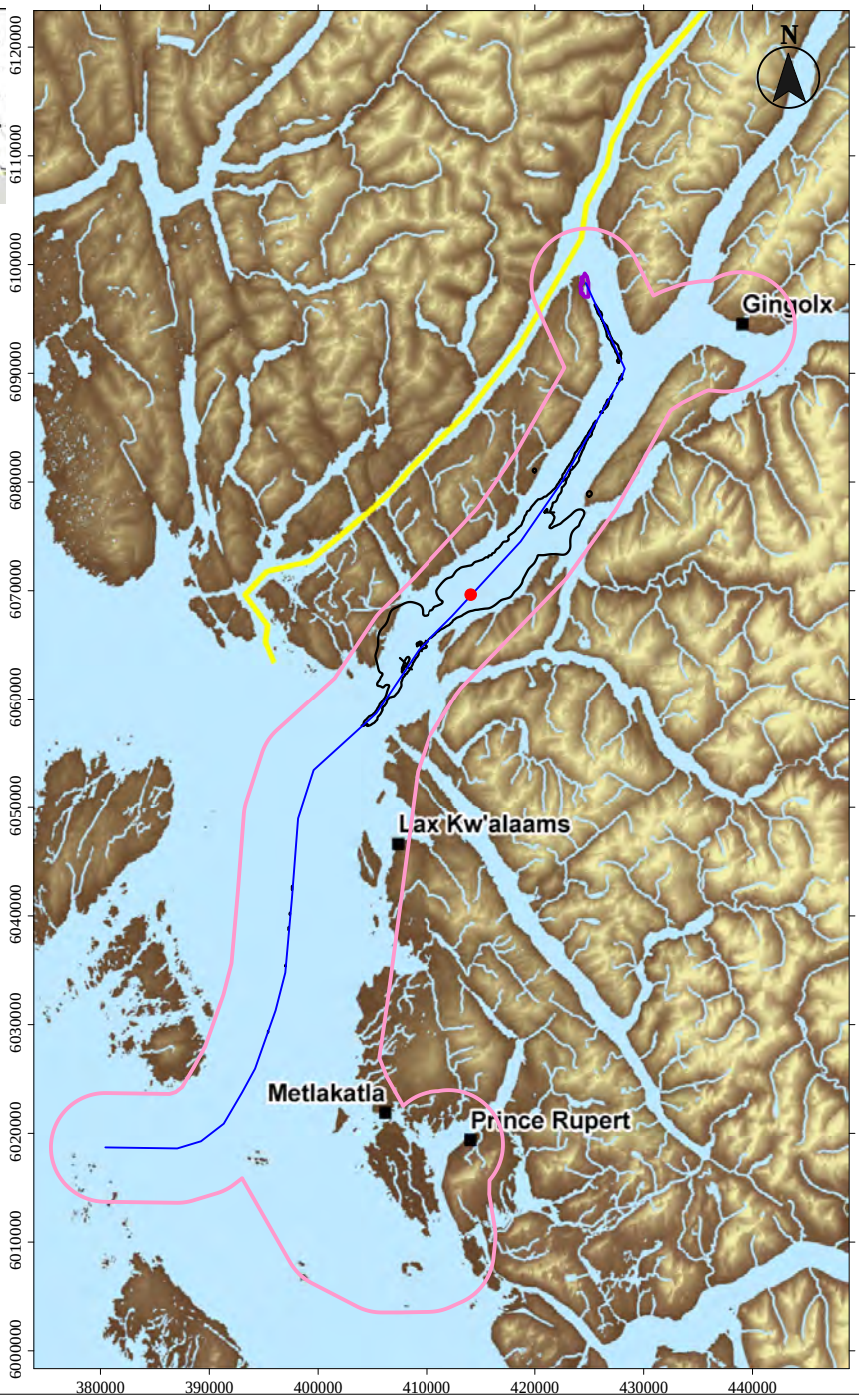
Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-38

Title
Operations Shipping Route Project-Alone Case
Predicted Ground-Level Annual Average
NO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.





KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Shipping Boundary
Shipping Route

Maximum 1-hour Average 99th Daily Maximum SO_2 Concentration: 28.6 µg/m³

1-hour SO_2 BC AQO: 183 µg/m³

Contour Levels: 18.3, 45.8, 91.5, 137.3, 170, 183 µg/m³

Baseline: not added

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

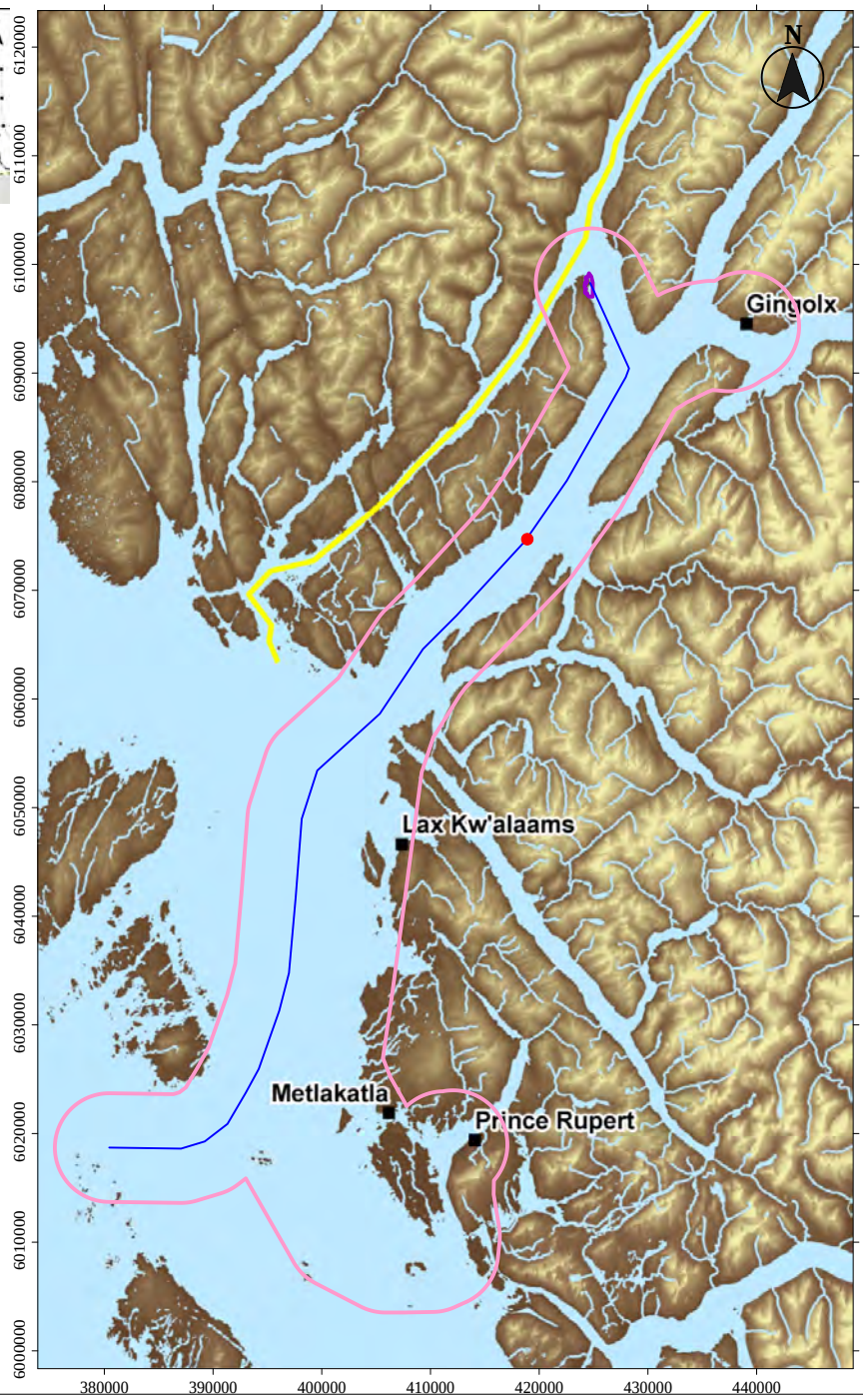
Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-39

