6.0 AIR QUALITY

The assessment of potential effects of the Project on air quality was provided in Section 6 of the EIS. This section of the EIS Addendum provides:

- An update to the potential project and cumulative effects on the Air Quality VC as a result of the project changes
- Responses to requests for additional information received from the federal government (August 14, 2014)
- An updated list of mitigation measures for the Air Quality VC
- Updated conclusions on the assessment of effects on the Air Quality VC, taking into account project changes and the requested additional information.

Table 6-1 lists the documents applicable to the Air Quality VC submitted by PNW LNG as part of the environmental assessment process to date and identifies if the information is either *updated by EIS Addendum, superseded*, *not relevant*, or *not affected* by information in the EIS Addendum. The following sections of the EIS Addendum contain information that updates the documents classified as *updated by EIS Addendum* in Table 6-1. Figure 6-1 has been updated from that provided in the EIS to reflect project changes and any other applicable updates.

Table 6-1 Status of Previously Submitted Documents

Document Name	Status
Section 6 and Appendix C (Air Quality Technical Data Report) of the EIS (February 2014)	Updated by EIS Addendum
Technical Memorandum: Revisions to Air Quality Figures (June 2014)	Not affected
Technical Memorandum: Assessment of SO_2 and NO_2 Emissions using US EPA Standards (June 2014)	Not affected
Technical Memorandum: Ambient Air Quality Predictions (June 2014)	Not affected
Responses to the Working Group (June 2014)	Not affected

6.1 PROJECT EFFECTS ASSESSMENT UPDATE

6.1.1 Baseline Conditions

The baseline conditions described in the EIS and the Technical Memorandum: *Ambient Air Quality Predictions* submitted in June 2014 continue to apply to the project changes. The marine terminal design mitigation results in the relocation of the marine terminal berth by about 510 m from the location described in the EIS; however, the ambient air quality conditions presented in the EIS and the subsequent Technical Memorandum: *Ambient Air Quality Predictions* submitted in June 2014 are considered to be representative of the local and regional assessment area including the new marine terminal berth location. In the absence of any nearby emitting source, the baseline air quality variation is insubstantial over short distances.

6.1.2 Effects Assessment

Project criteria air contaminant (CAC) emissions will result in adverse effects on air quality. The potential effect addressed in the air quality assessment is the “increase of criteria air contaminant (CAC) concentrations” due to project air emissions.

6.1.2.1 Construction Phase

The marine terminal design mitigation will eliminate air emissions from dredging equipment at the marine terminal. As described in the EIS, dredging was planned to occur at the site of the materials off-loading facility (MOF) and at the marine terminal berth. The marine terminal design mitigation eliminates dredging at the marine terminal and reduces the dredging activity from approximately 27 months (MOF and marine terminal berth) to 6 months (MOF only). Table 6-2 compares the total estimated land and marine CAC emissions in tonnes per year (t/y) presented in the EIS to total estimated CAC emissions after the marine terminal design mitigation. Sulfur dioxide (SO_2) emissions from marine activities are reduced by as much as 83% from reducing the dredging activities originally presented in the EIS.

Table 6-2 Changes in Estimated CAC Emissions from Land and Marine Project Construction Activities due to the Marine Terminal Design Mitigation

Construction Period		CAC Emissions (t/y)					
		SO_2	NO_X	CO	PM_{10}	$PM_{2.5}$	VOC
Year 1	EIS	2.55	150	152	8.59	8.24	23.0
	EIS Addendum	2.55	150	152	8.59	8.24	23.0
	Amount of decrease in emissions	**0**	**0**	**0**	**0**	**0**	**0**
	Percent decrease in emissions	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Year 2 to year 5	EIS	5.75	83.2	84.5	4.91	4.72	11.1
	EIS Addendum	0.97	58.1	66.1	3.80	3.65	10.1
	Amount of decrease in emissions	4.78	25.0	18.4	1.10	1.07	0.99
	Percent decrease in emissions	**83%**	**30%**	**22%**	**22%**	**23%**	**9%**

NOTES
SO_2 = sulfur dioxide; NO_X = nitrogen oxides; CO = carbon monoxide; PM_{10} = particulate matter less than 10 microns; $PM_{2.5}$ = particulate matter less than 2.5 microns; VOC = volatile organic compounds

6.1.2.2 Operations Phase

Air emission estimates from marine vessels [liquefied natural gas (LNG) carriers and tugboats] at the terminal during operations will be the same as presented in the EIS. Effects of the marine terminal design mitigation on the air quality assessment findings during operations will be negligible overall.

PNW LNG will allow LNG carriers with engines that are not nitrogen oxides (NO_X) Tier III compliant to berth at the marine terminal. Therefore PNW LNG has recalculated the emissions from LNG carriers to reflect the worst case emissions scenario by removing the NO_X Tier III adjustment factor used in the EIS. The analysis presented in the EIS assumed NO_X Tier III compliance for all ships berthing at the marine terminal. This update resulted in a 9.1% increase in the annual total NOX emissions from the Project during operations. Recalculation details are presented in Section 6.3.1. Since the response to the federal government Information Request #3 affects the information presented in the EIS, the updates are incorporated into this EIS Addendum.

