# 6 AIR QUALITY

## 6.1 Introduction

Air Quality is a valued component (VC) because of its intrinsic importance to the health and well-being of people, wildlife, vegetation and other biota. The atmosphere is an important pathway for the transport of contaminants to the freshwater, terrestrial and human environments.

Air quality assessment findings are referenced in other assessment sections: Greenhouse Gas (GHG) Management (Section 7), Vegetation and Wetland Resources (Section 10), Freshwater Aquatic Resources (Section 12), and Human and Ecological Health (Section 19). Potential effects on the Air Quality VC from accidents and malfunctions are addressed in Section 22. Technical details supporting this air quality assessment are presented in the Air Quality Technical Data Report (TDR) (Appendix C).

## 6.2 Scope of Assessment

### 6.2.1 Regulatory and Policy Setting

This assessment is based on the requirements of the British Columbia Ministry of the Environment (BC MOE) *Guidelines for Air Quality Dispersion Modelling in British Columbia* (the Guidelines) (BC MOE 2008).

BC regulatory agencies use a variety of ambient air quality objectives (AAQOs) developed at the national and provincial level to inform decisions on the management of criteria air contaminants (CACs). These Canada and BC AAQOs provide the framework for evaluating observed or predicted air contaminant concentrations and are collectively referred to as “applicable air quality objectives” or “applicable objectives”. The air contaminants for which objectives have been established are referred to as CACs. The AAQOs are described in Section 6.2.4.2.

The Project will require a waste discharge permit under the authority of the *BC Environmental Management Act* (BC MOE 2004) to authorize emissions of CACs. The AAQOs guide permit development. Carbon dioxide ($CO_2$) emissions are not regulated by the *Environmental Management Act*; however, reporting GHG emissions will be required (see Section 7 of the EIS/Application) if the Project exceeds Canada and BC emission thresholds.

### 6.2.2 Influence of Consultation on the Assessment

Pacific NorthWest LNG Limited Partnership (PNW LNG) has consulted with the Canadian Environmental Assessment Agency, BC Environmental Assessment Office, the working group, and Aboriginal groups throughout project development and planning. The following consultation activities resulted in additional air quality issues being assessed:

- PNW LNG’s Detailed Air Quality Dispersion Modelling Plan (Stantec 2013) was delivered to BC MOE on June 26, 2013. BC MOE reviewed and approved the model plan on September 11, 2013. At the request of the BC MOE, three full years of meteorological data were included in the dispersion modelling exercise to simulate a broader range of possible meteorological conditions.

- Potential effects of acid deposition and eutrophication on marine, freshwater and vegetation resources from project emissions were added to the scope of the assessment.
- Volatile organic compounds (VOCs) emissions were added to the assessment.
- The local assessment area (LAA) was expanded to include Prince Rupert.

### 6.2.3 Selection of Potential Effects

Project CAC emissions will result in adverse effects on the atmospheric environment. The key potential effect addressed in the air quality assessment is the increase of CAC concentrations due to project air emissions.

### 6.2.4 Selection of Measurable Parameters

Measurable parameters facilitate qualitative or quantitative measurement of project and cumulative effects, and provide a means to determine the change to a VC. The measurable parameters for the air quality assessment are provided in Table 6-1.

**Table 6-1: Measurable Parameters for Air Quality**

| Effect | Measurable Parameter(s) and Units of Measurement | Notes or Rationale for Selection of the Measureable Parameter |
|---|---|---|
| Increase in criteria air contaminant (CAC) concentrations | Airborne concentrations (in μg/m$^3$) of CACs ($SO_2$, $NO_2$, CO, $PM_{10}$, $PM_{2.5}$, and $H_2S$) and VOCs<br>Increase in magnitude and spatial extent when compared with baseline concentration levels | Exceeding the BC Ambient Air Quality Objectives (BC AAQOs) and National Ambient Air Quality Objectives (NAAQO) can negatively affect human and ecological health) |

Currently no AAQOs for VOCs exist in Canada or BC. Although regulatory objectives for VOCs are not available, VOC emissions are estimated in this assessment. These emissions are quantified in the Air Quality TDR (Appendix C).

Changes to baseline ozone ($O_3$) levels are not expected. The north coast of BC is far removed from strong sources of precursor emissions (e.g., large urban areas and/or concentrated industrial activities). In BC, ozone issues are largely confined to the Lower Fraser Valley and some instances in southern BC. The incremental addition of precursor emissions attributable to the proposed Project is unlikely to alter the existing conditions meaningfully. Secondary $O_3$ formed as a result of project sources will be quickly consumed through reactions with existing nitric oxide (NO). Therefore, the effects of changes in $O_3$ concentrations are not considered further in this assessment.

#### 6.2.4.1 Substances of Concern

The following descriptions provide details about each substance of concern included in this assessment and their regulation in the context of assessment.

**Sulfur dioxide**—Sulfur dioxide ($SO_2$) is a colourless gas with a distinctive pungent sulfur odour. It is produced in combustion processes by the oxidation of sulfur compounds, such as hydrogen sulphide ($H_2S$), in fuel. At high enough concentrations, $SO_2$ can have adverse effects on plant and animal health, particularly with respect to respiratory systems. Sulfur dioxide can also be further oxidized and may combine with water to form the sulfuric acid component of “acid rain”.

Anthropogenic emissions make up approximately 95% of total global atmospheric $SO_2$ emissions. The largest anthropogenic contributor to atmospheric $SO_2$ is the industrial and utility combustion of heavy oils and coal. The oxidation of reduced sulfur compounds emitted by ocean surfaces accounts for nearly all biogenic emissions and volcanic activity accounts for much of the remainder. Motor vehicles are relatively small contributors to the $SO_2$ content of the atmosphere (Wayne 1991).

Project emissions of $SO_2$ will be from power generation, compression, and other onsite combustion processes. Small amounts of $SO_2$ emissions will result from flaring and marine activities. During normal operations, vent gases are not expected to be routed to the flares and flare emissions will be limited to combustion of pilot and purge gas only. Higher rates of $SO_2$ emissions will occur for short periods during emergency and upset flaring.

**Nitrogen oxides**—Nitrogen oxides ($NO_x$) are produced in most combustion processes and are almost entirely made up of nitric oxide (NO) and nitrogen dioxide ($NO_2$). $NO_2$ is an orange to reddish gas that is corrosive and can be toxic at high concentrations. Most $NO_2$ in the atmosphere is formed by the oxidation of NO, which is emitted directly by combustion processes, particularly those processes occurring at high temperature and pressure, such as with internal combustion engines.

Anthropogenic emissions make up approximately 93% of total global atmospheric emissions of $NO_x$. The largest anthropogenic contributor to atmospheric $NO_x$ is the combustion of fuels such as natural gas, oil, and coal. Forest fires, lightning, and anaerobic processes in soil account for nearly all biogenic emissions (Wayne 1991).

Project emissions of $NO_x$ will be from power generation, compression, and other onsite combustion processes. Small amounts of $NO_2$ emissions will result from flaring and marine activities.

**Carbon monoxide**—Carbon monoxide (CO) is a colourless, odourless gas. As a product of incomplete combustion, emission sources include fossil fuel and wood combustion. Motor vehicles, industrial processes, and forest fires are common sources. Typical concentrations in the atmosphere are 120 $\mu g/m^3$.

In the context of this Project, CO emission sources include construction equipment, power generation, compression, and other onsite combustion processes.

**Particulate matter**—Particulate matter (PM) is classified by the size of the particles. Particle size and density determine the velocity with which gravitational settling occurs and the ease with which they penetrate the human respiratory tract. Generally, large particles settle out very close to the source, while very fine particles can remain in the atmosphere for many days, travelling long distances. Inhalable particulate matter ($PM_{10}$) consists of particles with diameters less than or equal to 10 µm. Respirable particulate matter ($PM_{2.5}$) consists of very small particles with diameters less than or equal to 2.5 µm.

For the purposes of this assessment, all PM from construction vehicle exhaust and project operations are considered to be within the $PM_{2.5}$ size range. Fugitive dust emissions of the more coarse particle categories of total suspended particulate (TSP) and $PM_{10}$ were also estimated for construction activities. Emissions details can be found in the Air Quality TDR (see Appendix C).