Title
Operations Shipping Route Project-Alone Case
Predicted Ground-Level 99th Percentile
of 1-hour Daily Maximum SO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.





KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Shipping Boundary
Shipping Route

Maximum Annual Average SO_2 Concentration: 0.9 µg/m³

Annual SO_2 BC AQO: 13 µg/m³

Contour Levels: 3.3, 6.5, 9.8, 13 µg/m³

Baseline: not added

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

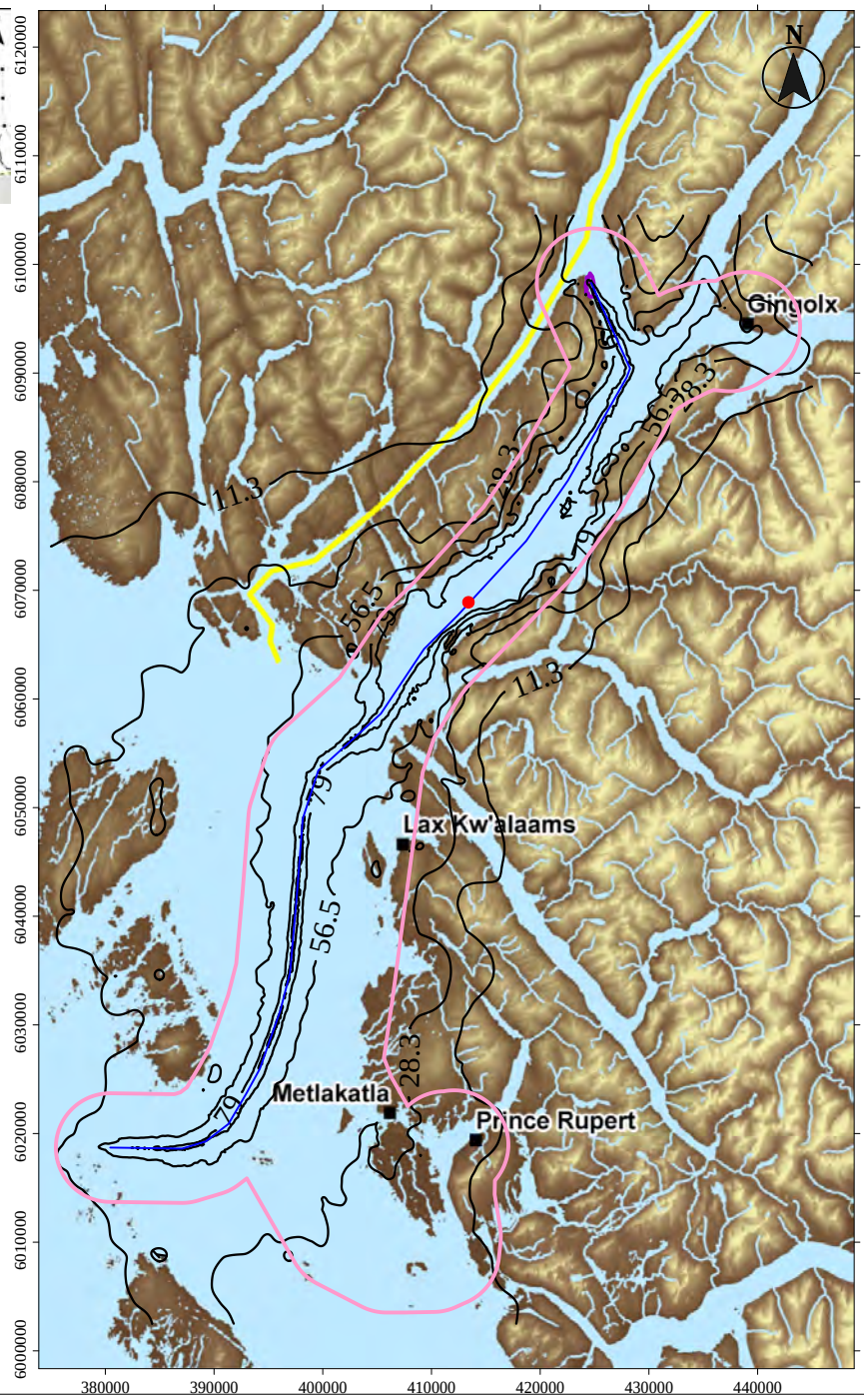
Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-40

Title
Operations Shipping Route Project-Alone Case
Predicted Ground-Level Annual Average
SO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.





KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Shipping Boundary
Shipping Route

