5.9 Surface Water Quality

5.9.1 Introduction

Water quality is a VC because of the importance of water to maintain aquatic life and for human consumption. As there is a potential for Project air emissions to interact with water quality, MOE requested that LNG Canada study the potential for acidification and eutrophication of surface freshwater bodies due to air emissions.

The LNG facility is expected to release air emissions, including SO_2 and NO_x, as it converts natural gas into LNG. These air emissions have the potential to react with water and oxygen in the atmosphere causing acid deposition, and resulting in the introduction of sulphate (SO_4) and nitrogen (N) forms into nearby freshwater systems (lakes and streams). This deposition may generate changes in water quality (chemistry) and ultimately cause adverse effects in freshwater systems through shifts in pH or in the nutrient regime (eutrophication).

Potential effects of acidification in freshwater systems have been assessed using the Steady State Water Chemistry (SSWC) model for which inputs are water chemistry data and SO_4 and NO_x deposition levels obtained from the Project air modelling results (discussed in Section 5.2). The assessment also considers the eutrophication potential of freshwater systems attributable to increases in nitrogen deposition.

Project effects on fish and fish habitat are assessed in the freshwater and estuarine fish and fish habitat section of the Application (Section 5.7), including, for example, changes in water quality related to increased levels of total suspended solids (TSS) generally associated with construction activities. Project effects on the marine environment are assessed in the marine resources section of the Application (Section 5.8).

5.9.2 Scope of Assessment

The scope of this assessment has been defined by the regulatory context and comments provided during consultation with Aboriginal Groups, regulatory agencies, and stakeholders in EAO Working Group sessions.

5.9.2.1 Regulatory and Policy Setting

The MOE provided the following guidance documents, not in a regulatory context, but to recommend the level of detail necessary for the assessment of potential acidification effects:

- *ICP Mapping Manual*, Mapping Critical Loads, section 5 (Reynolds 2004)
- *ICP Mapping Manual*, Exceedance Calculations, section 7 (Posch 2004), and
- Draft Critical Loads Screening Chart (BCMOE 2013a).

The MOE guidance defines critical load screening thresholds for nitrogen and sulphate (15 meq/m^2/y) and for nitrogen alone (35.7 meq/m^2/y) for identification of areas in which waterbodies have the potential to be affected by acidification and eutrophication and most likely will require Level 1 (quantitative) assessments. These values are based on wet and dry deposition incorporating air emissions from existing and permitted sources, including predicted air emissions from the LNG facility. The *ICP Mapping Manual* describes the SSWC model and calculation methods for the Level 1 quantitative assessment.

For eutrophication, where guidance documents were not available, methods are derived from current scientific literature (Carlson and Simpson 1996; Dodds 1998).

5.9.2.2 Consultations' Influence on the Identification of Issues and the Assessment Process

The scope of the assessment is based on the AIR, which was developed through consultation with Aboriginal Groups, the public, the EAO Working Group, and other interested parties. These meetings resulted in the refinement of the proposed approach used to evaluate effects on water quality. The most substantial refinements were an agreement to complete a quantitative assessment of potential acidification effects in freshwater systems, the inclusion of streams as well as lakes in the assessment, and incorporation of additional sampling locations proposed by MOE.

Through LNG Canada's consultation program, Aboriginal Groups including the Gitxaala Nation, Gitga'at First Nation, Kitsumkalum First Nation, Haisla Nation, and Kitselas First Nation expressed concern about acidifying emissions and the potential effects on lakes and streams. Regulatory agencies were also concerned about the eutrophication potential for lakes and streams that might result from Project emissions. Concerns related to protecting water quality and freshwater systems have been incorporated in the assessment, particularly through the refinement of the approach used to predict potential Project-related changes in water quality. Concerns identified by Aboriginal Groups as they relate to potential adverse effects on Aboriginal Interests are assessed in Section 14.

5.9.2.3 Traditional Knowledge and Traditional Use Incorporation

TK and TU information was gathered from Project-specific studies submitted to LNG Canada and publicly available sources. The available TK and TU information at the time of writing is used to inform aspects of the assessment. Haisla Nation and Gitxaala Nation each provided a Project-specific study to LNG Canada (Powell 2013; Calliou Group 2014). Information from these studies, along with other available information provided to LNG Canada (Kitselas Band Council n.d.; McDonald 2003; Lax Kw'alaams 2004) contributed to the list of freshwater systems that are important for Aboriginal harvesters and important for Aboriginal traditional uses (see Freshwater and Estuarine Fish and Fish Habitat Section 5.7.2.5, and Aboriginal Interests Section 14.3.2). Acidification and eutrophication assessments are conducted on these waterways or near the identified Aboriginally important areas (see Stantec 2014c, Section 3.1).