**Hydrogen sulphide**—Hydrogen sulphide ($H_2S$) is a colourless gas. While it has a rotten egg odour at very low concentrations (e.g., less than 20 $\mu g/m^3$), at these low concentrations it does not negatively affect human health, nor does it have a substantial effect on the receiving environment.

Biogenic emissions make up approximately 96% of total global atmospheric $H_2S$ levels. Reduced sulfur compounds emitted by ocean surfaces account for nearly all biogenic emissions. The largest anthropogenic contributors to atmospheric $H_2S$ are industrial, i.e., pulp and paper mills, petroleum refiners, and heavy water manufacture (Wayne 1991).

Project-related emissions of $H_2S$ are expected to be very small. One of the main functions of the Project's processing system will be to process $H_2S$ out from the pipeline grade feed gas before venting to the atmosphere.

**Volatile Organic Compounds**—Volatile Organic Compounds (VOCs) are carbon-containing (organic) compounds that readily evaporate into the air under existing conditions. Many VOCs are of natural origin including methane ($CH_4$). Others may be potentially harmful to the environment, either directly or indirectly as a contributor to ground-level ozone formation. Project-related sources of VOCs include the operation of heavy equipment and other internal combustion engines.

#### 6.2.4.2 Ambient Air Quality Objectives

The selected measurable parameters are the CAC concentration levels and the criteria provided by the Canada and BC AAQOs are listed in Table 6-2.

The Canada ambient air quality objectives are defined as follows:

- The **maximum desirable level** is the long-term goal for air quality and provides a basis for anti-degradation policy for unpolluted parts of the country, and for the continuing development of control technology.
- The **maximum acceptable level** is intended to provide adequate protection against effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being.
- The **maximum tolerable level** denotes time-based concentrations of air contaminants beyond which, due to a diminishing margin of safety, appropriate action is required to protect the health of the general population.

The Canadian Ambient Air Quality Standards (CAAQS) for 2015 and 2020 were adopted by the Canadian Council of Ministers of the Environment (CCME) (Government of Canada 2013). The new CAAQS supersede the Canada-wide Standards for PM and $O_3$. A review of the CAAQS 2020 standards is expected in 2015.

In BC, the AAQOs are denoted as Levels A, B, and C, which are defined as follows:

- **Level A** is set as the objective for new and proposed discharges and, within the limits of best achievable technology, to existing discharges by planned staged improvements for these operations.
- **Level B** is set as the intermediate objective for all existing discharges to meet within a period of time specified by BC MOE, and as an immediate objective for existing discharges that may be increasing in quantity or altered in quality as a result of process expansion or modification.
- **Level C** is set as the immediate objective for all existing chemical and petroleum industries to reach within a minimum technically feasible period of time.

BC has announced the development of 'interim' AAQOs for $NO_2$ and $SO_2$, to be released in Q1 or Q2 2014. In the interim, they have asked that proponent's reference selected AAQO from other jurisdictions for information purposes. As best as can be determined, the value that BC wishes proponents to reference, for both $NO_2$ and $SO_2$, is 200 µg/m$^3$ for the 1-hour averaging interval. Revisions of applicable objectives for other time averaging intervals have not been communicated by the BC MOE.

**Table 6-2: Applicable Canada and BC Ambient Air Quality Objectives**

| Contaminant | Averaging Period | BC Objective (µg/m$^3$) | | | Canada Objective (µg/m$^3$) | | |
|---|---|---|---|---|---|---|---|
| | | Level A | Level B | Level C | Maximum Desirable | Maximum Acceptable | Maximum Tolerable |
| $SO_2$ | 1-hour | **450** | 900 | 900 – 1,300 | 450 | 900 | – |
| | 3-hour | **375** | 665 | – | – | – | – |
| | 24-hour | **160** | 260 | 360 | 150 | 300 | 800 |
| | Annual | **25** | 50 | 80 | 30 | 60 | – |
| $NO_2$ | 1-hour | – | – | – | – | **400** | 1,000 |
| | 24-hour | – | – | – | – | **200** | 300 |
| | Annual | – | – | – | **60** | 100 | – |
| CO | 1-hour | **14,300** | 28,000 | 35,000 | 15,000 | 35,000 | – |
| | 8-hour | **5,500** | 11,000 | 14,300 | 6,000 | 15,000 | 20,000 |
| $PM_{10}$ | 24-hour | **50** | | | – | – | – |
| $PM_{2.5}$ | 24-hour | **25**[a] | | | 28 (27)[c] | | |
| | Annual | **8** (6)[b] | | | 10 (8.8)[d] | | |
| $H_2S$[e] | 1-hour | **7** | 28 | – | – | – | – |
| | 24-hour | **3** | 6 | – | – | – | – |

**NOTES:**

[a] Based on the 98th percentile value for one year.

[b] The BC AAQO for $PM_{2.5}$ define a planning goal of 6 µg/m$^3$ (annual average) intended as a voluntary target to guide airshed planning efforts. The objective is 8 µg/m$^3$ (BC MOE 2013).

[c] The Canadian Ambient Air Quality Standards (CAAQS) are referenced to the annual 98th percentile of daily 24-hour average concentrations, averaged over three years. The first CAAQS is the standard effective in 2015; the new standard proposed for 2020 is given in brackets (Government of Canada 2013).

[d] The Canadian Ambient Air Quality Standards (CAAQS) are referenced to the 3-year average of annual average concentrations. The first CAAQS shown is the standard effective in 2015; the new standard proposed for 2020 is given in brackets (Government of Canada 2013).

[e] BC AAQO for total reduced sulfur as compounds measured as $H_2S$ (BC MOE 2013). This supersedes previous objectives specific to $H_2S$.

– No objective has been established for this category.

Values in **bold** identify the most stringent existing objectives applicable to the Project.

The BC Emission Criteria for Gas Turbines (BC MOE 1992) are currently under review. In the interim, the 1992 criteria are assumed to be applicable to this Project. For gas turbines with capacity greater than 25 MW, the 1-hour $NO_x$ and CO criteria of 48 mg/m$^3$ and 58 mg/m$^3$, respectively, apply (BC MOE 1992), with a requirement for continuous monitoring. BC MOE is proposing to replace the existing criteria. The revisions may include new limits for $NO_x$, CO, and ammonia. BC MOE considers the existing criteria as rescinded; however, in the absence of new, approved criteria, the rescinded criteria are considered to be applicable to this Project.

## 6.2.5 Boundaries

### 6.2.5.1 Temporal Boundaries

Based on the current project schedule, the temporal boundaries for each phase are:

- **Construction:** Q1 2015 – Q4 2018
- **Operations:** Q1 2019 – 2048+
- **Decommissioning:** 2048+

Site preparation is expected in the first year. Construction of Phase 1 (Train 1 and Train 2) is expected to require four years. The first shipment of LNG is planned for early 2019. Phase 2 (Train 3) will be constructed starting in 2019, pending favorable market conditions.

### 6.2.5.2 Spatial Boundaries

The Guidelines (BC MOE) provide guidance on selecting an appropriate spatial boundary for an assessment of air quality. The Guidelines specify that project and cumulative effects representing 10% of the CAC AAQOs must be present within the assessment area for the local assessment area (LAA) and regional assessment area (RAA), respectively.

For this assessment, an RAA measuring 50 km by 50 km centered on the project site (Lelu Island and the trestle) is appropriate for determining cumulative effects. Project-alone effects are focused on the 30 km by 30 km LAA centered on the project site.

Figure 6-1 illustrates the spatial boundaries for this VC.

### 6.2.5.3 Administrative and Technical Boundaries

Air quality modelling was conducted following the Guidelines (BC MOE 2008) and is consistent with the BC OGC waste discharge permit application requirements. The assessment method is summarized in the PNW LNG Detailed Air Quality Dispersion Modelling Plan (Stantec 2013).

Technical boundaries include the accuracy of datasets used as inputs to the models, and the accuracy in the skill of meteorological and dispersion models used in the assessment.

## 6.2.6 Residual Effects Description Criteria

Terms that are used to characterize residual effects on Air Quality are provided in Table 6-3.