Maximum predicted annual, 24-hour, and 1-hour ground-level nitrogen dioxide (NO_2) concentrations reported in the EIS and the subsequent Technical Memorandum: *Assessment of SO_2 and NO_2 Emissions using US EPA Standards* submitted in June 2014 are summarized in Table 6-7. All predictions are below the applicable ambient air quality objectives (AAQO). If predicted project NO_X emissions increase by 9.1%, the maximum predicted NO_2 concentrations will still remain below the applicable objectives for all modelled cases. An increase of 9.1% in the project total NO_X emissions will have no impact on the Application case and the cumulative effects assessment (CEA) case concentration predictions (see Section 6.3.1 for the details of the analyses). This update does not account for the fact that not all NO_X emitted will become NO_2, and as such, the concentrations at the maximum point of impingement will not increase as much as the increased estimate of NO_X emissions from LNG carriers.

6.1.2.3 Characterization of Residual Effects

There will be a considerable reduction in marine-based CAC emissions during construction due to substantially reduced dredging activities. These project changes, while reducing the adverse effects, do not change the characterization of residual effects (i.e., context, magnitude, extent, duration, frequency, reversibility) or predicted significance of those effects (i.e., remains not significant) (Table 6-10).

There will be an increase in NO_X emissions from LNG carriers during project operations as a result of changes to estimate assumptions requested during EIS review. Emission estimates from all other project activities remained unchanged. Updated predicted ground-level NO_2 concentrations associated with the project-alone case are well below applicable AAQO. There are no changes to the characterization of the project-alone residual effects for air quality from the EIS (see Table 6-10).

6.2 CUMULATIVE EFFECTS ASSESSMENT UPDATE

The cumulative effects assessment provided in the EIS was reviewed with respect to the marine terminal design mitigation, location of the accommodation camp, and additional information requests related specifically to the cumulative effects assessment.

6.2.1 Construction Phase

The change in the location of the accommodation camp will require the transportation of workers from the camp to the Lelu Island worksite. Based on the maximum peak number of construction workers in the camp (4,500 workers per day for a period of 6 months), assuming 2 shift changes per day, and an average of 45 passengers per shuttle, traffic on Skeena Drive associated with camp relocation could amount to 200 additional vehicle movements (or 100 shuttle round trips) per day. Based on the average number of construction workers in the camp (2,560 workers per day over 46 month life cycle of the camp), assuming 2 shift changes per day, and an average of 45 seats per shuttle, traffic on Skeena Drive associated with camp relocation could amount to 114 additional vehicle movements (or 57 shuttle round trips) per day. The 2012 annual average daily traffic on Skeena Drive was approximately 1,498 vehicles per day, down from an average of 3,305 vehicles per day in 1995. With the expected traffic increase due to the Project, the annual average daily traffic on Skeena Drive will likely be less than the 1995 historic traffic volumes.

Estimated air emissions associated with worker transportation at peak and average workforce are provided in Table 6-3. The estimates assume transportation buses will rely on low-sulphur diesel for fuel. The estimates also assume that the total distance travelled per round trip is 20 km, with each shuttle travelling at a speed of 50 km per hour. Table 6-3 compares the average annual shuttle emissions to the revised PNW LNG annual air emission estimates for construction activities occurring between year 2 and year 5 (excluding dredging). Table 6-3 also compares annual shuttle emissions to project emissions at full build-out. Please note that the shuttle emissions during construction are not expected to overlap temporally and therefore cumulatively, with project emissions during operations at full build-out (three trains). The contribution of air emissions from worker transportation will be low compared to air emissions associated with the remaining PNW LNG construction activities.

Table 6-3 Estimated Air Emissions Associated with Shuttle Transport at Peak and Average PNW LNG Construction Workforce

Parameter	Units	SO_2	NO_X	CO	PM_{10}	$PM_{2.5}$	VOC
Urban diesel bus emission factor [1]	g/mile	- [3]	14.7	3.38	0.30	0.27	0.35
Monthly emissions at peak workload [2]	kg/month	2.52 [3]	606	139	12.2	11.3	14.3
Monthly emissions at average workload [4]	kg/month	1.34 [3]	323	74.0	6.51	6.01	7.65
Average annual shuttle emissions	kg/year	15.8 [3]	3,803	871	76.6	70.7	90.1
Year 2 – 5 PNW LNG construction total emissions (land-based and marine-based, no shuttle)	kg/year	971	58,143	60,066	3,804	3,651	10,065
Operations emissions at full build-out	kg/year	172,000	4,400,000	4,179,000	285,000	284,000	128,000

NOTES

[1] NO_X, CO, PM_{10}, $PM_{2.5}$ and VOC emission factors based on national average data representing the in-use urban and school bus fleet as of July 2008 (US EPA 2008).

[2] Peak workforce assumed 4,800 workers at the camp for a period of 6 months.

[3] SO_X emissions calculated assuming fuel consumption rate of 149.25 litre/100 km (Yang et al. 2012), 15 milligram per kilogram sulphur content, and 0.85 grams per litre diesel fuel density.

[4] Average workforce assumed 2,560 workers at the camp over the 46 month life cycle of the camp.

Units: g = grams; kg = kilograms

Changes in the construction activities and schedule for the Project have not affected the outcomes of the cumulative effects assessment for air quality. Conclusions on significance of cumulative effects on air quality are based on effects occurring during operations; therefore, changes in the construction activities and schedule do not affect these conclusions.