Aboriginal Groups will have additional opportunities to provide information from their traditional land use studies after the Application has been submitted. Ongoing community engagement is summarized in Section 13, Table 13.2-2.

5.9.2.4 Selection of Effects

Two potential effects of the Project on surface water quality (lakes and streams) were identified through EAO Working Group discussions (particularly with the MOE), consultation with Aboriginal Groups, public consultation, and professional judgment and experience of the assessment team:

- change in acidification potential, and
- change in trophic status with potential for eutrophication.

5.9.2.5 Selection of Measurable Parameters

Measurable parameters reflect baseline water quality conditions and are used to assess the potential for acidification and eutrophication in freshwater systems. Measurable parameters are listed in Table 5.9-1. These parameters are based on the needs of the SSWC model for estimating acidification and the inputs required for estimating eutrophication potential.

Table 5.9-1: Potential Effects on Surface Water Quality and Measurable Parameters

Potential Adverse Effects	Measurable Parameters
Change in acidification potential of streams and lakes (related to SO_2 and NO_X emissions)	▪ Water chemistry: routine water quality parameters (e.g., TSS, temperature, total phosphorous, dissolved oxygen), major anions (e.g., chloride, sulphate), dissolved organic carbon (DOC), pH, alkalinity, major cations (e.g., calcium, magnesium) ▪ Acid neutralizing capacity (ANC)[a] ▪ Critical load exceedances (SO_4 and NO_x) in water[b] ▪ Physical stream characteristics (e.g., catchment area, annual flow regimes)
Change in trophic status resulting in eutrophication of lakes and streams (related to N emissions)	▪ Major anions (e.g., sulphate, chloride) and nutrients (e.g., total nitrogen, nitrate, ammonia, nitrite, total phosphorus)

NOTES:

[a] Acid neutralizing capacity is the overall buffering capacity of the water against acidification and is calculated with equivalent weights of anions and cations and with concentrations of organic carbon.

[b] The critical load exceedance is the amount by which the depositional nitrogen and or sulphur is above the critical load (the maximum amount of acid input to protect aquatic ecosystems).

5.9.2.6 Boundaries

5.9.2.6.1 Spatial Boundaries

Spatial boundaries are defined by the modelled nitrogen and sulphate depositional data, as described in the Air Quality TDR (Stantec 2014b).The deposition data incorporates the air emission estimates from all existing and permitted emissions sources, including emissions from the Project. Areas with deposition concentrations above the MOE screening thresholds for acidification (nitrogen and sulphate 15 meq/m^2/y) and for eutrophication (nitrogen alone 35.7 meq/m^2/y) are identified as areas in which a Level 1 (quantitative) critical load and eutrophication assessment will most likely be required (BCMOE 2013a).

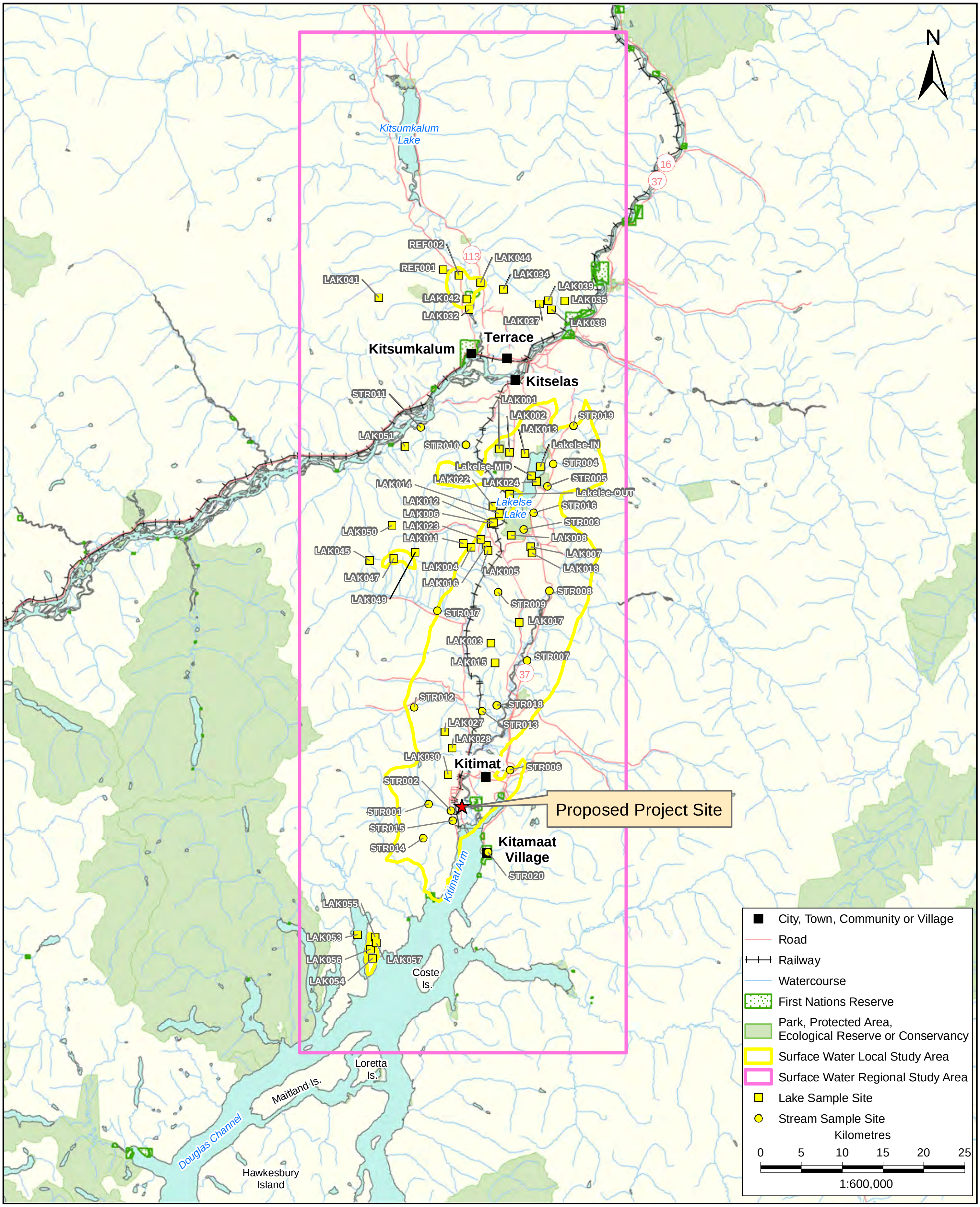
The study areas for the acidification and eutrophication assessments are as follows (see Figure 5.9-1):