**Table 6-3: Characterization of Residual Effects for Air Quality**

| Characterization | Description | Quantitative Measure or Definition of Qualitative Categories |
|---|---|---|
| **Characterization of Residual Effects** | | |
| Context | Refers primarily to the current and future sensitivity and resilience of the VC to change caused by the Project. Consideration of context draws heavily on the description of existing conditions of the VC, which reflect cumulative effects of other projects and activities that have been carried out, and especially information about the impact of natural and human-caused trends in the condition of the VC. (i.e., low, medium or high resilience) | **L**— Low resilience: occurs in a fragile ecosystem and/or highly disturbed environment<br>**M**— Moderate resilience: occurs in a stable ecosystem and/or moderately disturbed environment<br>**H**— High resilience: occurs in viable ecosystem and/or undisturbed environment |
| Magnitude | Refers to the expected size or severity of the residual effect. When evaluating magnitude of residual effects, considers the proportion of the VC affected within the spatial boundaries and the relative effect (i.e., negligible, low, moderate, high) | **N**— No measurable adverse residual effect<br>**L**— residual effect occurs that is detectable but is within normal variability of baseline conditions<br>**M**— residual effect occurs that would cause an increase with regard to baseline but is within regulatory limits and objectives<br>**H**— 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 | Refers to the spatial scale over which the residual effect is expected to occur (i.e., within the PDA, LAA, or RAA) | **LAA**— residual effects extend into the LAA<br>**RAA**— residual effects extend into the RAA |
| Duration | The period of time the residual effect will persist. | **Short-term**— residual effect occurs for less than four years (i.e., construction period)<br>**Medium-term**— residual effect occurs between 4 and 30 years<br>**Long-term**— residual effect persists beyond project decommissioning years |
| Reversibility | Pertains to whether or not the residual effect on the VC can be reversed once the physical work or activity causing the disturbance ceases (i.e., reversible or irreversible) | **R**— residual effect ceases when project operations cease<br>**I**— residual effect continues after project operations cease |
| Frequency | Refers to how often the residual effect occurs and is usually closely related to the frequency of the physical work or activity causing the residual effect (i.e., single event, multiple irregular events, multiple regular events, continuous) | **O**— residual effect occurs once<br>**S**— residual effect occurs at irregular intervals<br>**R** —residual effect occurs on a regular basis at regular intervals<br>**C**— residual effect occurs continuously |
| **Likelihood of Residual Effects** | | |
| Likelihood | Refers to whether or not a residual effect is likely to occur | **L**—Low probability of occurrence<br>**M**—Medium probability of occurrence<br>**H**—High probability of occurrence |

### 6.2.7 Significance Thresholds for Residual Effects

An effect on air quality would be considered significant if predicted concentrations of criteria air contaminants exceed Canada or BC applicable objectives for ambient air quality (i.e., to be high in magnitude) and are of concern relative to the geographical extent of predicted exceedances and/or their frequency of occurrence.

Significant residual effects warrant a comprehensive human health or ecological risk assessment (or both) for the affected receptors or areas.

## 6.3 Baseline Conditions

The understanding of climate and meteorological conditions within the RAA is essential in interpreting the temporal and spatial dispersion patterns of the project air emissions. The current air quality within the RAA is an aggregated effect of the emissions from both natural and anthropogenic activities and existing facilities. Information presented in this section is also found in the Air Quality TDR (Appendix C), which contains detailed climate and meteorological analyses.

In this assessment, background levels represent ambient air quality conditions based on air contaminant concentrations measured at specific monitoring stations. Baseline levels, predicted through dispersion modelling of existing air emission sources, form the basis for the subsequent dispersion model analyses. This section provides an overview of background datasets applicable to the Project. Modelling methods are presented in detail in Section 6.5.1.1 and in Appendix C. Baseline case modelling results are presented in Section 6.5.2.1.

### 6.3.1 Background Methods and Data Sources

Background climate and air quality conditions were determined from data representative of project site conditions. A meteorological analysis was performed on data recorded at the Prince Rupert Airport and the Holland Rock meteorological stations. Precipitation data was also analyzed from the Prince Rupert Mont Circ, Prince Rupert Park and Prince Rupert Shawatlans Canadian climate stations.

To fully account for all emission sources inside and outside of the RAA that have not been included in the dispersion modelling assessment, the Guidelines (BC MOE 2008) recommend adding background air quality values to the predicted concentrations. Understanding existing background conditions provides insight into any potential overlap of existing conditions with predicted project effects. The Guidelines provide the following methodology to determine the background concentration levels:

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

The background air quality is derived from measurements of the substances of concern at the nearest, most representative continuous monitoring stations near the Project. This assessment of background air quality considers measurements of $NO_2$, $SO_2$, CO and $PM_{2.5}$ at several Port Edward, Prince Rupert and Kitimat monitoring sites. Following analysis, it was determined that most monitoring data are not representative of site conditions as:

- Monitoring station records are not long-term and do not monitor all species in the Prince Rupert area
- Air quality in Kitimat is not representative of Prince Rupert
- Existing air quality varies greatly throughout the airshed as it depends on local meteorology, terrain features and proximity to sources of air emissions.

For completeness, the results of the background analysis are presented in Appendix C.

### 6.3.2 Overview of Background Conditions

#### 6.3.2.1 Climate Background

The project site is located on Lelu Island on the northwest coast of BC. Lelu Island and surrounding area is a flat, low plain that is mostly below 30 m in elevation. The area to the east consists of rugged coastal terrain rising up to 1,400 m in elevation with intermittent ocean channels and inlets. Lelu Island is adjacent to Port Edward.

The region is characterized by frequent cloud cover and substantial precipitation during the cooler winter months. Background temperatures and precipitation patterns are strongly influenced by westerly flow from the Pacific Ocean. The precipitation patterns can change abruptly when the flow changes and the outflow winds from inland BC prevail.

#### 6.3.2.2 Air Quality Background

Following a review of the data, it was determined that existing monitoring data in Prince Rupert and Kitimat are not representative of site conditions. Much of the Prince Rupert data was collected at a time when facilities (i.e., pulp mill) known to emit significant quantities of air emissions were operational, but have since been decommissioned. The full analysis of available monitoring data is provided in Appendix C.

## 6.4 Project Interactions with Air Quality

Table 6-4 ranks project interactions with the effect for Air Quality. Activities identified as having no interaction with air quality are ranked as 0 and are not assessed further. Interactions that may have some effect on air quality but can be managed to acceptable levels through mitigation or the application of best management practices are ranked as 1. Interactions that need a detailed assessment (in Section 6.5) are ranked as 2. The ranking takes a conservative approach, whereby interactions with a meaningful degree of uncertainty, even though they would otherwise be assigned a rank of 1, are assigned a rank of 2.

During construction, the main sources of air emissions will include ground disturbance, site clearing, operation of heavy construction equipment, and the delivery of equipment and supplies to the project site. Following commissioning, the primary emissions sources during routine operations will include land and marine project activities. Land-based emissions will be produced by gas compressor drivers, power generators, thermal oxidizers, and flares. Marine-based sources of air emissions will include LNG carrier vessels and a team of assist tugboats.

**Table 6-4: Potential Effects on Air Quality**

| Project Activities and Physical Works | Potential Effects |
|---|---|
| | Increase in CAC Concentrations |
| **Construction** | |
| Site preparation (land-based) | 2 |
| Onshore construction | 2 |
| Vehicle traffic | 2 |
| Dredging | 2 |
| Marine construction | 2 |
| Waste management and disposal | 0 |
| Disposal at sea | 1 |
| Operational testing and commissioning | 1 |
| Site clean up and reclamation | 1 |
| **Operations** | |
| LNG facility and supporting infrastructure on Lelu Island | 2 |
| Marine terminal use | 2 |
| Shipping | 2 |
| Waste management and disposal | 0 |
| Fish habitat offsetting | 0 |
| Wetland habitat compensation | 0 |
| **Decommissioning** | |
| Dismantling facility and supporting infrastructure | 1 |
| Dismantling of marine terminal | 1 |
| Waste disposal | 0 |
| Site clean up and reclamation | 1 |

**KEY:**

0 = No interaction.

1 = Potential adverse effect requiring mitigation, but further consideration determines that any residual adverse effects will be eliminated or reduced to negligible levels by existing codified practices, proven effective mitigation measures, or best management practices.