Maximum 1-hour Average 98th Daily Maximum NO_2 Concentration: 86.7 µg/m³

1-hour NO_2 BC AQO: 113 µg/m³

Contour Levels: 11.3, 28.3, 56.5, 79, 84.8, 113 µg/m³
Baseline: 2.6 µg/m³ added

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

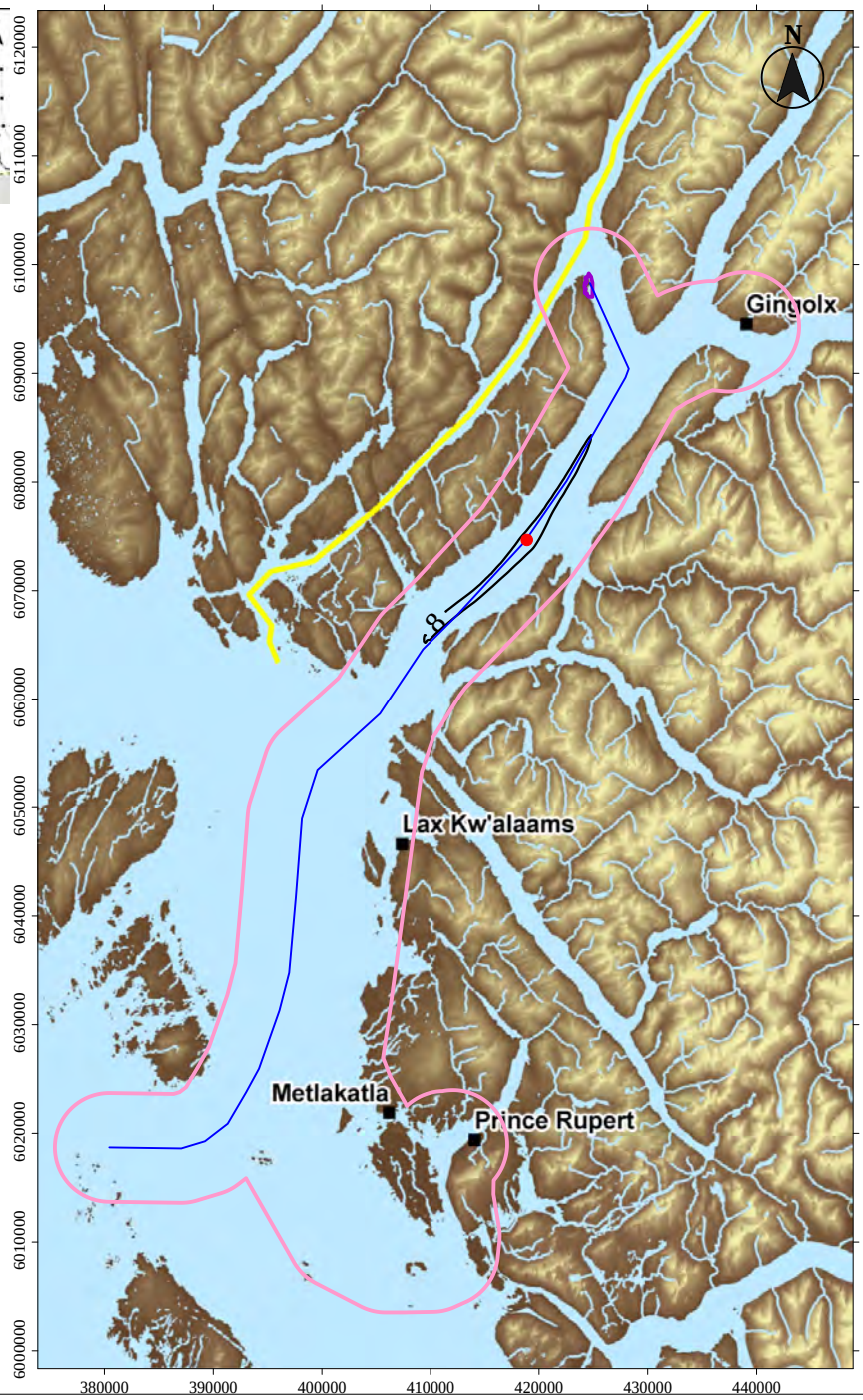
Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-41

Title
Operations Shipping Route Application Case
Predicted Ground-Level 98th Percentile
of 1-hour Daily Maximum NO_2 Concentrations (µg/m3)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.





KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Shipping Boundary
Shipping Route

Maximum Annual Average NO_2 Concentration: 9.7 µg/m³

Annual NO_2 BC AQO: 32 µg/m³

Contour Levels: 8, 16, 24, 32 µg/m³

Baseline: 2.6 µg/m³ added

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

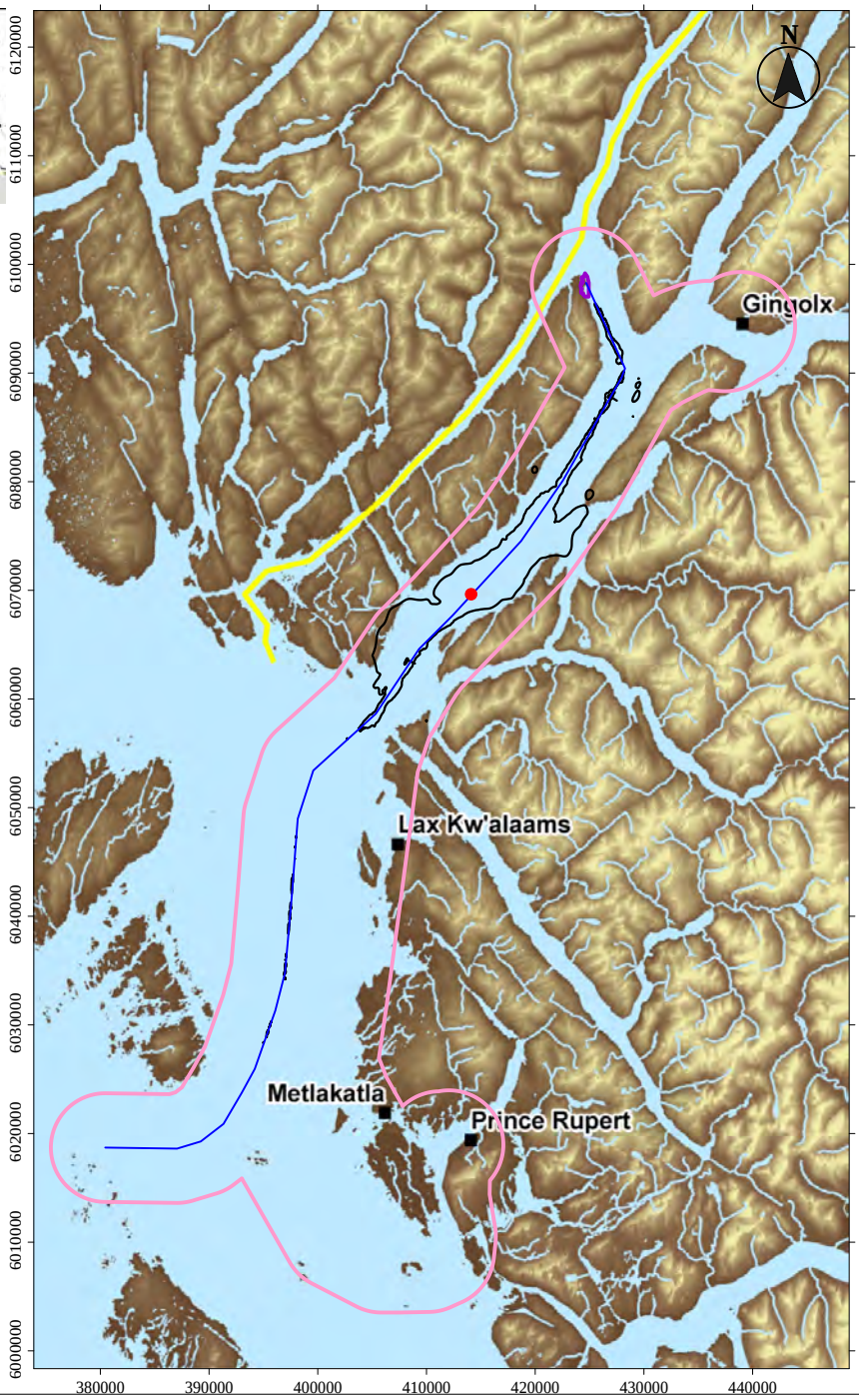
Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-42

Title
Operations Shipping Route Application Case
Predicted Ground-Level Annual Average
NO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.





KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Shipping Boundary
Shipping Route

Maximum 1-hour Average 99th Daily Maximum SO_2 Concentration: 29.4 µg/m3

1-hour SO_2 BC AQO: 183 µg/m3

Contour Levels: 18.3, 45.8, 91.5, 137.3, 170, 183 µg/m3

Baseline: 0.8 µg/m3 added

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

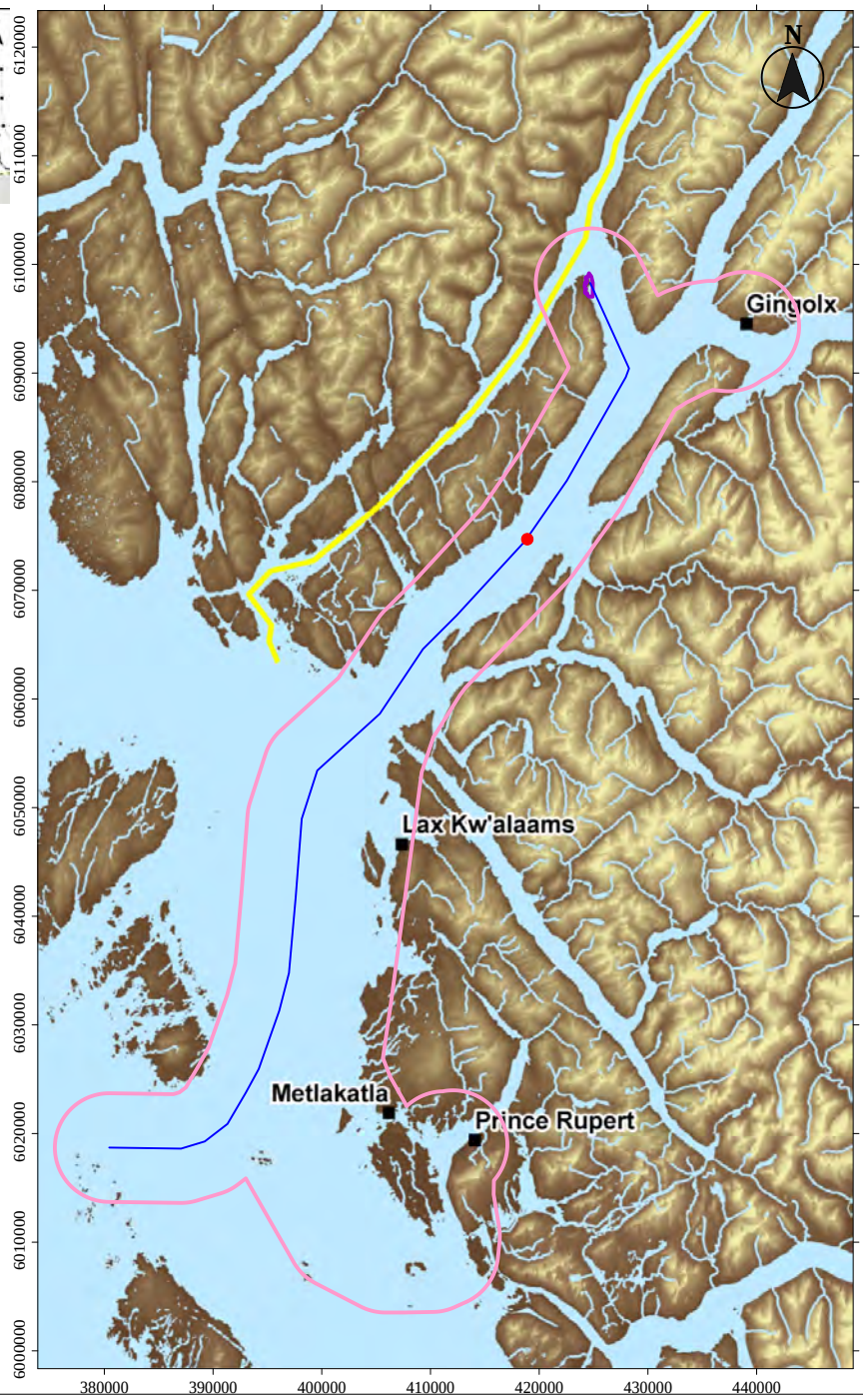
Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-43

Title
Operations Shipping Route Application Case
Predicted Ground-Level 99th Percentile
of 1-hour Daily Maximum SO_2 Concentrations (µg/m3)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.





KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Shipping Boundary
Shipping Route

Maximum Annual Average SO_2 Concentration: 1.7 µg/m³

Annual SO_2 BC AQO: 13 µg/m³

Contour Levels: 3.3, 6.5, 9.8, 13 µg/m³

Baseline: 0.8 µg/m³ added

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

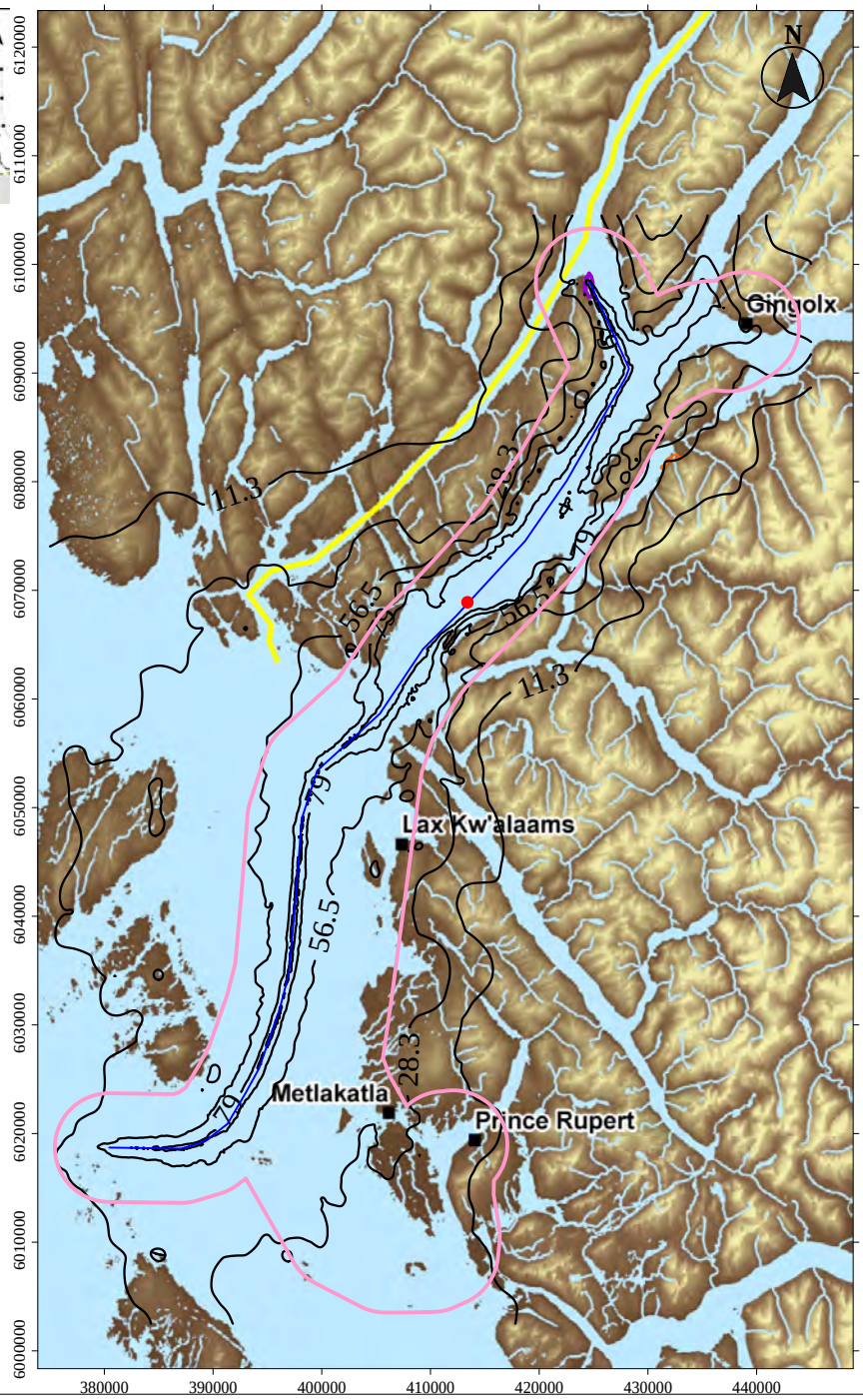
Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-44