- The Project footprint is the area of physical disturbance associated with construction and operation of the Project.
- The LSA encompasses the modelled concentrations that are above the combined sulphate and nitrogen screening threshold (15 meq/m^2/y) as well as sensitive freshwater systems identified as acidic or highly acid sensitive at baseline but not necessarily located in the screening threshold area. The LSA is approximately 79,830 ha and extends approximately 35 km north and 13 km southwest of the LNG facility. Because the area above the eutrophication threshold is restricted to a small area around the LNG facility and is incorporated in the boundary defined by the acidification threshold, only the acidification threshold is used to define the LSA.
- The RSA is approximately 377,950 ha, and it provides a regional context in order to gauge natural conditions. The boundary for the RSA is defined by the area anticipated to receive measurable nitrogen and sulphate deposition below the MOE screening thresholds, and it is the same as the modelling domain developed for assessing air quality.

5.9.2.6.2 Temporal Boundaries

Based on the current Project schedule, the temporal boundaries are:

- construction, Phase 1 (trains 1 and 2) to be completed approximately five to six years following issuance of permits, the subsequent phase(s) (trains 3, 4) to be determined based on market demand
- operation, minimum of 25 years after commissioning, and
- decommissioning, approximately two years at the end of the Project life.



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SURFACE WATER
ACIDIFICATION AND EUTROPHICATION ASSESSMENT

SURFACE WATER LOCAL AND REGIONAL STUDY AREAS

LNG CANADA EXPORT TERMINAL
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PROJECTION UTM9	DRAWN BY SS
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5.9.2.6.3 Administrative and Technical Boundaries

Administrative boundaries for this assessment are the MOE regulatory guidance documents and threshold values. Although not a regulatory requirement, these boundaries are associated with the Draft Critical Loads Screening Chart (BCMOE 2013). That document is classified as a screening procedure to determine if a Level 1 critical load analysis is required for evaluating potential effects of sulphur and nitrogen deposition on freshwater systems.

The technical boundaries include limitations in scientific information, data analyses, and data interpretation relevant to the assessment of Project interactions and effects on watercourses located in the LSA and RSA. These boundaries are also defined by the LSA and RSA spatial boundaries, applicable historical data, and baseline modelling programs for the Project. Limitations in scientific information are mostly related to climate change and seasonal changes. Because climate change effects are expected to occur relatively slowly (i.e., over several decades), they will likely not occur until well into the Project's decommissioning phase. Seasonal changes are addressed by adopting conservative assumptions for the modelling to cover the range of natural variability that may occur in the RSA and LSA.

5.9.2.7 Residual Effects Description Criteria

Residual effects on surface water quality are characterized using the criteria listed in Table 5.9-2.