2 = Interaction may occur and the resulting effect may exceed acceptable levels without implementation of project-specific mitigation. Further assessment is warranted.

### 6.4.1 Justification of Interaction Rankings

Waste management of solid and hazardous materials will be managed and not open to fugitive emissions to air. Fish habitat offsetting and wetland habitat compensation are construction activities overlapping the operations phase, and the air emissions from water-based activities should be negligible. During operations, waste management and disposal have insubstantial emissions. Decommissioning activities are expected to cause minimal air emissions; the air emissions are expected to be of lower intensity than those from construction activities. Therefore these interactions are ranked 0 and not assessed further.

Interactions between a number of activities (disposal at sea, operational testing and commissioning, site clean-up and reclamation [during construction and decommissioning], and dismantling of the facility, supporting infrastructure, and marine terminal) and potential increases in CAC emissions have been ranked as 1, therefore requiring some mitigation. These interactions are considered here.

During construction, power delivery may include on-site diesel-powered electrical power generators. If diesel power generators are required the equipment will use ultra-low sulfur diesel, and the overall air emissions are expected to be negligible and of short duration. Site clean-up and reclamation will cause minor ground disturbance, but emissions will be negligible. Emissions generated during facility operational testing and commissioning are expected to be negligible in comparison to emissions generated by normal plant operations; these emissions are expected to be relatively small in magnitude and short in duration. Project CAC emissions generated by fugitive losses from valves and flanges, on-site vehicle traffic, maintenance and repairs will be low to negligible and are not considered in this assessment. Because these interactions result in emissions that are negligible compared the main, long-term emission sources, and effects of these emissions can be mitigated through standard designs and management practices, no additional analysis is warranted.

Interactions ranked 2 have the potential to cause a significant adverse effects and are carried forward for further assessment.

## 6.5 Effects Assessment

### 6.5.1 Analytical Methods

#### 6.5.1.1 Analytical Assessment Techniques

Air quality dispersion model simulations are used to predict the effects of project emissions on the baseline air quality within the LAA and RAA. Four modelling scenarios are used for the analysis:

- The **baseline case** considers emissions from existing RAA facility sources.
- The **project-alone case** considers the project land-based and marine-based emissions at full build-out (i.e., Phase 2).
- The **application case** combines the results of the baseline case and project-alone case emissions.
- The **cumulative effects assessment (CEA) case** combines the results of the application case with the effects of reasonably foreseeable future projects.

Dispersion simulations of the air emissions were completed using the CALPUFF modelling system with input from the CALMET meteorological model. Air dispersion modelling was completed in accordance with regulatory guidance from the BC MOE in the Guidelines (BC MOE 2008). Further details regarding emissions estimation for these cases, dispersion modelling scenarios, model selection, meteorological data, and terrain and receptors are included in the Air Quality TDR (Appendix C). A brief summary of the modelling system components is provided below.

**CALPUFF Dispersion Modelling System**

CALPUFF is a multi-layer, multi-species, non-steady-state puff dispersion model, which can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and deposition. 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. Most of the algorithms contain options to treat physical processes at differing levels of detail depending on the requirements for the particular model application, such as atmospheric dispersions, chemical transformations and dry and wet deposition. These features are required to predict baseline concentrations and substance depositions. The deposition of all resulting sulfur and nitrogen bearing compounds after chemical transformations is used to calculate potential acid input (PAI) and eutrophication effects (described in more detail in the AQ TDR, Appendix C).

**CALMET Meteorological Model**

Meteorology plays a major role in determining air quality changes downwind of emission sources. Both the wind and atmospheric stability greatly affect dispersion conditions. Local influences due to terrain and land-cover factors can also be important. For dispersion modelling, the CALMET meteorological model was used in conjunction with the CALPUFF air quality dispersion model. Input data for CALMET consisted of surface and upper air data for three full years (January 1, 2008 through December 31, 2010).

Due to distance and the strong influence of terrain on west coast wind patterns, data from the nearest upper air observing station (Annette Island, Alaska, approx. 120 km northwest) are not representative of RAA meteorological conditions. For that reason, the Weather Research and Forecasting (WRF) numerical weather prediction system was used to produce meso-meteorological upper air data with 4 km resolution for the same three-year period.

The CALMET surface layer characterization was enhanced with compatible data (for the three-year period) from meteorological stations most representative of RAA conditions. Measured and observed data from the Prince Rupert Airport and Holland Rock stations was assimilated into the CALMET meteorological model.

**Topography and receptors**—Following site preparation, the facility will be installed at an elevation of 25 metres above sea level masl. Model terrain and receptor elevations were extracted from the Natural Resources Canada Canadian Digital Elevation Data (CDED). The CDED data (Geobase 2011) consists of an ordered array of ground level elevations at regularly spaced intervals. Consistent with the Guidelines (BC MOE 2008), a series of nested Cartesian grids with increasing receptor density closer to the project site boundary were developed. As per recommendations in the Guidelines (BC MOE 2008), flagpole receptors with elevations of 15 m above ground level were modelled to assess tree-top $SO_2$ concentrations.

Sensitive receptor locations can be individual residences or sensitive ecosystem areas. The selected sensitive receptor are schools, daycares, hospitals and senior housing, nearest residences, First Nations small fishing communities, commercial locations and traditional use sites. Traditional use locations for cabins, fishing, hunting, and walking are identified in the traditional knowledge and traditional use studies (Sections 21 and 27). Maximum predicted CAC concentrations were determined for these locations for both the project-alone case and CEA case.

**Building downwash effects**—Buildings, tanks, and other solid structures may affect the flow of air near an emission source and cause building downwash (e.g., eddies on the downwind side) which have potential to reduce plume rise and increase concentrations near the surface. The effects of building downwash were incorporated into the dispersion modelling.

**NO to $NO_2$ conversion**—Oxides of nitrogen ($NO_x$) comprise both NO and $NO_2$. AAQOs exist for $NO_2$ rather than for NO or total $NO_x$. Therefore, it is important to be able to estimate the portion of predicted ground-level $NO_x$ comprising $NO_2$. For these predictions, the CALPUFF RIVAD NO to $NO_2$ chemical transformation method was used (Appendix C).

**Potential acid input (PAI)**—PAI deposition is derived from the total sulfur compound contribution plus the total nitrogen compound contribution, minus the neutralizing effect of base compounds found in the RAA surface layer. CALPUFF was used to predict the deposition of sulfur and nitrogen bearing compounds from the RAA emission sources.

**Eutrophication**—Eutrophication focuses on nitrogen bearing compound depositions only. CALPUFF was used to predict the deposition of nitrogen bearing compounds from the RAA emission sources (Appendix C).

#### 6.5.1.2 Assumptions and the Conservative Approach

Air quality models are as accurate as the inputs and assumptions employed in the modelling. Emission rates used in the modelling were taken from the front-end engineering studies and discussions with the engineering team. Some physical parameters (e.g., stack height, exit temperature and velocity) associated with specific emission sources were estimated based on similar project experience. It is assumed that the emission sources are continuous and the equipment operating at full load. In reality, actual emissions vary from hour-to-hour and day-to-day. Because of the conservative nature of this approach, emissions are likely overestimated.

Regulatory models, such as CALPUFF, are designed to be conservative under most conditions. The model employs assumptions to simplify the random behaviour of the atmosphere into short periods of average behaviour. These assumptions limit the capability of the model to replicate every individual meteorological event. To compensate for these simplifications, the emissions were treated with three years of varied meteorological conditions. The results from the worst overall year (maximum concentrations in 2009) are used in the assessments. Usually, the worst results for the time duration assessed are singular events and occur infrequently.

A detailed discussion of modelling assumptions is provided in the Air Quality TDR (Appendix C).

### 6.5.2 Increase in Criteria Air Contaminant Concentrations

The following sections detail the CAC emission estimates and the dispersion modelling results for each of the baseline and project-alone cases.