6.2.2 Operations Phase

The Application and Cumulative Effects Assessment (CEA) model cases include air emissions associated with the operations phase and reflect worst-case realistic conditions. In light of changes to the predicted ambient air quality concentrations (see Section 6.3.1), and given that British Columbia (BC) is moving towards adopting 1-hour SO_2 and NO_2 AAQO in line with those defined by the United States Environmental Protection Agency (US EPA) national ambient air quality standards (NAAQS) (see Table 6-4 and Table 6-5). The dispersion modelling predictions are compared to the US EPA NAAQS for 1-hour NO_2 and 1-hour SO_2 [based on direction from BC Ministry of Environment (BC MOE)]. Applicable AAQO for other averaging periods reflect the most stringent BC or Canada objectives at 100th percentile, unless otherwise stated.

Table 6-4 Maximum Predicted Concentrations for the Application Case (Table 6-14 from the EIS)

Contaminant	Averaging Period	Application Case Maximum Predicted Concentrations (µg/m^3)	Applicable AAQO (µg/m^3)
SO_2	1-hour	34 (33 [1]) [2]	200 [2]
	3-hour	26 (27 [1])	375 [3]
	24-hour	7.7 (7.7 [1])	150 [3]
	Annual	0.9 (1.0 [1])	25 [3]
NO_2	1-hour	80 [3]	188 [3]
	24-hour	101	200 [3]
	Annual	4.1	60 [3]
CO	1-hour	303	14,300 [3]
	8-hour	142	5,500 [3]
PM_{10}	24-hour	32	50 [3]
	Annual	3.4	-
$PM_{2.5}$	24-hour	10	25 [5]
	Annual	1.9	8 [3]

NOTES
[1] Values in brackets are tree-top concentrations predicted at 15 m flag pole receptor heights.
[2] The US EPA metric for SO_2 references the annual 99th percentile value of daily 1-hour maxima averaged over 3 consecutive years.
[3] Metrics for the most stringent existing BC or Canada AAQO reference the maximum (100th percentile) predicted concentrations.
[4] The US EPA metric for NO_2 references the annual 98th percentile value of daily 1-hour maxima, averaged over 3 consecutive years.
[5] The BC metric for predicted $PM_{2.5}$ concentrations references the 24-hour 98th percentile value averaged over 1 year.
"-" means "not applicable".
µg/m^3 = micrograms per cubic metre.

Updated maximum predicted concentrations associated with the CEA case are provided in Table 6-5.

Table 6-5 Maximum Predicted Concentrations Associated with the CEA Case (Table 6-16 from the EIS)

Contaminant	Averaging Period	CEA Maximum Predicted Concentrations ($\mu g/m^3$)	Applicable AAQO ($\mu g/m^3$)
SO_2	1-hour	89 (99 [1]) [2]	200 [2]
	3-hour	81 (83 [1])	375 [3]
	24-hour	31 (33 [1])	150 [3]
	Annual	2.9 (3.1 [1])	25 [3]
NO_2	1-hour	123 [3]	188 [3]
	24-hour	132	200 [3]
	Annual	8.7	60 [3]
CO	1-hour	339	14,300 [3]
	8-hour	154	5,500 [3]
PM_{10}	24-hour	32	50 [3]
	Annual	3.7	-
$PM_{2.5}$	24-hour	11 [5]	25 [5]
	Annual	2.1	8 [3]

NOTES
[1] Values in brackets are tree-top concentrations predicted at 15 m flag pole receptor heights.
[2] The US EPA metric for SO_2 references the annual 99th percentile value of daily 1-hour maxima averaged over 3 consecutive years.
[3] Metrics for the most stringent existing BC or Canada AAQO reference the maximum (100th percentile) predicted concentrations.
[4] The US EPA metric for NO_2 references the annual 98th percentile value of daily 1-hour maxima, averaged over 3 consecutive years.
[5] The BC metric for predicted $PM_{2.5}$ concentrations references the 24-hour 98th percentile value averaged over 1 year.
"-" means "not applicable".

Since all predicted concentrations associated with the CEA case are well below the applicable AAQO, cumulative effects including project operations are assessed as not significant. A summary of cumulative residual environmental effects on air quality is presented in Table 6-10. There are no changes to the assessment of cumulative effects due to the project changes.

6.3 RESPONSES TO THE OUTSTANDING INFORMATION REQUESTS

6.3.1 Air Quality Information Request #3

6.3.1.1 Government of Canada – Outstanding Information

Confirm that the Project will only allow NO_X Tier III (or equivalent) ships to berth at the marine terminal, or conduct a recalculation of the NO_X emission from LNG carriers for the worst case scenario, i.e., without this adjustment factor.

6.3.1.2 Response

The analysis presented in the EIS assumed NO_X Tier III compliance. The Project will allow ships with engines that are not NO_X Tier III compliant to berth at the marine terminal. Therefore PNW LNG has recalculated the emissions from LNG carriers to reflect the worst case emissions scenario by removing the NO_X Tier III adjustment factor used in the EIS.