Table 5.9-2: Characterization of Residual Effects for Surface Water Quality

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Characterization of Residual Effects		
Magnitude	The expected size or severity of effect. Low magnitude effects may have negligible to little effect, while high magnitude effects may have a substantial effect.	**Negligible**—no measurable change from baseline conditions. **Low**—a measurable change from baseline but no critical load exceedance (acidification), or no change in trophic status (eutrophication). **Moderate**—a measurable change from baseline conditions resulting in a critical load exceedance, and sites are considered acid sensitive or acidic at baseline (acidification), or a change in trophic status from oligotrophic to mesotrophic (eutrophication). **High**—a measurable change from baseline conditions resulting in a critical load exceedance, and sites are considered to have moderate to low acid sensitivity at baseline (acidification), or a change in trophic status to eutrophic (eutrophication).
Geographic Extent	The spatial scale over which the residual effects of the Project are expected to occur. The geographic extent of effects can be local or regional. Local effects may have a lower effect than regional effects.	**Project footprint**—residual effects are restricted to the Project footprint. **LSA**—residual effects extend into the LSA. **RSA**—residual effects extend into the RSA.

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Duration	The length of time the residual effect persists. The duration of an effect can be short term or longer term.	**Short-term**—residual effect restricted to the construction phase. **Medium-term**—residual effect extends through operation phase. **Long-term**—residual effect extends beyond closure. **Permanent**—residual effect unlikely to recover to baseline.
Frequency	How often the effect occurs. The frequency of an effect can be frequent or infrequent. Short term and/or infrequent effects may have a lower effect than long term and/or infrequent effects.	**Single event**—occurs once. **Multiple irregular event (no set schedule)**—occurs sporadically at irregular intervals throughout operation. **Multiple regular event**—occurs on a regular basis and at regular intervals throughout operation. **Continuous**—occurs continuously throughout operation.
Reversibility	Whether or not the residual effect on the VC can be reversed once the physical work or activity causing the disturbance ceases. Effects can be reversible or permanent. Reversible effects may have lower effect than irreversible or permanent effects.	**Reversible**—residual effect will recover to existing baseline conditions after Project closure and reclamation. **Irreversible**—residual effect is permanent.
Context	Refers primarily to the sensitivity and resilience of the VC. 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 information about the impact of natural and human-caused trends on the condition of the VC. Project effects may have a higher effect if they occur in areas or regions that: ▪ Have already been adversely affected by human activities (i.e., disturbed or undisturbed) ▪ Are ecologically fragile and have little resilience to imposed stresses (i.e., fragile).	**Low resilience** – low capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance. **Moderate resilience** – moderate capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance. **High resilience** – high capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance.
Likelihood of Residual Effects		
Likelihood	Whether or not a residual effect is likely to occur.	**Low –** low likelihood that there will be a residual effect. **Medium –** moderate likelihood that there will be a residual effect. **High –** high likelihood that there will be a residual effect.

5.9.2.8 Significance Thresholds for Residual Effects

Significance thresholds are based on mandates of the Task Force of the International Cooperative Programme on Modelling and Mapping Critical Loads and Levels and their Air Pollution Effects, Risks and Trends (*ICP Mapping Manual*) and provincial regulatory guidance documents (see Section 5.9.2.1). The thresholds reflect the limits of an acceptable state for surface water quality. Where these do not exist, thresholds are based on scientific literature, aquatic processes (e.g., desired states for freshwater systems), and professional judgment and experience of the assessment team.

Residual effects are considered significant if the predicted:

- acid input exceeds the calculated critical load (defined as the maximum acid input level to protect aquatic biota) and is a concern for site-specific characteristics (i.e., change from baseline conditions, geographical extent, and the frequency of the predicted exceedances (acidification), and
- residual effect results in a change in the trophic status from baseline, with a high likelihood of the waterbody becoming eutrophic (eutrophication).

5.9.3 Baseline Conditions

The following subsections provide a summary of baseline conditions; for a detailed description of baseline conditions, refer to the Surface Water Quality TDR (Stantec 2014c).

5.9.3.1 Baseline Data Sources

Data and information sources used to characterize baseline conditions and to assess acidification and eutrophication in the LSA and RSA were compiled from previous studies and additional field surveys:

- historical data from the RTA *Sulphur Dioxide Technical Assessment Report* (RTA STAR), which were collected during field surveys in August 2012 and included water chemistry data for 41 lakes and 20 stream sites (ESSA Technologies 2013), and
- supplemental data collected by Stantec during field surveys in September 2013, which included water chemistry data collection for 12 lakes and 8 stream sites previously sampled by ESSA Technologies and 2 lakes not previously sampled.

Lakes and streams were selected to reflect a range of conditions (watershed size, elevation, proximity to Kitimat and the LNG facility) encountered in the LSA and RSA.