#### 6.5.2.1 Potential Effects

**Baseline Case**

For the baseline case, applying the measured air contaminant values (background) from monitoring station data is equivalent to an assumption that the entire regional area has the same level of air contaminant concentrations, and should be avoided. Following analysis, it was determined that existing monitoring data are not representative of site conditions (see Appendix C). The data was collected at a time when significant sources of air emissions existed in the Prince Rupert area (e.g., pulp mill). Since these activities have ceased, background air quality is expected to have improved. Adding these background estimates to the baseline case would overstate existing emissions for an airshed that is considered to have good air quality.

Air emissions from the following existing regional operations are included in the dispersion modelling simulations:

- Northland Terminal
- Ridley Island Coal Terminal
- Prince Rupert Grain Ltd.
- BC and Alaska Ferries
- Fairview Terminal (Phase I).

Emissions rates for these sources are based on previously-published work (Stantec 2009; Stantec 2011). Since regional emissions are well understood, background concentrations were not added to the modelling results to avoid double-counting. This baseline case directly includes the effects of emissions from the existing regional facilities. Each of these regional facilities has a land-based and a marine-based component producing air emissions (see Table 6-5). Total emissions are presented in units of tonnes per year (t/y).

**Table 6-5: Annual Land-Based and Marine-Based Emission Rates Associated with the Baseline Case**

| Source | CAC Emissions (t/y) | | | | | |
|---|---|---|---|---|---|---|
| | $SO_2$ | $NO_X$ | CO | $PM_{10}$ | $PM_{2.5}$ | VOCs |
| Land-based | 16.1 | 223 | 168 | 224 | 125 | 28.0 |
| Marine-based | 235 | 269 | 23.1 | 8.54 | 6.84 | 10.0 |
| **Total Emissions** | **251** | **492** | **191** | **232** | **132** | **38.0** |

Table 6-6 lists the maximum baseline case concentration modelling results. All CAC maxima for the baseline case are below the most stringent applicable air quality objectives. The detailed source and emission parameters used in the baseline case dispersion modelling are included in the Air Quality TDR (see Appendix C).

**Table 6-6: Maximum Predicted Concentrations Associated with the Baseline Case**

| Contaminant | Averaging Period | Baseline Case Maximum Predicted Concentrations ($\mu g/m^3$) | Applicable AAQO ($\mu g/m^3$) |
|---|---|---|---|
| $SO_2$ | 1-hour | 50 (44)[a] | 450 |
| | 3-hour | 25 (27)[a] | 375 |
| | 24-hour | 7.6 (7.5)[a] | 150 |
| | Annual | 0.8 (0.9)[a] | 25 |
| $NO_2$ | 1-hour | 347 | 400 |
| | 24-hour | 93 | 200 |
| | Annual | 3.4 | 60 |
| CO | 1-hour | 303 | 14,300 |
| | 8-hour | 141 | 5,500 |
| $PM_{10}$ | 24-hour | 32 | 50 |
| | Annual | 3.4 | - |
| $PM_{2.5}$ | 24-hour | 9.9 | 25[b] |
| | Annual | 1.8 | 8 |

**NOTE:**
[a] Values in brackets are tree-top concentrations predicted at 15 m flag pole receptor heights.
[b] Based on the 98th percentile value for one year.
– No objective has been established for this category.

### Project-Alone Case: Construction

CAC emissions from construction activities may have a short-term and temporary effect on the background air quality. These emissions are associated with site preparation, onshore construction, vehicle traffic, dredging, marine construction, waste management, disposal at sea, operational testing and commissioning and site clean-up and reclamation. Generally, construction CAC emissions are proportional to the disturbed land area and the level of construction activity and limited to periods of the day and week when the construction activities take place.

Predicted project-related CAC emissions in tonnes per year (t/y) are summarized in Table 6-7.

Construction of the first two trains is expected to take up to five years. Year 1 of construction will focus on establishing bridge and road access, site preparation and the construction of the materials off-loading facility (MOF). Subsequent years (Year 2 to Year 5) will focus on Phase 1 construction, including the facility installation (Train 1 and Train 2), dredging and installation of the LNG trestle. Phase 2 (Train 3 installation) will be scheduled pending favourable market conditions; CAC emissions from Phase 2 construction activities will be much less than the emissions from Phase 1.

Construction $PM_{10}$ and $PM_{2.5}$ emissions are included in the exhaust from mobile equipment engines only. Fugitive dust emissions from ground disturbance are not quantified as they are expected to be minimal due to long periods of rain and snow suppressing dust emissions. During non-precipitating days, the fairly damp nature of surface material handled (muskeg and peat) will prevent dust emissions. Further details regarding construction phase CAC emission estimation is available in the Air Quality TDR (see Appendix C).

**Table 6-7: Summary of Predicted CAC Emissions from Project during Construction Phase**

| Equipment Type[a] | CAC Emissions (t/y) | | | | | |
|---|---|---|---|---|---|---|
| | $SO_2$ | $NO_X$ | CO | $PM_{10}$ | $PM_{2.5}$ | VOCs |
| **Year 1 – Bridge and road access, site preparation, MOF construction** | | | | | | |
| Land-based [b] | 0.14 | 131 | 135 | 7.58 | 7.27 | 21.5 |
| Marine-based [c] | 2.40 | 19.8 | 17.1 | 1.01 | 0.97 | 1.48 |
| **Total** | **2.55** | **151** | **152** | **8.59** | **8.24** | **23.0** |
| **Year 2 to Year 5 – Facility installation, dredging** | | | | | | |
| Land-based [b] | 0.13 | 46.9 | 54.7 | 3.15 | 3.02 | 8.66 |
| Marine-based [c] | 5.62 | 36.3 | 29.8 | 1.76 | 1.70 | 2.40 |
| **Total** | **5.75** | **83.2** | **84.5** | **4.91** | **4.72** | **11.1** |

**NOTES:**

[a] Detailed equipment list is provided in the Air Quality TDR (see Appendix C).

[b] Based on emission factors and methodologies developed by the United States Environmental Protection Agency (US EPA) for Nonroad Diesel Equipment (US EPA 2010).

[c] Based on emission factors and methodologies developed by the US EPA for commercial marine vessels (ICF 2009).

Table 6-8 shows a comparison of the construction emissions relative to the total emissions used for the baseline assessment. The increases in $SO_2$ and PM emissions are minor. The increase in the $NO_2$ emissions is greater; however, these construction emissions are short-term, transient, reversible, and will not contribute measurably to any regional cumulative issues of concern. The construction emission totals are also minor compared to the operations emission totals shown in Table 6-10. For these reasons, construction emissions are not included in the dispersion simulations, since the effects will be minor compared to the effects of the operations emissions.

**Table 6-8: CAC Emissions: Comparison of Construction and Existing RAA Emissions**

| Source | CAC Emissions (t/y) | | | | | VOCs |
|---|---|---|---|---|---|---|
| | $SO_2$ | $NO_X$ | CO | $PM_{10}$ | $PM_{2.5}$ | |
| Total predicted construction emissions (Year 1) | 2.55 | 151 | 152 | 8.59 | 8.24 | 23.0 |
| Total predicted construction emissions (Year 2-5) | 5.75 | 83.2 | 84.5 | 4.91 | 4.72 | 11.1 |
| Total existing emissions in the LAA | 251 | 492 | 191 | 232 | 132 | 38.0 |
| Year 1 construction emissions relative to existing emissions in the LAA (%) | 1.0 | 31 | 80 | 3.7 | 6.2 | 61 |
| Year 2 to Year 5 construction emissions relative to existing emissions in the LAA (%) | 2.3 | 17 | 44 | 2.1 | 3.6 | 29 |

### Project-Alone Case: Operations

Project activities are operation of the LNG facility and supporting infrastructure, marine terminal use and shipping (see Table 6-4). This assessment considers potential effects of the Project at full operational build-out (3 trains). Each liquefaction train will have an identical set of continuous emissions sources. At full build out, the Project will rely on nine natural gas 26.8 MW turbines (three on standby) to supply processing power. Each of the three processing trains will consist of two 85.4 MW compressor mechanical drivers, and one thermal oxidizer. The compressor turbines will provide power for the compression function only. The generator turbines will provide power for the entire facility. Turbine selection will be in accordance with BC MOE best achievable technology policy for controlling air emissions (BC MOE 2012).