MARPOL Annex VI Regulation 13 provides for progressive reductions in global marine NO_X emissions by implementing a tiered system for marine diesel engines installed on ocean-going vessels. There are three tiers of allowable diesel engine NO_X emissions which are a function of the ship construction date. Marine diesel engines installed on a ship constructed on or after January 1, 2011 must comply with the Tier II standard. Marine diesel engines installed on a ship constructed on or after 1 January 2016 will be required to comply with the more stringent Tier III NOx standard, when operated in a designated NO_X Emission Control Areas (ECA). The Prince Rupert Port Authority area is located within the North American ECA. Engines installed before 2000 (Tier I) or from 2011-2015 (Tier II), will be "grandfathered" based on Tier limits at the date of commissioning. During the project start-up years, it should be assumed that most of the LNG carriers will not be Tier III compliant. However, the visits by non-Tier III compliant vessels should lapse sometime within the life of the Project.

The emission estimates presented in the Air Quality Technical Data Report (TDR) (Appendix C of the EIS) assumed the NO_X Tier II to Tier III adjustment factor of 0.6 for main engines and 0.58 for auxiliary engines (ICF International 2009). The assumption was also made that marine gas oil was always the fuel of choice. When the NO_X Tier III adjustment (i.e., reduction) factor is removed from the calculation, the estimate of average annual LNG carrier emissions increases from 518 t/y to 885 t/y NO_X. This increases the total predicted NOx emissions during project operations from 4,033 t/y to 4,400 t/y (or by 9.1%). The average annual NO_X emissions with and without the NO_X Tier III adjustment factor are summarized in Table 6-6. This assessment update assumes the 9.1% increase represents the potential worst-case scenario for project emissions at full build-out. Marine gas oil fuelled LNG carriers are expected to be replaced with newer LNG carriers relying on either boil-off gas, marine gas oil, or a hybrid of both. This will result in a gradual decrease in NO_X emissions over the life of the Project.

About 2% of the average annual project operations emissions are from tugboat activities. The NO_X emission total from four tugboats deployed during the LNG carrier visits is about 82 t/y. Tugboat emission estimates reflect infield testing and manufacturer specifications. Tugboats are also assumed to be constructed prior to the Tier III implementation date; therefore, the tugboat emission total reflects worst-case scenario without the NO_X adjustment factor and a correction to the tugboat NO_X emission estimates is not required. Tugboat emission input into dispersion modelling includes 25% of total tugboat emissions generated during each 37 km voyage between the pilot station at Triple Island and the PNW LNG marine terminal. The 25% adjustment accounts for the fact that tugboats will escort LNG carriers over a shorter distance of 6 km (each way) between Kinahan Island and the PNW LNG marine terminal.

Table 6-6 Average Annual NOx Emissions with and without the Tier II to Tier III Adjustment Factor (0.6)

Operations Emission Source		Average Annual NO_X Emission Rate (t/y) with Tier III Adjustment Factor [3]	Average Annual NO_X Emission Rate (t/y) without Tier III Adjustment Factor	% Increase over the EIS estimates
Marine-based	LNG carriers [1]	518	885	71
	Tugboats [2]	82	82	none
Land-based		3,433	3,433	none
Total Operations		**4,033**	**4,400**	**9.1**

NOTES:
[1] Emission estimates assumes all LNG carriers are Q-Flex size as this is the largest carrier expected to use the marine terminal.
[2] Tugboat emission estimates are based on infield testing and manufacturer specifications.
[3] Long-term average annual emission estimates are provided in Table 19 and Table 25 of the Air Quality Technical Data Report.

Maximum predicted annual, 24-hour, and 1-hour ground-level NO_2 concentrations reported in the EIS and the subsequent Technical Memorandum: *Assessment of SO_2 and NO_2 Emissions using US EPA Standards* submitted in June 2014 are summarized in Table 6-7. All predictions are below the applicable AAQO (BC MOE 2013, US EPA 2010). If predicted project NO_X emissions increase by 9.1 %, the maximum predicted NO_2 concentrations will still be well below the applicable objectives for all modelled cases. For example, in the project-alone case, an increase of 9.1 % in project NO_X emissions will increase the maximum predicted annual, 24-hour, and 1-hour NO_2 concentrations to approximately 2.6, 56, and 80 micrograms per cubic metre ($\mu g/m^3$), respectively.

Table 6-7 Maximum Predicted NO2 Ground-Level Concentrations in Comparison to Applicable Ambient Air Quality Objectives

Modelling Case	Maximum Predicted NO_2 Concentration ($\mu g/m^3$)		
	Annual [1]	24-Hour	1-Hour [3]
Baseline	3.4	93	68
Project-alone	2.4	51	73
Project-alone plus 9.1% increase in project emissions	2.6	56	80
Application	3.8	93	73
Application plus 9.1 % increase in project emissions	4.1	101	80
Cumulative Effects Assessment	8.0	121	113
Cumulative Effects Assessment plus 9.1 % increase in project emissions	8.7	132	123
Applicable AAQO	**60** [2]	**200** [2]	**188** [3]

NOTES:
[1] Concentrations reported in Tables 6-6, 6-10, 6-14, and 6-16 of the EIS.
[2] Metrics for the most stringent existing BC or Canada AAQO reference the maximum (100th percentile) predicted concentrations.
[3] The US EPA metric for NO_2 references the annual 98th percentile value of daily 1-hour maxima, averaged over 3 consecutive years.