Title
Operations Shipping Route Application Case
Predicted Ground-Level Annual Average
SO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.





KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Shipping Boundary
Shipping Route
Enbridge Nasoga Compressor Station

Maximum 1-hour Average 98th Daily Maximum NO_2 Concentration: 86.7 µg/m³

1-hour NO_2 BC AQO: 113 µg/m³

Contour Levels: 11.3, 28.3, 56.5, 79, 84.8, 113 µg/m³
Baseline: 2.6 µg/m³ added

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

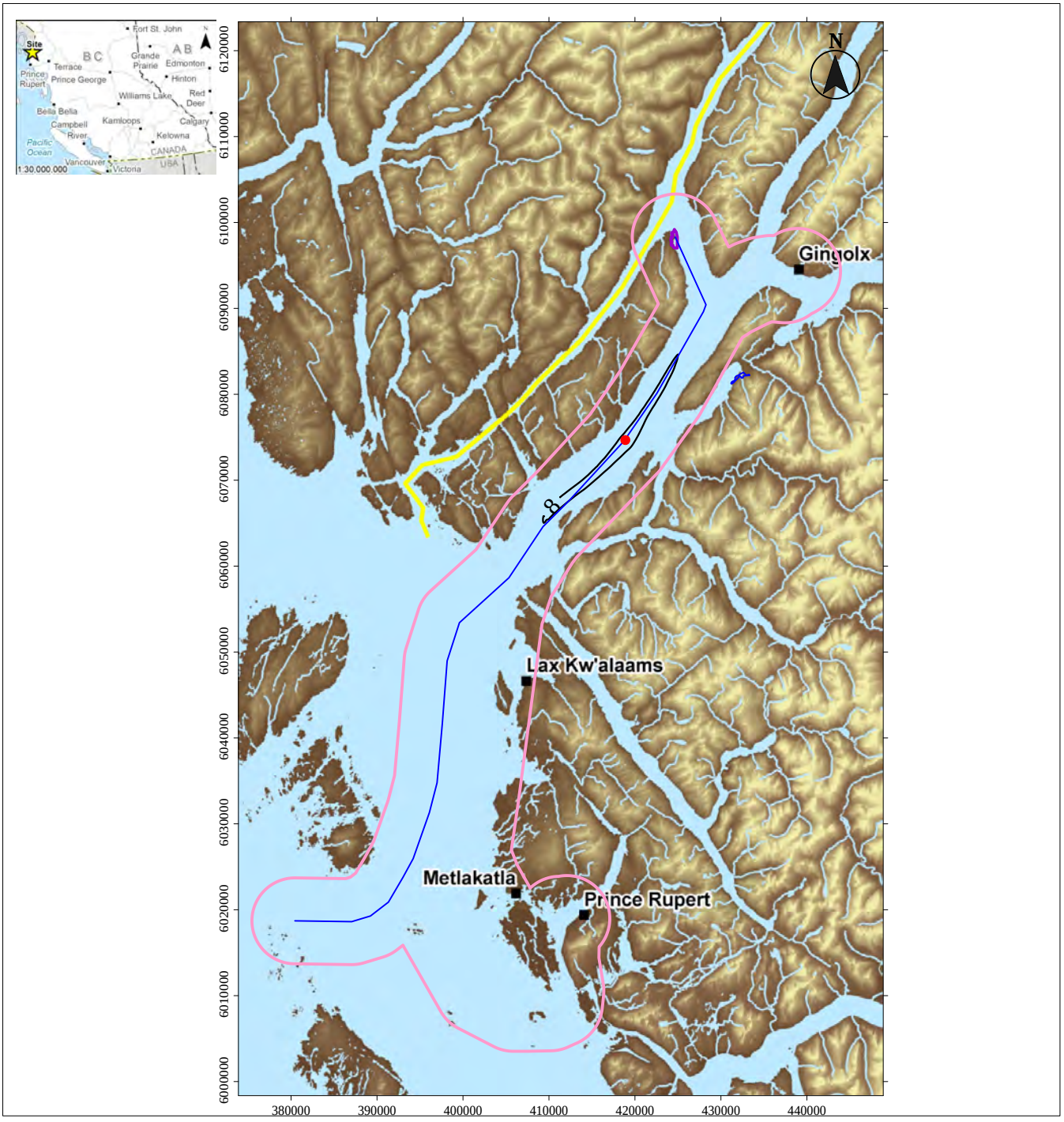
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-45

Title
Operations Shipping Route Cumulative Case
Predicted Ground-Level 98th Percentile
of 1-hour Daily Maximum NO_2 Concentrations (µg/m3)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Maximum Annual Average NO_2 Concentration: 9.8 µg/m³