It assumed that all $H_2S$ directed to the thermal oxidizer is converted to $SO_2$. Minimal emissions will occur from the shared flare stacks. The Project will adopt a zero flaring philosophy during normal operations. Flares will only be used for reliable and safe disposal of hydrocarbon streams in upset operating conditions and emergencies (see Section 22). During normal operations, flare emissions will result only from the continuously ignited pilot light, which ensures readiness in the event of an upset condition.

CAC emissions will be generated by the operation of LNG carrier vessels and assist tugboats used to manoeuver the vessels to and from the marine wharf. The wharf will be designed to handle a range of vessel sizes, however a standard Q-flex LNG carrier size is assumed for the assessment.

Details of the emission sources and emission parameters used in the project-alone case dispersion modelling are included in the Air Quality TDR (Appendix C). A summary of the total project land and marine emissions at full build out are provided in Table 6-9. The dispersion modelling uses the short-term emission rates for the CAC concentrations for all averaging periods except for the annual averaging period. Annual CAC predictions are based on long-term emissions.

**Table 6-9: Annual Land-Based and Marine-Based Emission Rates for Project-Alone Operation**

| Source | CAC Emissions (t/y) | | | | | |
|---|---|---|---|---|---|---|
| | $SO_2$ | $NO_X$ | CO | $PM_{10}$ | $PM_{2.5}$ | VOCs |
| Land based | 144 | 3,433 | 4,104 | 273 | 273 | 100 |
| Marine based – short term | 79 | 1,916 | 243 | 35.4 | 32.8 | 97.6 |
| Marine based – long term | 27.5 | 600 | 74.6 | 11.7 | 11.0 | 28.3 |
| **Total – short term** | 223 | 5,349 | 4,348 | 308 | 306 | 198 |
| **Total – long term** | 172 | 4,033 | 4,179 | 285 | 284 | 128 |

Project-alone case predictions of maximum ground-level CAC concentrations are summarized in Table 6-10. All CAC concentration maxima are below the most stringent applicable objectives.

VOC emissions were not treated with dispersion simulations, since applicable objectives are not available for comparison. Thermal oxidizer operation will oxidize most of the VOC in the waste gas stream and it is expected that none of the remaining constituents will be toxic. Therefore, increased concentration levels of the waste gas constituents should not have an adverse effect.

**Table 6-10: Maximum Predicted Concentrations Associated with the Project-Alone Case**

| Contaminant | Averaging Period | Project-Alone Case Maximum Predicted Concentrations ($\mu g/m^3$) | Applicable AAQO ($\mu g/m^3$) |
|---|---|---|---|
| $SO_2$ | 1-hour | 26 (26)[a] | 450 |
| | 3-hour | 16 (17)[a] | 375 |
| | 24-hour | 5.0 (5.0)[a] | 150 |
| | Annual | 0.3 (0.3)[a] | 25 |
| $NO_2$ | 1-hour | 173 | 400 |
| | 24-hour | 51 | 200 |
| | Annual | 2.4 | 60 |
| CO | 1-hour | 186 | 14,300 |
| | 8-hour | 59 | 5,500 |
| $PM_{10}$ | 24-hour | 3.4 | 50 |
| | Annual | 0.3 | - |
| $PM_{2.5}$ | 24-hour | 1.7 | 25[b] |
| | Annual | 0.3 | 8 |

**NOTE:**
[a] Values in brackets are tree-top concentrations predicted at 15 m flagpole receptor heights.
[b] Based on the 98th percentile value for one year.
– = No objective has been established for this category.

### Project Decommissioning

The project activities for the decommissioning phase are similar but much more limited that the activities assumed for the construction phase. Therefore, the air emissions and corresponding effects are assumed to be much lower.

### Predictions at Sensitive Receptors

For all contaminants and averaging periods, the predictions at each of the receptors are well below the applicable objectives, see Appendix C.

### 6.5.2.2 Mitigation

Throughout construction and operations, PNW LNG will plan to limit the air quality effects due to CAC emissions from project activities. To do so, the following mitigations will be implemented:

- Best achievable technology (BC MOE 2012) will be incorporated into project design 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).

- Thermal oxidizers will be used to oxidize $H_2S$, to achieve negligible $H_2S$ emission effects, oxidize VOCs, and vaporize any hydrocarbon solids in the waste gas stream before venting.
- Best management practices for the processing systems will be instituted and maintained (i.e., use of treated feed gas as fuel for power generation).
- A natural gas leak detection program 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 tuning and maintenance.
- Vehicle idling times during all project phases will be kept to a minimum.

#### 6.5.2.3 Characterization of Residual Effects

All predicted CAC concentration maxima from operations are below the most stringent applicable objectives. Therefore, the residual effects can be characterized as adverse and continuous over the operations (medium) phase, but of low to medium magnitude. Isopleth maps contained in the Air Quality TDR (Appendix C) show the geographic extent of the most adverse effects to be local and the remainder of affected areas will have a low level of disturbance. A time series analysis shows that the most adverse effects occur only sporadically and with a very limited frequency. When the operations phase is over, all effects are reversible. As such, the atmospheric environment is expected to demonstrate a high degree of resilience to changes in air quality caused by the Project.

The magnitudes of CAC emissions from the construction phase activities have been shown to be lower than the operations phase, so the same characterizations, but to a lesser degree apply to the construction phase. The decommission phase activities, and corresponding emissions, are of even lower intensities.

#### 6.5.2.4 Likelihood

The construction and operation of the Project will result in emissions of CACs. Therefore, there is a high likelihood of a residual effect on air quality.

#### 6.5.2.5 Determination of Significance of Residual Effects

The effects of individual substances emitted by the Project vary in magnitude from low to moderate. Most of these effects occur in the immediate vicinity of the land facility adjacent to the property line or vessel loading area. Because applicable air quality objectives are not exceeded, the residual effects are not significant.

#### 6.5.2.6 Confidence and Risk

Assessment prediction confidence is high based on the quality of the emissions data and analytical techniques. The evaluation of the effects of increased CAC emissions depends primarily upon the ability of air dispersion models to predict changes to background air concentrations. A detailed discussion of assessment confidence is provided in the Air Quality TDR (Appendix C).

Since the confidence in this prediction is not low, no additional risk analysis has been conducted.

### 6.5.3 Summary of Residual Effects

Residual effects of the Project on air quality are summarized in Table 6-11. Because emissions are largest during operations, the residual effects of increased CAC concentrations during operations are assumed to characterize the entire Project.

**Table 6-11: 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<br>▪ Best management practices<br>▪ Natural gas leak detection system<br>▪ Thermal oxidizer operation<br>▪ Dust suppression<br>▪ Equipment maintenance and low sulfur fuel<br>▪ Vehicle idling restrictions<br>▪ Adherence to the International Convention for the Prevention of Pollution from Ships (MARPOL). | H | L | L | ST | R | S | H | N | H | None. |
| 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 | | | | |

| Project Phase | Mitigation Measures | Residual Effects Characterization | | | | | | Likelihood | Significance | Confidence | Follow-up and Monitoring |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Context | Magnitude | Extent | Duration | Reversibility | Frequency | | | | |

**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

**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)

**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

**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

## 6.6 Cumulative Effects

### 6.6.1 Context for Cumulative Effects

Project residual effects can overlap and act cumulatively with the effects of other activities (present and reasonably foreseeable). The residual effects of past operations of other projects (no longer in operation) are assumed to have been reversed. A cumulative effects assessment is required to determine if project-alone emissions are likely to interact with present regional and reasonably foreseeable project sources in a manner that is likely to result in significant cumulative effects.

Existing and reasonably foreseeable projects located within the RAA are summarized below (see Table 6-12). J.S. McMillan Fisheries, ICEC Terminals, WatCo Pulp Mill (formerly China and Paper Group Pulp Mill) projects are not considered in this assessment because the projects are either closed, cancelled or have no reasonably foreseeable starting date.

### 6.6.2 Cumulative Effects Assessment

The cumulative effects assessment is based on an effect-by-effect basis, with a two-step process to determine the potential for cumulative effects on air quality. In conducting the cumulative effects assessment, the residual effects arising from interactions that have been ranked as 1 or 2 in Table 6-4 are considered. The first step consists of two questions:

- Is there a project residual effect?
- Does the project residual effect overlap spatially and temporally with those of other past, present or reasonably foreseeable future projects?