Eutrophication was not evaluated in the RTA STAR (ESSA Technologies 2013). Therefore, the eutrophication assessment is completed for the 14 lakes and 8 streams sampled by Stantec in 2013.

5.9.3.2 Baseline Overview

Lake and stream water in the LSA and RSA is typical of coastal freshwater systems, with relatively low conductivity, pH, alkalinity, and nutrient levels. Conductivity ranges from 2 µS/cm to 180 µS/cm; pH from 4.6 to 8.3; alkalinity from below detection limit (less than 2.0 mg/L) to 91.5 mg/L; total nitrogen from 0.025 mg/L to 1.0 mg/L; and total phosphorus from 0.003 mg/L to 0.09 mg/L. Water quality parameters were compared with BC Water Quality Guidelines for the protection of aquatic life, and where appropriate, the CCME guidelines (BCMOE 2013b; CCME 2004; CCME 2007). The full baseline dataset is listed and described in the Surface Water Quality TDR (Stantec 2014c).

Waterbodies are further defined in terms of acid sensitivity for the acidification assessment and trophic status for the eutrophication assessment as part of a qualitative analysis (or the Level 0 approach), which is followed by a quantitative (or Level 1) assessment.

Acidification

Acid sensitivity is assessed by calculating the critical load from the acid neutralizing capacity (ANC) and the annual catchment runoff (Q) using the following equation:

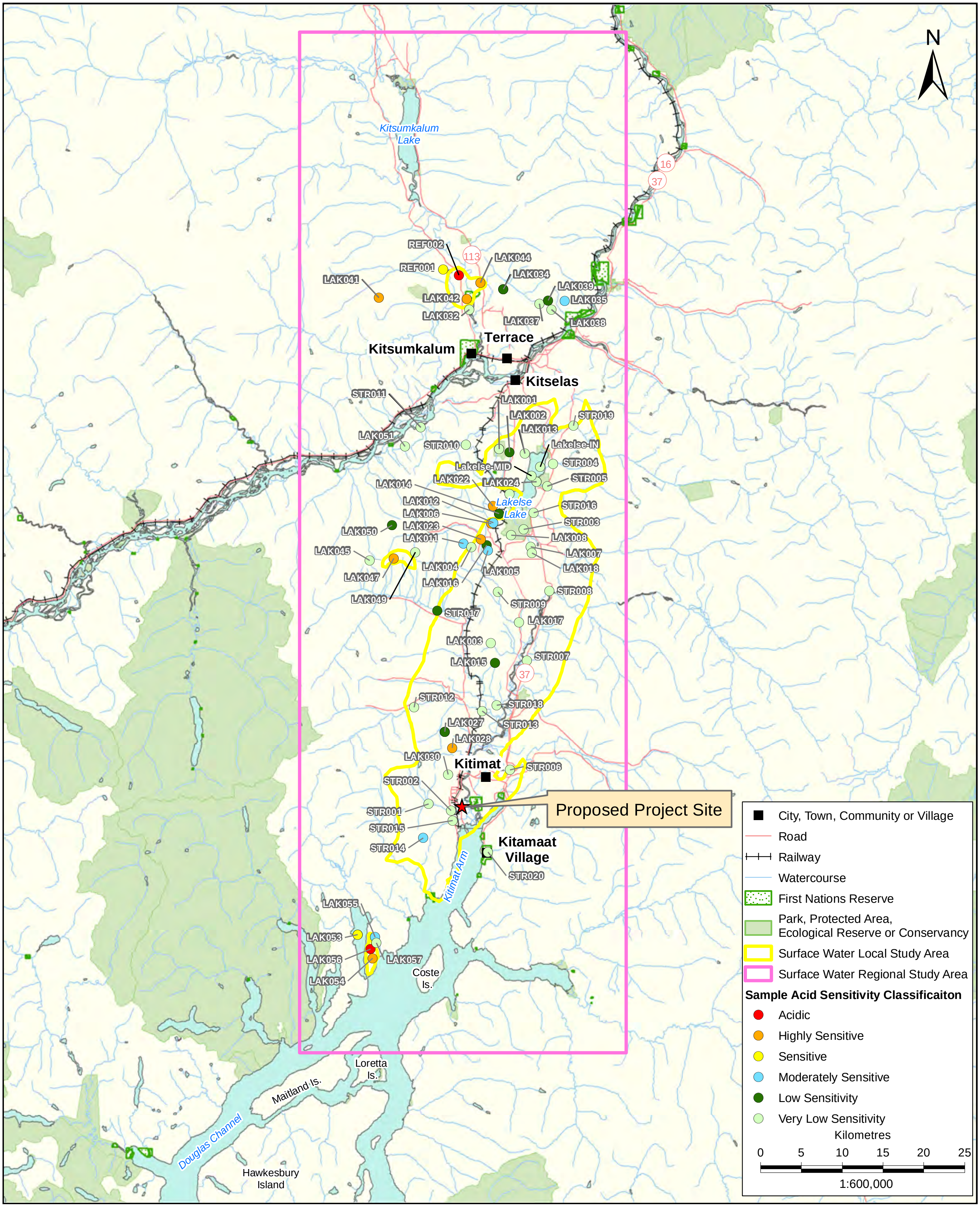
$$\text{Critical Load} = Q\,(ANC - ANC_{limit})$$