Annual NO_2 BC AQO: 32 µg/m³

Contour Levels: 8, 16, 24, 32 µg/m³

Baseline: 2.6 µg/m³ added

Shipping Boundary
Shipping Route
Enbridge Nasoga Compressor Station

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

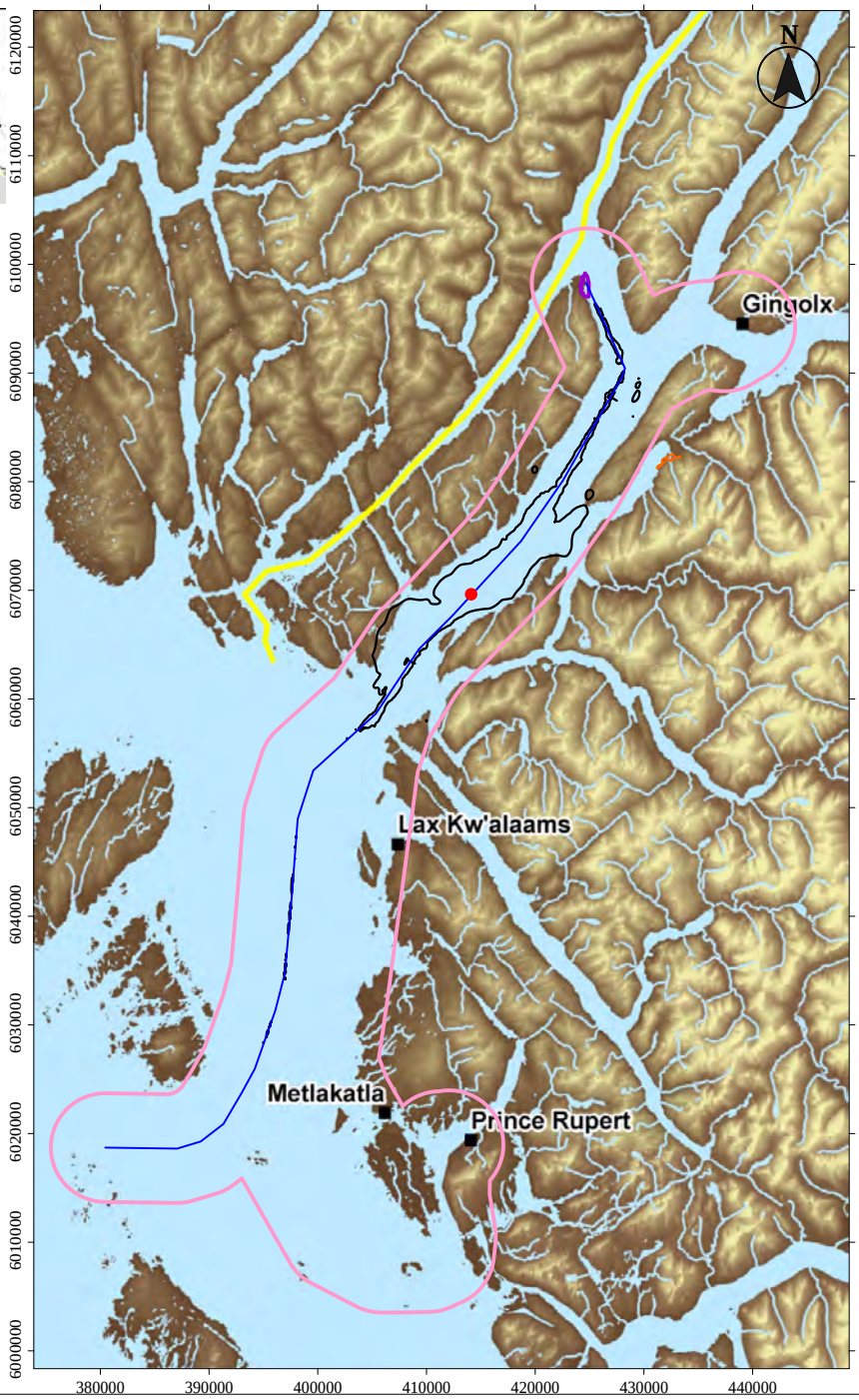
Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-46

Title
Operations Shipping Route Cumulative Case Predicted Ground-Level Annual Average NO_2 Concentrations (µg/m³)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Shipping Boundary
Shipping Route
Enbridge Nasoga Compressor Station

Maximum 1-hour Average 99th Daily Maximum SO_2 Concentration: 29.4 µg/m3

1-hour SO_2 BC AQO: 183 µg/m3

Contour Levels: 18.3, 45.8, 91.5, 137.3, 170, 183 µg/m3

Baseline: 0.8 µg/m3 added

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

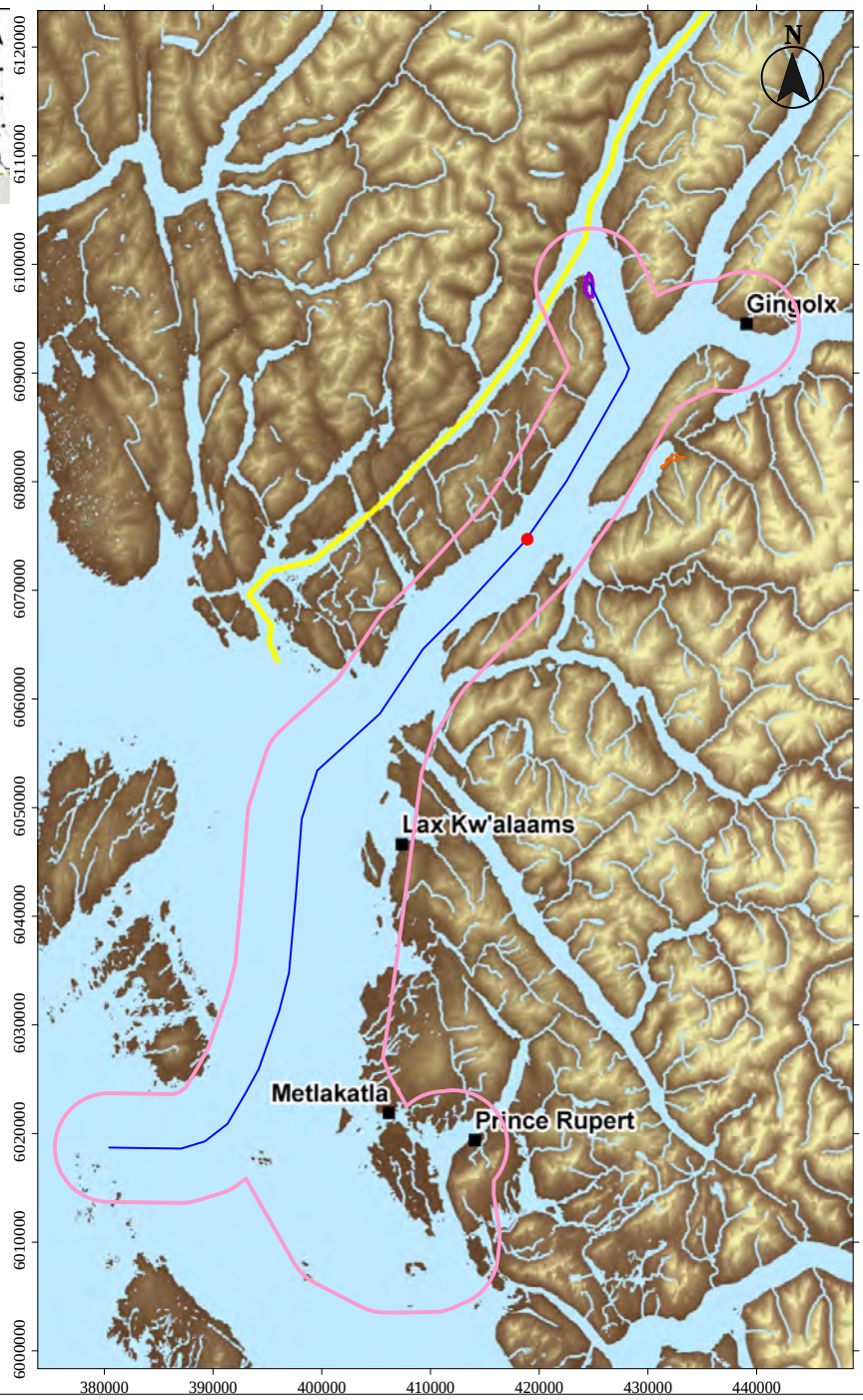
Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-47