Where the answers to both of these two questions are affirmative, a check in Table 6-12 indicates that there is potential for the Project to contribute to cumulative effects on air quality. Potential contribution of these project effects to cumulative effects is assessed below. The second step consists of one question:

- Is there a reasonable expectation that the contribution (i.e., addition) of the Project's residual effects would cause a change in cumulative effects that could affect the viability or sustainability of the VC?

Where the answer to this question is affirmative, additional assessment of the potential cumulative effects is described below.

Major planned projects to be located in the RAA include:

- Fairview II expansion facility
- Canpotex facility
- Prince Rupert LNG facility.

Emissions information for the Fairview Terminal II facility was obtained from the Fairview Terminal Phase II environmental assessment (Stantec 2009). Emissions associated with the operation of the Canpotex facility were taken from the Canpotex environmental assessment (Stantec 2011).The proposed pipeline infrastructure for each of the two LNG facilities proposed in Prince Rupert will contribute negligible amounts of air emissions within the RAA. All of the compressor stations supporting the Prince Rupert Gas Transmission Project and the Westcoast Connector Gas Transmission Project are outside the RAA and are not included in the assessment. Other facilities expected to contribute low to negligible overlapping effects include the Atlin Terminal, Pinnacle Pellet Inc., Odin Seafood, the Prince Rupert industrial park, Ridley Island log sort and the Westview Terminal.

**Table 6-12: Potential Cumulative Effects on Air Quality**

| Other Projects and Activities with Potential for Cumulative Effects | Project Status | Potential Cumulative Effects |
|---|---|---|
| | | Increase in Criteria Air Contaminant Concentrations |
| Atlin Terminal | Operational | |
| Canpotex Potash Export Terminal | Approved | ✓ |
| CN Rail Line | Operational | ✓ |
| Douglas Channel LNG | Approved | |
| Enbridge Northern Gateway Project | Approved | |
| Fairview Container Terminal Phase I | Operational | ✓ |
| Fairview Container Terminal Phase II | Approved | ✓ |
| Kitimat LNG Terminal Project | Approved | |
| LNG Canada Project | Proposed | |
| Mount McDonald Wind Power Project | Approved | |
| NaiKun Wind Energy Project | Approved | |
| Northland Cruise Terminal | Operational | ✓ |
| Odin Seafood | Operational | |
| Pinnacle Pellet Inc. | Approved | |
| Prince Rupert LNG Facility | Proposed | ✓ |
| Prince Rupert Gas Transmission Project | Proposed | |
| Prince Rupert Ferry Terminal | Operational | ✓ |
| Prince Rupert Industrial Park | Operational | |
| Prince Rupert Grain Limited | Operational | ✓ |
| Ridley Island Log Sort | Operational | |
| Ridley Terminals Inc. | Operational | ✓ |
| Rio Tinto Alcan Aluminium Smelter and Modernization Project | Existing/Approved | |
| WatCo Pulp Mill | Proposed | |
| Westcoast Connector Gas Transmission Project | Proposed | |

**NOTES:**
✓ = Those ‘other projects and activities’ whose effects are likely to interact cumulatively with the Project’s residual effects.

#### 6.6.2.1 Increase in Criteria Air Contaminant Concentrations

To determine if the project-alone residual effects meet the three criteria, the following modelling cases are used:

- The application case combines the results of the baseline case and project-alone case emissions.
- The CEA case combines the results of the application case with the effects of reasonably foreseeable future projects.

**Application Case Scenario**

The short-term emissions are higher than the long-term emissions because of the intermittent operation of the LNG carrier activities (see Table 6-13 for the total emissions).

**Table 6-13: Land-Based and Marine-Based Emission Rates Associated with the Application Case Included in Dispersion Modelling**

| Source | CAC Emissions (t/y) | | | | | |
|---|---|---|---|---|---|---|
| | $SO_2$ | $NO_X$ | CO | $PM_{10}$ | $PM_{2.5}$ | VOCs |
| Land based | 160 | 3,656 | 4,272 | 497 | 398 | 128 |
| Marine based – short term | 314 | 2,185 | 267 | 44 | 40 | 108 |
| Marine based – long term | 263 | 869 | 98 | 20 | 18 | 38 |
| **Total – short term** | 474 | 5,841 | 4,538 | 541 | 438 | 236 |
| **Total – long term** | 423 | 4,525 | 4,370 | 517 | 416 | 166 |

Maximum application case modelling results are summarized in Table 6-14. Short-term emission rates are used for all averaging periods except for the annual period. Annual predictions are based on the long-term emission rates. All CAC maxima for the application case are far below the most stringent applicable objectives, except for the $NO_2$ 1-hour result, which is 13% below the objective. Most of the contribution for the $NO_2$ concentration comes from existing regional sources. A large component of these emissions is attributed to marine-based activities (i.e., ferries, bulk carrier vessels and tugs) (Table 6-13). Emissions rates for these sources are based on previously-published material (Appendix C) and do not include compliance with the International Marine Organization North American Emission Control Area emission standards (MARPOL 2008) expected to take effect in 2015. Based on the proposed clean fuel targets, $SO_2$, $NO_x$ and PM emissions from marine vessels are expected to be reduced. For this reason, the results of this case are overly conservative. A detailed description of the results is presented in the Air Quality TDR (Appendix C).

**Table 6-14: Maximum Predicted Concentrations for the Application Case**

| Contaminant | Averaging Period | Application Case Maximum Predicted Concentrations ($\mu g/m^3$) | Applicable AAQO ($\mu g/m^3$) |
|---|---|---|---|
| $SO_2$ | 1-hour | 50 (44)[a] | 450 |
| | 3-hour | 26 (27)[a] | 375 |
| | 24-hour | 7.7 (7.7)[a] | 150 |
| | Annual | 0.9 (1.0)[a] | 25 |
| $NO_2$ | 1-hour | 349 | 400 |
| | 24-hour | 93 | 200 |
| | Annual | 3.8 | 60 |
| CO | 1-hour | 303 | 14,300 |
| | 8-hour | 142 | 5,500 |
| $PM_{10}$ | 24-hour | 32 | 50 |
| | Annual | 3.4 | |
| $PM_{2.5}$ | 24-hour | 10.1 | 25[b] |
| | Annual | 1.9 | 8 |

**NOTE:**
[a] Values in brackets are tree-top concentrations predicted at 15 m flag pole receptor heights.
[b] Based on the 98th percentile value for one year.
– = No objective has been established for this category.

### Cumulative Effects Assessment Case

The CEA case combines the effects from regional (baseline case) and normal project operations (project-alone case) with effects from foreseeable projects proposed within the RAA and listed in Table 6-12. The total emissions are presented in Table 6-15.

**Table 6-15: Land-Based and Marine-Based Emission Rates Included in the Dispersion Modelling of the Cumulative Effects Assessment Case**

| Source | CAC Emissions (t/y) | | | | | |
|---|---|---|---|---|---|---|
| | $SO_2$ | $NO_X$ | CO | $PM_{10}$ | $PM_{2.5}$ | VOCs |
| Land based | 327 | 4,420 | 8,608 | 794 | 692 | 272 |
| Marine based – short term | 1,135 | 5,621 | 4,910 | 404 | 389 | 379 |
| Marine based – long term | 866 | 2,226 | 236 | 59 | 51 | 97 |
| **Total – short term** | 1,462 | 10,041 | 13,519 | 1,198 | 1,080 | 650 |
| **Total – long term** | 1,193 | 6,646 | 8,845 | 853 | 743 | 368 |

Maximum CEA case concentrations are summarized in Table 6-16. As with the other cases, short-term emission rates are used for all averaging periods except for the annual period. Annual concentrations are based on the long-term emission rates.

All CAC maxima for the CEA case are far below the most stringent applicable objectives, except for the $NO_2$ 1-hour result that is 17% higher than the objective. A time series analysis shows that there are two occurrences exceeding the 1-hour applicable objectives in the three-year simulation period. These exceedances occur west of Prince Rupert, on the east side of Digby Island and are about 2.3 km apart.