The critical load is the maximum annual amount of acid deposition the aquatic environment can receive without effects on ecosystem health (Reynolds 2004). Although Reynolds refers to ecosystem health, there is no specific reference to ecosystem characteristics, except for referring to water quality guidelines for pH (between 6.0 and 9.0), which does not recognize that some waterbodies have naturally low pH. The ANC limit is defined as 40 µeq/L and is the amount of alkalinity required to protect aquatic biota from acidification (Henriksen 2002). The ANC provides an indication of the baseline buffering capacity of the water and is calculated as the difference between the base cations and acid anions (including influences from organic acids) using the following equation:

$$ANC = ([Ca^{2+}] + [Mg^{2+}] + [K^{+}] + [Na^{+}]) - ([SO_4^{2-}] + [NO^{3-}] + [Cl^{-}] + \tfrac{1}{3} * m * TOC)$$

Where TOC is total organic carbon (mg/L) and *m* is the charge density of the organic matter (10.2 µeq/mg, based on Hruska et al. 2001).

Baseline acid sensitivity in the waterbodies is classified as acidic, highly sensitive, sensitive, moderate, low, or very low. Table 5.9-3 provides the definitions in terms of critical load and lists the number of lakes and streams in each category. Figure 5.9-2 shows the locations of the waterbodies and their associated baseline acid sensitivity classification.



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SURFACE WATER
ACIDIFICATION AND EUTROPHICATION ASSESSMENT

ACID SENSITIVITY CLASSIFICATION

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Table 5.9-3: Categories of Acid Sensitivity and Baseline Conditions for Lakes and Streams in the Regional Study Area

Acid Sensitivity	Critical load ($meq/m^2/y$) [a]	Lake Sites	Stream Sites
Acidic	≤0[b]	2	0
High	0 to 20	9	0
Sensitive	20 to 40	2	0
Moderate	40 to 60	5	1
Low	60 to 100	8	1
Very Low	> 100	20	18
Total Sampled Sites		**46**	**20**

NOTES:
[a] ESSA et al. 2013
[b] In addition to the critical load criteria, acidic waterbodies will also have an ANC value less than 0, whereas highly sensitive acid-sensitive waterbodies will have an ANC value greater than 0.

Most sampled lakes (61%) were identified as having low to very low baseline acid sensitivity. Two lakes were identified as acidic (REF 02 [near the southwest border of the RSA] and LAK 56 [near the northern border of the RSA]). Nine lakes were identified as having a high acid sensitivity, with pH ranging from 4.98 to 6.51 (lower than the BC Water Quality Guideline for the Protection of Freshwater Aquatic Life, which ranges from 6.5 to 9.0 [BCMOE 2013b]).

Most sampled streams (90%) were identified as having very low acid sensitivity. One stream was classified as moderate acid sensitivity (STR 14) and one as low acid sensitivity (STR 17). The ANC values for streams were generally well above 100 μeq/L and pH was higher than 6.0, indicating a high buffering capacity and, therefore, protection against acidification.

Eutrophication

The baseline trophic status of the lakes is estimated using the trophic state index (TSI), which uses a logarithmic calculation to produce numerical TSI values ranging from 0 to 100 associated with a trophic class (i.e., oligotrophic, mesotrophic, eutrophic, or hypereutrophic) (Carlson and Simpson 1996). The trophic status in streams is assessed using a classification based on total nitrogen concentrations. The methods used to determine trophic status of lakes and streams are described in detail in the Surface Water Quality TDR (Stantec 2014c).

Ten of the 12 lakes and all 8 streams sampled in 2013 were classified as either oligotrophic (low algal growth) or mesotrophic (moderate algal growth). Two lakes (REF 02 and LAK 23) were classified as eutrophic (high algal growth) and are also in the acid sensitivity classes (REF 02 is acidic and LAK 23 is highly acid sensitive).

The total nitrogen to total phosphorus (TN:TP) ratio ranged from 2:1 to 32:1, with an average ratio of 18:1. According to Stockner and Shortreed (1988), a ratio of less than 14:1 suggests that a water system is nitrogen limited and provides some of the necessary conditions for the predominance of cyanobacteria. The TN:TP ratio was less than 14:1 in 7 of the 22 lakes (suggesting nitrogen limitation) and higher than 14:1 for the remainder (suggesting phosphorus limitation).