Title
Operations Shipping Route Cumulative Case
Predicted Ground-Level 99th Percentile
of 1-hour Daily Maximum SO_2 Concentrations (µg/m3)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.





KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

Ksi Lisims LNG Plant Boundary

City/Town
International Boundary
Watercourse
Waterbody
Elevation (m)
High : 1704
Low : 0

Maximum Annual Average SO_2 Concentration: 1.7 µg/m³

Annual SO_2 BC AQO: 13 µg/m³

Contour Levels: 3.3, 6.5, 9.8, 13 µg/m³

Baseline: 0.8 µg/m³ added

Shipping Boundary
Shipping Route
Enbridge Nasoga Compressor Station

Metres
0 15000 30000

Stantec

Project Location
Pearse Island, BC

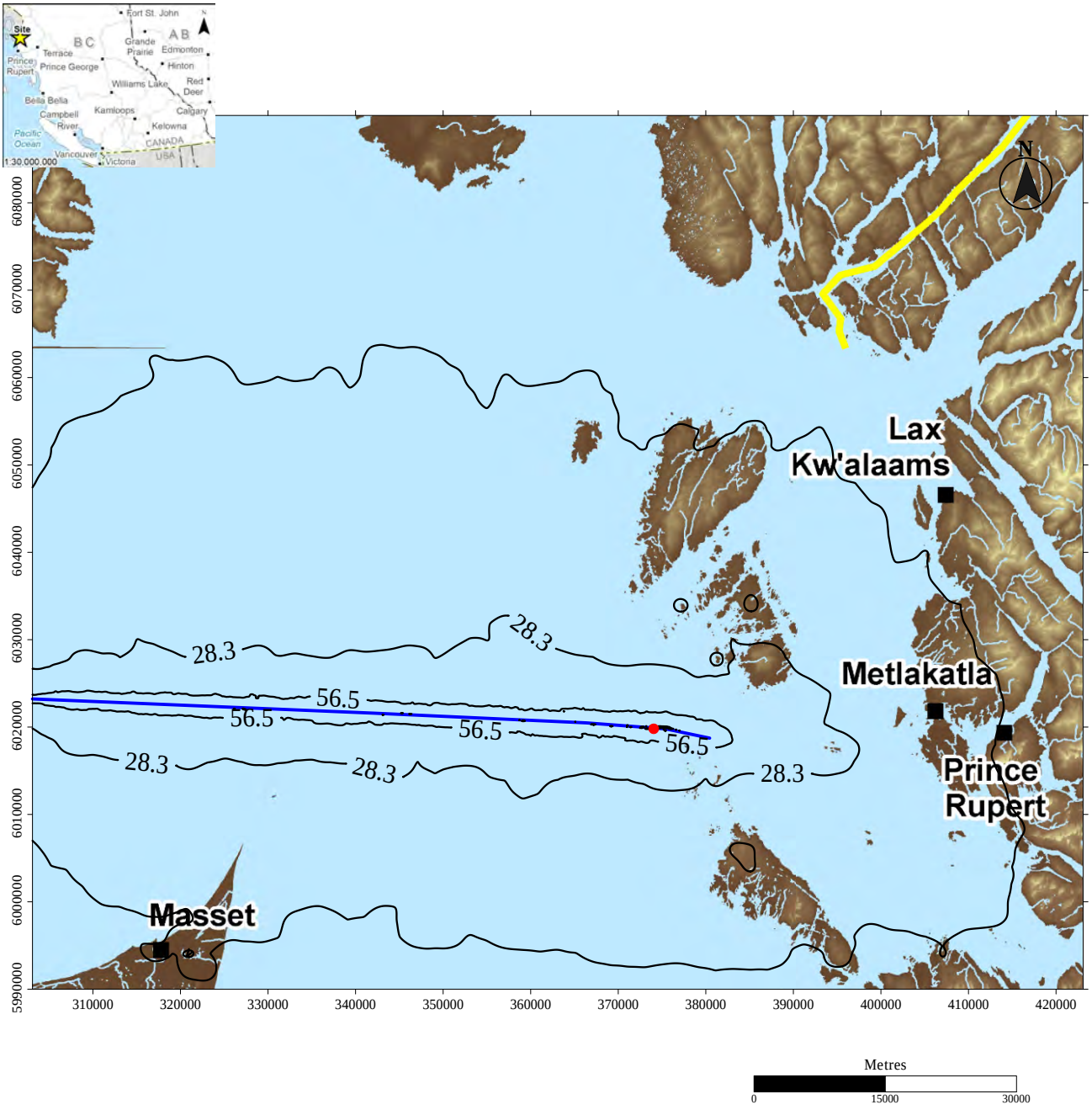
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-48

Title
Operations Shipping Route Cumulative Case Predicted Ground-Level Annual Average SO_2 Concentrations (µg/m³)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

City/Town
International Boundary
Watercourse
Waterbody
Value
High : 1250
Low : 0

Shipping Route

Maximum 1-hour Average 98th Daily Maximum NO_2 Concentration: 80.6 µg/m³

1-hour NO_2 BC AQO: 113 µg/m³

Contour Levels: 11.3, 28.3, 56.5, 79, 84.8, 113 µg/m³

Baseline: not added

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-49

Title
Open Water Assessment Project-Alone Case
Predicted Ground-Level 98th Percentile
of 1-hour Daily Maximum NO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.





KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

City/Town
International Boundary
Watercourse
Waterbody
Value
High : 1250
Low : 0

Shipping Route

Maximum Annual Average NO_2 Concentration: 1.3 µg/m³

Annual NO_2 BC AQO: 32 µg/m³

Contour Levels: 8, 16, 24, 32 µg/m³

Baseline: not added

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-50

Title
Open Water Assessment Project-Alone Case
Predicted Ground-Level Annual Average
NO_2 Concentrations (µg/m³)

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KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

City/Town
International Boundary
Watercourse
Waterbody
Value
High : 1250
Low : 0

Shipping Route

Maximum 1-hour Average 99th Daily Maximum SO_2 Concentration: 8.9 µg/m³

1-hour SO_2 BC AQO: 183 µg/m³

Contour Levels: 18.3, 45.8, 91.5, 137.3, 170, 183 µg/m³

Baseline: not added

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-51

Title
Open Water Assessment Project-Alone Case
Predicted Ground-Level 99th Percentile
of 1-hour Daily Maximum SO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

City/Town
International Boundary
Watercourse
Waterbody
Value
High : 1250
Low : 0

Shipping Route

Maximum Annual Average SO_2 Concentration: 0.1 µg/m³

Annual SO_2 BC AQO: 13 µg/m³

Contour Levels: 3.3, 6.5, 9.8, 13 µg/m³

Baseline: not added

Stantec

Project Location
Pearse Island, BC

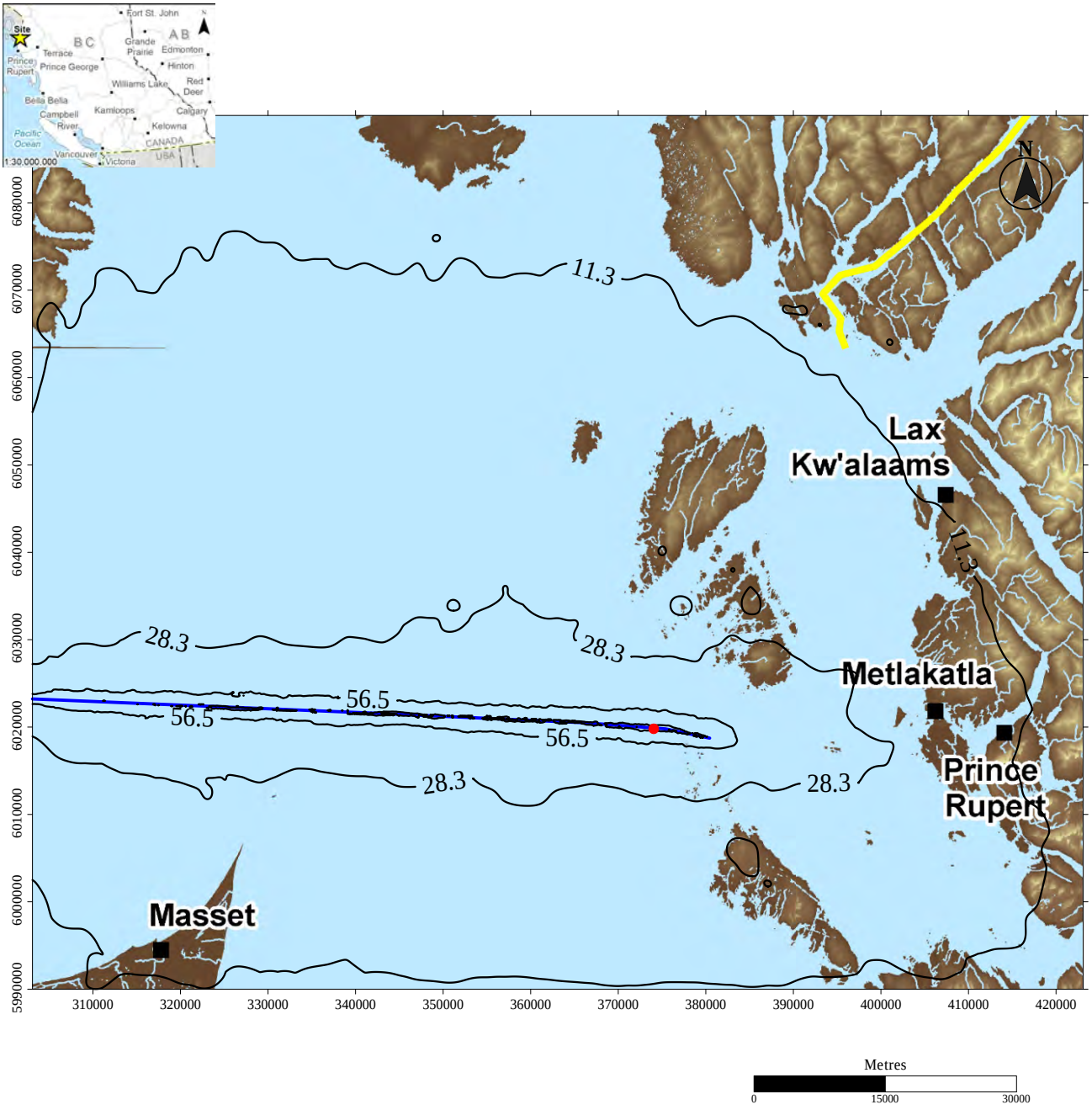
Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-52

Title
Open Water Assessment Project-Alone Case
Predicted Ground-Level Annual Average
SO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

City/Town
International Boundary
Watercourse
Waterbody
Value
High : 1250
Low : 0

Shipping Route

Maximum 1-hour Average 98th Daily Maximum NO_2 Concentration: 83.2 µg/m³

1-hour NO_2 BC AQO: 113 µg/m³

Contour Levels: 11.3, 28.3, 56.5, 79, 84.8, 113 µg/m³

Baseline: 2.6 µg/m³ added

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-53

Title
Open Water Assessment Application Case
Predicted Ground-Level 98th Percentile
of 1-hour Daily Maximum NO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

City/Town
International Boundary
Watercourse
Waterbody
Value
High : 1250
Low : 0

Shipping Route

Maximum Annual Average NO_2 Concentration: 3.9 µg/m³

Annual NO_2 BC AQO: 32 µg/m³

Contour Levels: 8, 16, 24, 32 µg/m³

Baseline: 2.6 µg/m³ added

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-54

Title
Open Water Assessment Application Case
Predicted Ground-Level Annual Average
NO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

City/Town
International Boundary
Watercourse
Waterbody
Value
High : 1250
Low : 0

Shipping Route

Maximum 1-hour Average 99th Daily Maximum SO_2 Concentration: 9.7 µg/m³

1-hour SO_2 BC AQO: 183 µg/m³

Contour Levels: 18.3, 45.8, 91.5, 137.3, 170, 183 µg/m³

Baseline: 0.8 µg/m³ added

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-55

Title
Open Water Assessment Application Case
Predicted Ground-Level 99th Percentile
of 1-hour Daily Maximum SO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.





KSI LISIMS LNG

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada, Stantec, Rockies LNG, Maxar

City/Town
International Boundary
Watercourse
Waterbody
Value
High : 1250
Low : 0

Shipping Route

Maximum Annual Average SO_2 Concentration: 0.9 µg/m³

Annual SO_2 BC AQO: 13 µg/m³

Contour Levels: 3.3, 6.5, 9.8, 13 µg/m³

Baseline: 0.8 µg/m³ added

Stantec

Project Location
Pearse Island, BC

Project Number 123221820

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal

Figure No.
D-56

Title
Open Water Assessment Application Case
Predicted Ground-Level Annual Average
SO_2 Concentrations (µg/m³)

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.