Most of the contribution to the $NO_2$ exceedances at that location is a result of emissions from existing and regional sources (baseline case), rather than from project emissions. As noted in the application case, a large portion of these emissions is attributed to marine-based activities. Published existing marine-based emissions did not account for the 2015 clean fuel regulation (MARPOL 2013). Emissions from proposed marine-based activities (including this Project) incorporated the clean fuel provision. Based on this, the results of the CEA case are overly conservative. If existing emissions estimates are revised, the 1-hour $NO_2$ exceedance is expected not to occur. A detailed description of the results is presented in the Air Quality TDR (Appendix C).

**Table 6-16: Maximum Predicted Concentrations Associated with the CEA Case**

| Contaminant | Averaging Period | CEA Maximum Predicted Concentrations ($\mu g/m^3$) | Applicable AAQO ($\mu g/m^3$) |
|---|---|---|---|
| $SO_2$ | 1-hour | 127 (130) [a] | 450 |
| | 3-hour | 81 (83) [a] | 375 |
| | 24-hour | 31 (33) [a] | 150 |
| | Annual | 2.9 (3.1) [a] | 25 |
| $NO_2$ | 1-hour | **470** | 400 |
| | 24-hour | 121 | 200 |
| | Annual | 8.0 | 60 |
| CO | 1-hour | 339 | 14,300 |
| | 8-hour | 154 | 5,500 |
| $PM_{10}$ | 24-hour | 32 | 50 |
| | Annual | 3.7 | |
| $PM_{2.5}$ | 24-hour | 10.7 | 25[b] |
| | Annual | 2.1 | 8 |

**NOTE:**
[a] Values in brackets are tree-top concentrations predicted at 15 m flag pole receptor heights.
[b] Based on the 98th percentile value for one year.
– = No objective has been established for this category.
Values in **bold** identify an exceedance to applicable AAQO.

**Predictions at Sensitive Receptors**

Detailed results for each of the sensitive receptors are presented in the Air Quality TDR (Appendix C). In summary, the maximum predicted concentrations for $SO_2$, $NO_2$, CO, $PM_{10}$ and $PM_{2.5}$ at the sensitive receptors generally increase, but only incrementally when comparing the CEA case results to the baseline case and application case. However, the results at each of the receptors were below the applicable objectives for all contaminants and averaging periods.

#### 6.6.2.2 Summary of Cumulative Effects

The application case dispersion modelling results indicate that project residual effects do not substantially overlap with the regional source effects. The CEA case dispersion modelling results indicate that the overlap of effects from reasonably foreseeable future projects in the assessment area do have an effect near the project site, but the cumulative effect is not significant.

The applicable objective for 1-hour $NO_2$ is exceeded at two locations in the modelling domain. These exceedances occur west of Prince Rupert on the east side or Digby Island and are about 2.3 km apart. A time series analysis shows that the exceedances only occur at different times during one hour of the three-year period. Further analysis shows that areal extent of the exceedance is localized.

Additionally, most of the contributions for those events originate from existing regional sources and are located far from the project site.

Therefore, the cumulative effects on the Air Quality VC are not significant.

## 6.7 Follow-up and Monitoring

The Project's primary air quality concerns are related to the increased $NO_2$ concentrations. Although the assumptions underlying the modelling result are conservative, the 1-hour cumulative $NO_2$ maxima are near the applicable objectives. Project-specific follow-up and monitoring requirements will be defined by BC MOE and BC OGC as a permit condition.

## 6.8 Conclusion

The assessed effect for the Air Quality VC is an increase in criteria air contaminant concentrations. Project, regional and foreseeable projects emissions estimations and dispersion modelling procedures were designed to provide conservative results. The maximum predicted concentrations for the CACs are well within the applicable objectives. The exceptions are the predictions of two 1-hour $NO_2$ concentration instances for a small area north of Prince Rupert. As the assessment is conservative at several levels, the effects on air quality will likely be less than those predicted by this assessment.

Therefore, the residual effects due to the increased CAC emissions are predicted to be not significant. Based on the quality and conservatism of air quality modelling, the level of confidence in this prediction is high. Cumulative effects within the RAA are also expected to be not significant.

## 6.9 References

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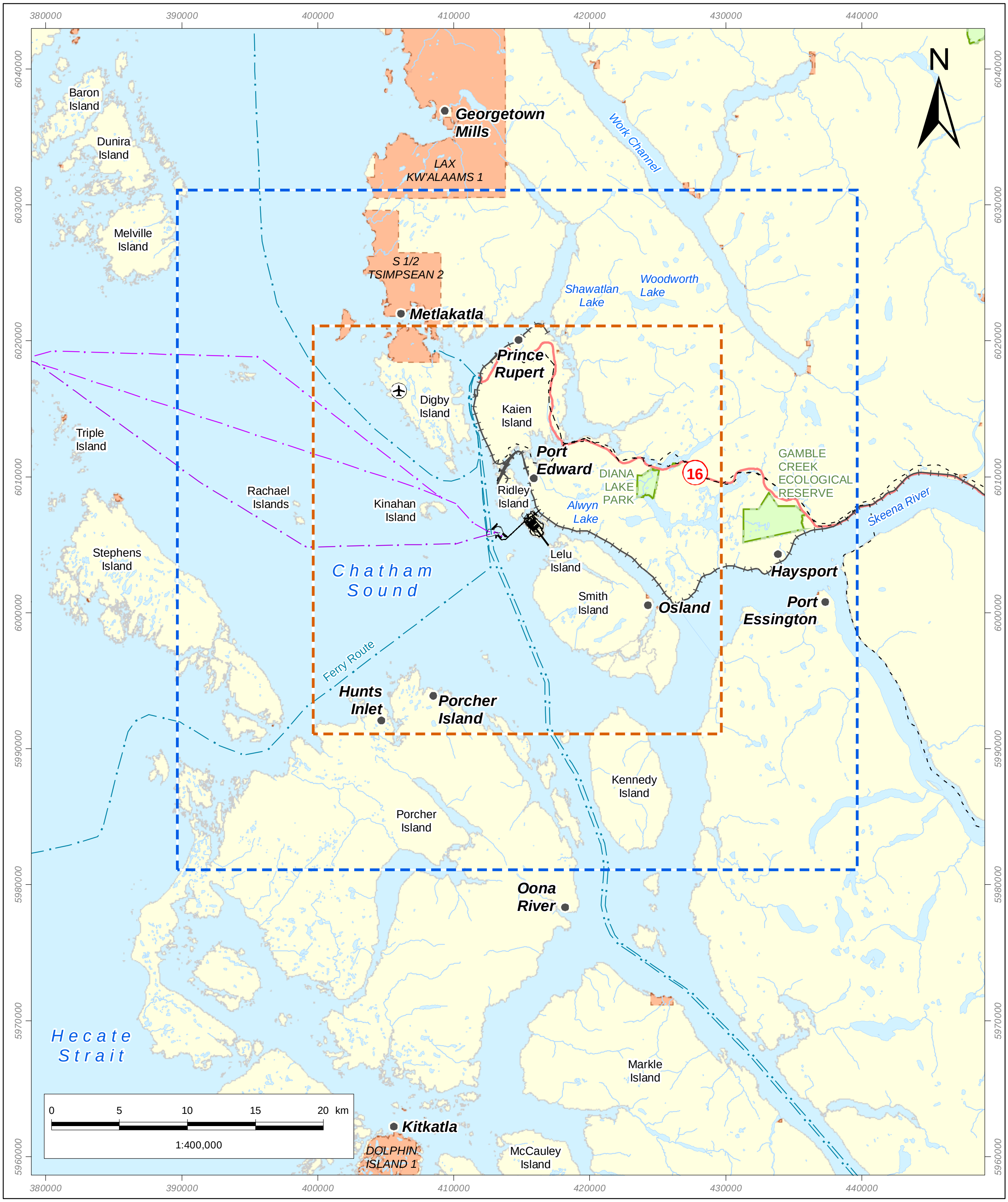
## 6.10 Figures

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**

*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: 06-FEB-14
FIGURE ID: 123110537-420
DRAWN BY: K. POLL

PROJECTION: UTM - ZONE 9
DATUM: NAD 83
CHECKED BY: A. POMEROY

PREPARED BY: Stantec

PREPARED FOR: Pacific NorthWest LNG

FIGURE NO: **6-1**

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