5.9.4 Project Interactions

Table 4.4-1 (Section 4) identifies potential interactions of concern between Project activities and each of the selected VCs that are assessed. The potential effects identified in Section 5.9.2.4 that may result in an adverse effect as a result of interactions with Project activities are assessed. The extent to which the interactions will be considered is ranked in Table 5.9-4. The ranking categories (i.e., 0, 1, or 2) in Table 5.9-4 are defined in a footnote to the table.

A conservative approach is taken in assigning a Rank of 1, whereby interactions with a meaningful degree of uncertainty are assigned Rank 2 so that a detailed effects assessment is conducted.

Table 5.9-4: Potential Effects on Surface Water Quality

Project Activities and Physical Works	Potential Effects	
	Change in Acidification Potential	Change in Trophic Status Causing Eutrophication
Facility Activities and Works		
Operation		
LNG production (including natural gas treatment, condensate extraction, storage, and transfer), storage, and loading	2	2

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 BMPs.
2= Interaction may occur and the resulting effect may exceed negligible or acceptable levels without implementation of Project-specific mitigation. Further assessment is warranted.
NOTE: Only activities with an interaction of 1 or 2 for at least one effect are shown.

5.9.4.1 Justification of Interaction Rankings

Shipping activities are ranked as 0 because they are not anticipated to overlap spatially with the surface water quality LSA and RSA.

5.9.4.1.1 Construction

Construction activities are ranked as 0 because air emissions that could interact with water quality and produce acidification or eutrophication of freshwater systems are considered short term and at lower levels when compared with operational air emissions. Air emissions from construction activities are not expected to significantly add to the Project deposition levels; therefore, these have not been included in the acid deposition model. Activities such as site clearing, soil stockpiling, access road development, construction of the LNG facility, and vehicle traffic that could interact with water quality by increasing the level of TSS are discussed in Section 5.7 (Freshwater and Estuarine Fish and Fish Habitat). Construction of the marine terminal and potential effects of dredging activities are discussed in Section 5.8 (Marine Resources).

5.9.4.1.2 Operation

Deposition resulting from Project air emissions of SO_2 and NO_x into receiving freshwater systems is the primary interaction between the Project and water quality. These depositions, mainly occurring during LNG production, including during natural gas treatment and condensate extraction, have the potential to cause acidification and eutrophication of freshwater systems. As such, this activity has been ranked as 2, and effects are assessed in Section 5.9.5.

Interactions between other activities (e.g., road upgrades, road use, vehicle traffic, maintenance, and repairs) and water quality will not result in acidification or eutrophication and are ranked as 0.

5.9.4.1.3 Decommissioning

Decommissioning activities are ranked as 0 because air emissions that could interact and cause acidification or eutrophication of freshwater systems are considered short term and at lower levels when compared with operational air emissions. Air emissions from decommissioning activities are not expected to significantly add to the Project deposition levels; therefore, these have not been included in the acid deposition model.

5.9.5 Assessment of Residual Effects from the LNG Facility

5.9.5.1 Analytical Methods

5.9.5.1.1 Analytical Assessment Techniques

The methods used to assess the potential for acidification and eutrophication of surface water are described in Section 5.9.5.2 and Section 5.9.5.3, respectively.

5.9.5.1.2 Assumptions and the Conservative Approach

The acidification and eutrophication assessments incorporate numerous conservative approaches and assumptions to account for uncertainty. One of the assumptions in the acidification assessment is related to the mobility of nitrogen and sulphate anions. These anions are generally associated with organic matter and sediments and, therefore, are not mobile in aquatic systems. However, the SSWC model assumes that nitrogen and sulphate are fully mobile as a worst-case estimate of their potential effects on freshwater systems. A conservative approach is followed in the calculation of the critical load by using an ANC limit of 40 µeq/L. The ANC limit is the amount of alkalinity required to protect aquatic biota from acidification and is derived from a pH of 6.0, which has been used across Canada as a threshold below which significant biological effects in surface water may occur. A pH of 6.0 roughly corresponds to alkalinity values ranging from 20 to 40 µeq/L (Henriksen 2002); therefore, the proposed ANC limit of 40 µeq/L is considered a conservative threshold. This conservative value does not recognize systems that are naturally low in alkalinity, but which support healthy aquatic ecosystems.

The eutrophication assessment assumes that 90% of the deposited nitrogen will be retained within a watershed, which is a conservative assumption because the amount of nitrogen fixed in freshwater systems generally ranges from 50% to 87% (Harrison et al. 2009).

A conservative approach has also been taken with the air quality model used as the basis for the water quality assessment, for example, in the emissions sulphur and nitrogen contents. A full description of the air modelling assumptions is in Section 5.2.