In the project-alone and Application case, the maximum NO_2 point of impingement (i.e., absolute highest concentration outside the project boundary) is observed at or near the PNW LNG facility on Lelu Island. Since the maximum NO_2 point of impingement in these two cases is close to the project development area, it is reasonable to assume that a 9.1% increase in total project emissions will result in a 9.1% increase in predicted maximum NO_2 concentrations.

In the Baseline and CEA cases, the respective maximum NO_2 points of impingement occur on the east side of Digby Island about 10 km northwest of the Project. These points of impingement are predominantly attributed to emissions from existing sources (e.g., ferries, bulk carrier vessels, and tugs) or other reasonably foreseeable projects (e.g., Fairview phase II) within the assessment area. However, as a worst-case approach, this update assumes that a 9.1% increase in project NO_X emissions increases NO_2 concentrations linearly in the CEA case. A 9.1% increase in project NO_X emissions will increase the maximum predicted annual, 24-hour, and 1-hour NO_2 concentrations to approximately 8.7, 132, and 188 $\mu g/m^3$, respectively. Even with this worst-case approach, all predicted maximum NO_2 concentrations for CEA case are well below applicable AAQO, assuming 100% conversion of NO_X to NO_2. This conversion is a function of atmospheric chemical transformations. As such, the increase in predicted ground-level NO_2 concentrations reported in this EIS Addendum is likely an overestimate.

Based on the results of this analysis, it is reasonable to conclude that an increase of about 9.1% to the project annual average NO_X emissions will not change the assessment outcome or the determination of potential effects. For this reason, the potential effects on air quality are predicted to be not significant.

6.3.2 Air Quality Information Request #9

6.3.2.1 Government of Canada – Outstanding Information

Provide a rationale as to why berth emissions were not included in the annual emissions average, or provide an annual emissions average that includes berth emissions.

6.3.2.2 Response

The air quality assessment presented in the EIS included marine-based emissions from LNG carriers and tugboats maneuvering in and out of the LNG carrier berth and while hotelling or on standby. An error was identified in Table 4-10 of the Air Quality TDR (Appendix C of the EIS). Numbers were incorrectly added to the table; however, this did not affect the accuracy of the calculation. Table 6-8 below includes the correction to the information presented in Table 4-10 of the EIS.

Table 6-8 Short-Term and Long-Term Emission Estimates for two LNG Carriers (Table 4-10 of Appendix C of the EIS)

Emission Parameters	Short-Term Scenario (Hourly/Daily)			Long-Term Scenario (Annual)			
	Main Engine RSZ [d]	Auxiliary RSZ [d]	Auxiliary Hotel	Main Engine RSZ [d]	Auxiliary RSZ [d]	Auxiliary Maneuver	Auxiliary Hotel
Load Factor (%)	0.22	0.28	0.26	0.22	0.28	0.33	0.26
Engine Power [kilowatt (kW)]	37,320	17,500	17,500	37,320	17,500	17,500	17,500
Reliquefaction Plant (kW) – Ballast	-	1,500	3,000	-	1,500	1,500	3,000

Emission Parameters	Short-Term Scenario (Hourly/Daily)			Long-Term Scenario (Annual)			
	Main Engine RSZ [d]	Auxiliary RSZ [d]	Auxiliary Hotel	Main Engine RSZ [d]	Auxiliary RSZ [d]	Auxiliary Maneuver	Auxiliary Hotel
Reliquefaction Plant (kW) – Laden	-	6,000	-	-	6,000	6,000	-
Fuel Sulphur Content (%)[a]	0.10%	0.10%	0.10%	0.10%	0.10%	0.10%	0.10%
ECA NOx Control adjustment factor (2020)[b]	0.60	0.58	0.58	0.60	0.58	0.58	0.58
Total LNG Vessels	1	1	1	350	350	350	350
Total Time in Port per LNG Carrier							
Total RSZ Time (hours/year)	1	1	-	6	6	-	-
25% of RSZ time (hours/year)	-	-	-	1.5	1.5	~~2~~ -	-
Total Maneuvering Time (hours/year)	-	-	-	-	-	2	~~26~~ -
Total Hotelling Time (hours/year)	-	-	1	-	-	-	26
Emission Factors (ICF 2009)							
SO_2 (g/kW-hr)[c]	0.36	0.42	0.42	0.36	0.42	0.42	0.42
NO_x (g/kW-hr)[c]	17.00	13.90	13.90	17.00	13.90	13.90	13.90
CO (g/kW-hr)[c]	1.40	1.10	1.10	1.40	1.10	1.10	1.10
PM-10 (g/kW-hr)[c]	0.19	0.18	0.18	0.19	0.18	0.18	0.18
PM-2.5 (g/kW-hr)[c]	0.17	0.17	0.17	0.17	0.17	0.17	0.17
HC (g/kW-hr)[c]	0.60	0.40	0.40	0.60	0.40	0.40	0.40
CO_2 (g/kW-hr)[c]	588.79	690.71	690.71	588.79	690.71	690.71	690.71
CH_4 (as CO_{2e} g/kW-hr)[c]	0.13	0.084	0.084	0.13	0.084	0.084	0.084
N_2O (as CO_{2e} g/kW-hr)[c]	9.61	9.61	9.610	9.61	9.61	9.610	9.610
Emission Rates							
SO_2 (kg/hr)	3.02	2.76	2.57	0.18	0.15	0.24	2.41
NOx (kg/hr as NO_2)	85.00	53.43	49.6	5.09	2.90	4.55	46.6
CO (kg/hr)	11.75	7.24	6.72	0.70	0.39	0.62	6.31
PM-10 (kg/hr)	1.59	1.18	1.10	0.10	0.06	0.10	1.03
PM-2.5 (kg/hr)	1.43	1.12	1.04	0.09	0.06	0.10	0.98
VOC (kg/hr)	5.04	2.63	2.44	0.30	0.14	0.22	2.30
CO_{2e} (kg/hr)	5,023	4167	4279	301	250	392	4,020
CO_2 (kg/hr)	4,941	4110	4220	296	246	387	3,964
CH_4 (as CO_{2e} kg/hr)	1.06	0.50	0.51	0.06	0.03	0.05	0.48
N_2O (as CO_{2e} kg/hr)	80.7	57.18	58.72	4.83	3.43	5.39	55.2

NOTES

[a] Fuel sulphur content defined per MARPOL (MARPOL 2008).

[b] MARPOL NO_x adjustment factor applies to marine emissions within the new ECA (ICF 2009).

[c] Emission factors defined by US EPA (ICF 2009) for Slow Speed Diesel main engines and auxiliary engines using low-sulphur marine gas oil (0.1% sulphur content).

[d] RSZ = restricted speed zone.

CO_{2e} = carbon dioxide equivalent.

The annual average emission rates (in grams per second) for both the LNG carriers and assist tugboats are shown in Table 19 of the Air Quality TDR (Appendix C of the EIS); a summary of the emissions from the same marine-based operations are then shown in Table 20. Table 6-9 provides the annual marine-based emissions estimates (in tonnes) calculated using the information from Table 19 and Table 20 of the Air Quality TDR.

Please note that the NO_X emission totals in the EIS (and in Table 6-9) included the application of the NO_X Tier III adjustment factor (see response to the request for Outstanding Information #3 above). The estimate for NO_X emissions without the adjustment factor is 885 t/y.

Table 6-9 Annual Emissions (Tonnes) for the Marine-Based Operations

Source	SO_2	NOx	CO	PM_{10}	$PM_{2.5}$	VOC
LNG carriers	26	518 [1]	70	11	11	26
Tugboats	1.5	82	4.3	0.4	0.3	2.3

NOTES:
[1] This emission estimate uses the rates as presented in the EIS, which included the NOx Tier III adjustment factor. Without the adjustment factor, the estimate of NOx emissions is 885 tonnes.

6.4 MITIGATION

6.4.1 Changes to Mitigation Measures Presented in the EIS

Based on the project changes and the feedback received during the environmental assessment process, the set of mitigation measures originally presented in the EIS to address potential effects to air quality are considered to be sufficient. There are no changes to the mitigation measures presented in the EIS.

6.4.2 Complete List of Current Mitigation Measures

All of the technically and economically-feasible mitigation measures currently being presented by PNW LNG to address potential effects to air quality are listed below. By implementing this full set of mitigation measures, PNW LNG is confident that the Project will not result in significant adverse effects to air quality.

- Best achievable technology will be incorporated into project designs to reduce air emissions. Control technologies will focus on managing NO_X emissions. $PM_{2.5}$ emissions are expected to be managed via the use of smokeless flare technology. CO and hydrocarbon emissions (e.g., VOCs) will be reduced by optimizing combustion. Management of GHG emissions is discussed separately (see Section 7 of the EIS)
- Thermal oxidizers will be used to oxidize hydrogen sulfide, to achieve negligible hydrogen sulfide emission effects, to oxidize VOCs, and to vaporize any hydrocarbon solids in the waste gas stream before venting
- Best management practices listed in Appendix J.4
- For the duration of project operations, a natural gas leak detection system will be implemented
- LNG carriers and assist tugs will use low-sulfur fuel in compliance with applicable marine emission standards (MARPOL 2008)
- Dust associated with the use of facility roads will be reduced by using dust suppressants and surface paving

- Vehicle and off-road equipment will use low-sulfur fuel when available, and will undergo regular engine tuning and maintenance
- Vehicle idling times during all project phases will be kept to a minimum.

6.5 CONCLUSION

Project changes were assessed for potential effects, including cumulative effects, on air quality. Based on this assessment there are no changes to the potential effects, mitigation measures, or the residual adverse effects that were identified in the EIS. The characterization of the residual adverse effects (i.e., context, magnitude, extent, duration, frequency, reversibility) and the determination of significance of those effects remain valid no changes are warranted (seeTable 6-10). Cumulative effects on air quality were reassessed in light of project changes and the requested additional information. The conclusions of the cumulative effects assessment on air quality do not change from those presented in the EIS (see Table 6-11).

Similarly, the outstanding information provided in response to the information requests does not change the conclusions of the assessment. The revised emissions estimates include a recalculation of NO_X emissions from LNG carriers. This results in a 9.1% increase in project NO_X emissions as a worst-case scenario. This change, while increasing the predicted NO_X emissions does not change the characterization of residual effects (i.e., context, magnitude, extent, duration, frequency, reversibility) or predicted significance of these effects (i.e., remains not significant) because all predicted CAC concentrations are well below the significance threshold of applicable AAQO.

Based on the findings of the updated Air Quality assessment, the conclusions of the assessment of effects on air quality do not change from those presented in the EIS.

Table 6-10 Characterization of Residual Effects for Air Quality

Project Phase	Mitigation Measures	Residual Effects Characterization						Likelihood	Significance	Confidence	Follow-up and Monitoring
		Context	Magnitude	Extent	Duration	Reversibility	Frequency				
Increase in Criteria Air Contaminant Concentrations											
Construction	• Best achievable technology • Best management practices • Natural gas leak detection system • Thermal oxidizer operation • Dust suppression • Equipment maintenance and low sulfur fuel • Vehicle idling restrictions • Adherence to the International Convention for the Prevention of Pollution from Ships (MARPOL).	H	L	L	ST	R	S	H	N	H	**Follow-up Programs:** • Aquatic Acidification and Eutrophication • Terrestrial Acidification and Eutrophication **Monitoring** • Compliance monitoring for permits
Operations		H	L/M	L	MT	R	C				
Decommissioning		H	L	L	ST	R	S				
Residual effects for all phases		H	L	L	MT	R	C				

<table>
<tr><th rowspan="2">Project Phase</th><th rowspan="2">Mitigation Measures</th><th colspan="6">Residual Effects Characterization</th><th rowspan="2">Likelihood</th><th rowspan="2">Significance</th><th rowspan="2">Confidence</th><th rowspan="2">Follow-up and Monitoring</th></tr>
<tr><th>Context</th><th>Magnitude</th><th>Extent</th><th>Duration</th><th>Reversibility</th><th>Frequency</th></tr>
<tr>
<td>KEY
CONTEXT:
L = Low resilience: occurs in a fragile ecosystem and/or highly disturbed environment
M = Moderate resilience: occurs in a stable ecosystem and/or moderately disturbed environment
H = High resilience: occurs in viable ecosystem and/or undisturbed environment</td>
<td colspan="2">MAGNITUDE:
N = Negligible: No measurable adverse effect anticipated
L = Low: Residual effect is detectable but within normal variability of baseline
M = Moderate: Residual effect will cause an increase relative to baseline but is within regulatory limits and objectives.
H = High: Residual effect occurs that would singly or as a substantial contribution in combination with other sources cause exceedances of objectives or standards beyond the project boundaries.

EXTENT:
LAA = residual effects extend beyond the activity area but remain within the LAA
RAA = residual effects extend to RAA (watershed/sub-regional level)</td>
<td colspan="5">DURATION:
ST Short term: Residual effects are measurable for less than 4 years.
MT Medium term: Residual effects are measurable for 4 to 30 years.
LT Long term: Residual effects are measurable for greater than 30 years.

FREQUENCY:
O Occurs once.
S Occurs sporadically at irregular intervals.
R Occurs on a regular basis and at regular intervals.
C Continuous.

REVERSIBILITY:
R = Reversible
I = Irreversible</td>
<td colspan="4">LIKELIHOOD OF RESIDUAL EFFECT:
Based on professional judgment.
L = Low probability of occurrence
M = Medium probability of occurrence
H = High probability of occurrence

SIGNIFICANCE:
S = Significant
N = Not Significant

CONFIDENCE AND RISK
Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation, and assumptions made.
L = Low level of confidence
M = Moderate level of confidence
H = High level of confidence</td>
</tr>
</table>

Table 6-11 Summary of Cumulative Residual Effects on Air Quality

Cumulative Environmental Effect and Project Contribution		Other Projects, Activities and Actions	Mitigation and Compensation Measures	Residual Cumulative Effects Characterization						Likelihood	Significance	Prediction Confidence	Follow-up and Monitoring Programs
				Context	Magnitude	Extent	Duration	Reversibility	Frequency				
Increase in Criteria Air Contaminant Concentrations • Exceeding the BC Ambient Air Quality Objectives (BC AAQO), National Ambient Air Quality Objectives (NAAQO) or US EPA National Ambient Air Quality Standards (NAAQS) can negatively affect human and ecological health).	**Cumulative effects with Project (CEA case in RAA)** • All CAC maxima for the CEA case are below applicable objectives.	**Operations:** • LNG facility and supporting infrastructure on Lelu Island • Marine terminal use and shipping. **Other Projects:** • Canpotex Potash Export Terminal • CN Rail Line • Fairview Container Terminal Phase I and II • Northland Cruise Terminal • Prince Rupert LNG Facility • Prince Rupert Ferry Terminal • Prince Rupert Grain Limited • Ridley Terminals Inc.	See Table 6-11 Characterization of Residual Effects for Air Quality	M	M	RAA	MT	R	C	H	N	H	**Follow-up Programs:** • Aquatic Acidification and Eutrophication • Terrestrial Acidification and Eutrophication **Monitoring** Compliance monitoring for permits
	Project contribution to existing cumulative effect (Application case in RAA) • All CAC maxima for the Application case are below applicable objectives.	**Construction:** • Site preparation (land-based) • Onshore construction • Vehicle traffic • Marine construction and dredging • Disposal at sea • Operational testing and commissioning • Site clean-up and reclamation • Transportation of workers between the accommodation camp and Lelu Island. **Operations:** • LNG facility and supporting infrastructure on Lelu Island • Marine terminal use and shipping. **Decommissioning:** • Dismantling facility and supporting Infrastructure • Dismantling of marine terminal • Site cleanup and reclamation.	See Table 6-11 Characterization of Residual Effects for Air Quality	H	L	LAA	MT	R	C	H	N	H	**Follow-up Programs:** • Aquatic Acidification and Eutrophication • Terrestrial Acidification and Eutrophication **Monitoring** Compliance monitoring for permits

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N = Not Significant

CONFIDENCE AND RISK: *Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation, and assumptions made.*
L = Low level of confidence
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H = High level of confidence

6.6 REFERENCES

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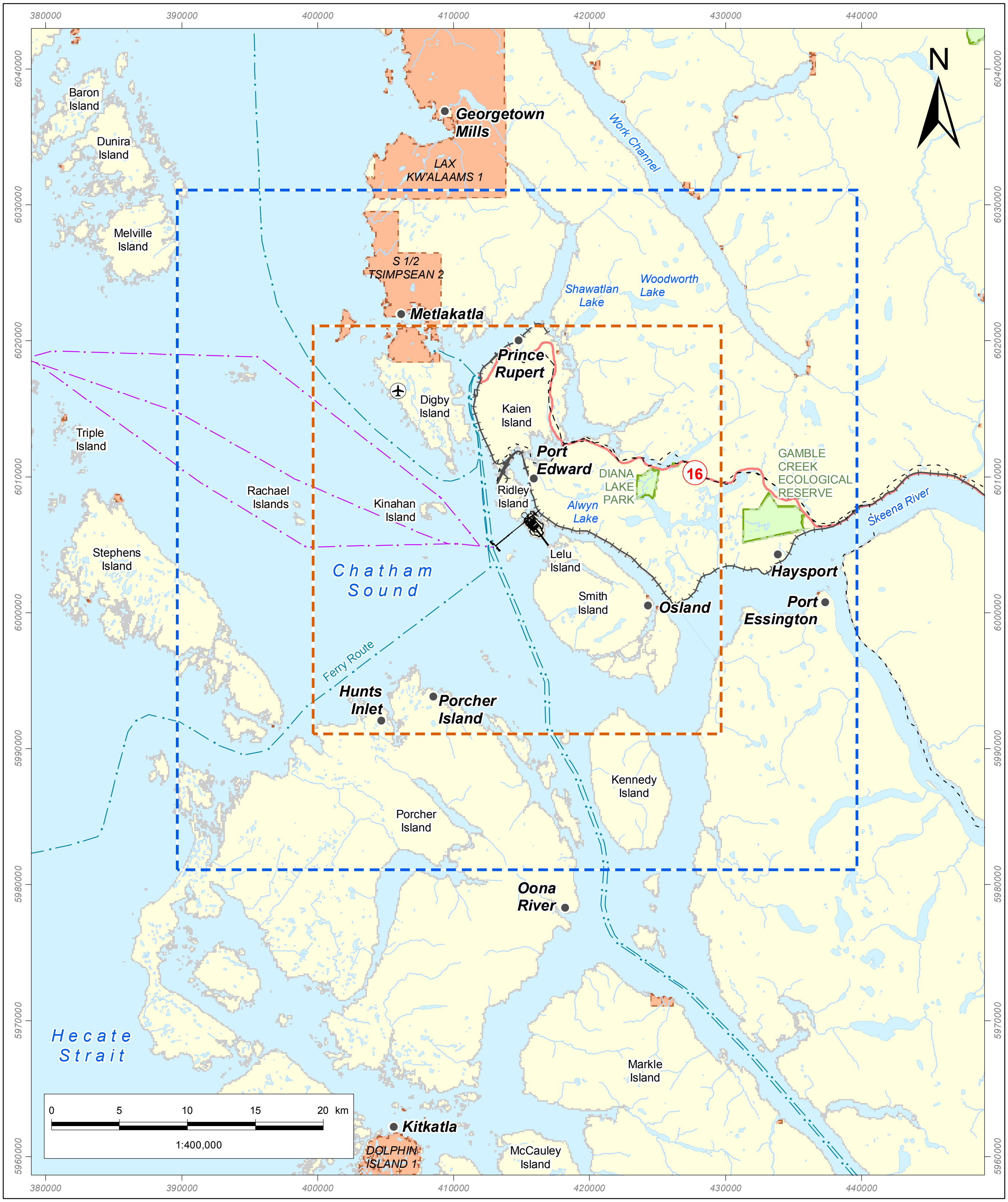
6.7 FIGURES

Please see the following pages.



Local Assessment Area
Regional Assessment Area
Potential Shipping Route
Project Component
Airport
City or Town
Electrical Power Transmission Line
Ferry Route
Highway
Railway
Watercourse
Indian Reserve
Protected Area
Waterbody

Pacific NorthWest LNG

Air Quality Local Assessment Area and Regional Assessment Area

EIS ADDENDUM

Sources: Government of British Columbia; Prince Rupert Port Authority; Government of Canada, Natural Resources Canada, Centre for Topographic Information; Progress Energy Canada Ltd.

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

DATE: 20-NOV-14	PROJECTION: UTM - ZONE 9
FIGURE ID: 123110537-420	DATUM: NAD 83
DRAWN BY: K. POLL	CHECKED BY: A. POMEROY

PREPARED BY: Stantec

PREPARED FOR: Pacific NorthWest LNG

FIGURE NO: **6-1**

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