5.9.5.2 Assessment of Change in Acidification Potential

The change in acidification potential is evaluated using four modelling scenarios: base case, Project-alone case, application case, and cumulative effects case. The base case describes the regional emissions (acid deposition) and current conditions of freshwater systems in the LSA, and it includes all past and present projects in which emissions are expected to overlap spatially and temporally with Project emissions. The emissions from the RTA Facility and Modernization Project and the Kitimat LNG Terminal are included in the base case (these projects are discussed further in Section 5.9.8). The application case includes both the base case and Project-alone case. The cumulative effects case (discussed in Section 5.9.8) includes the base case, the Project emissions, and future projects in the area with emissions that are anticipated to spatially and temporally overlap with those of the Project. Acid deposition from each modelling scenario is used to calculate the critical load exceedance and determine potential regional and Project effects.

The exceedance is defined as the value by which expected nitrogen and sulphur deposition (Ndep and Sdep) will exceed the critical load (capacity of the lake to buffer increasing acidity). This exceedance is calculated using the following equation:

$$\text{Exceedance} = S_{dep} + N_{dep} - \text{Critical Load}$$

This method is taken from the Exceedance Calculations Chapter in the *ICP Mapping Manual* (Posch 2004), where a negative exceedance value indicates Sdep and Ndep is less than the critical load and a positive exceedance indicates Sdep and Ndep is greater than the critical load. The methods used to determine critical load are described briefly in Section 5.9.3 and further in the Surface Water Quality TDR (Stantec 2014c).

5.9.5.2.1 Description of Project Effect Mechanisms for Change in Acidification Potential

During the operation phase, the Project facility will emit SO_2 and NO_x as a result of LNG treatment and production. These emissions have the potential to be deposited into freshwater systems, causing acidification effects. The SO_2 and NO_x can cause acid deposition by reacting with water and oxygen in the atmosphere, with SO_4 and nitrogen forms entering freshwater systems through wet and dry deposition. Once deposited into the waterbody, the sulphate and nitrogen react with hydrogen to produce acidic compounds (e.g., H_2SO_4 and NH_4NO_3). This acid input may generate changes in surface water quality such as a reduction in pH and ultimately cause adverse effects in freshwater systems.

Emissions from existing projects in the area and from the Project are assumed to be dispersed in the atmosphere, with concentrations of SO_2 and NO_x decreasing with distance from operating facilities. While the air emissions will result in increased deposition of SO_2 and NO_x throughout the airshed, the focus of this surface water quality assessment is on depositions that could exceed the lowest screening criteria proposed by MOE (less than 5 $meq/m^2/y$). Increases in the acid deposition are expected to occur in the RSA; however, the residual effects are determined by changes in the acidification potential from the base case. Depositional isopleths are included in the Surface Water Quality TDR (Stantec 2014c).

5.9.5.2.2 Mitigation for Change in Acidification Potential

The following mitigation measures will be implemented to limit the Project emissions of SO_2 and NO_x and their subsequent deposition into surface water:

- Diesel fired equipment will be powered by low sulphur fuel (Mitigation 5.2-7).
- Manage, through Project engineering design and operational procedures, the continuous NOx emissions associated with the gas turbine exhaust to meet regulatory requirements. (Mitigation 5.2-5).

Through engineering design and management plans aimed to reduce emissions of SO_2 and NO_x, the amount of acid deposition introduced into surface water will be decreased.

5.9.5.2.3 Characterization of Change in Acidification Potential

The Sdep and Ndep values used in air quality modelling and critical load calculations assume use of the mitigation measures described in Section 5.9.5.2.2. Most of the evaluated waterbodies (86%) have no exceedance to the critical load (the maximum acid input level to protect aquatic biota) for the application case. However, an exceedance to the critical load in 9 lakes (out of the 66 sampled sites, representing 14% of the sampling sites), is predicted for the application case. Qualitative classification of acid sensitivity based on water chemistry data indicated that these 9 lakes are currently acidic or highly sensitive to acid inputs (Section 5.9.3.2). This result can be due to current emissions from other operations, natural conditions, such as geology and acidic soils that may have influenced the nature of these lakes, or a combination of factors. For streams, no exceedance to the critical load occurs for any of the sampled sites.

The base case and application case critical load exceedance values are shown in Table 5.9-5. Eight lakes have critical load exceedances modelled for the base case, and an increase in the exceedance is modelled for the application case. The application case is predicted to have only one additional critical load exceedance, in End Lake (LAK 06). The magnitude of this exceedance is low and represents about 1% of the sampled sites. For all other lakes and streams, there are no changes from the base case in the number and location of critical load exceedances when compared with the application case. Site locations and application case exceedances are shown in Figure 5.9-3.

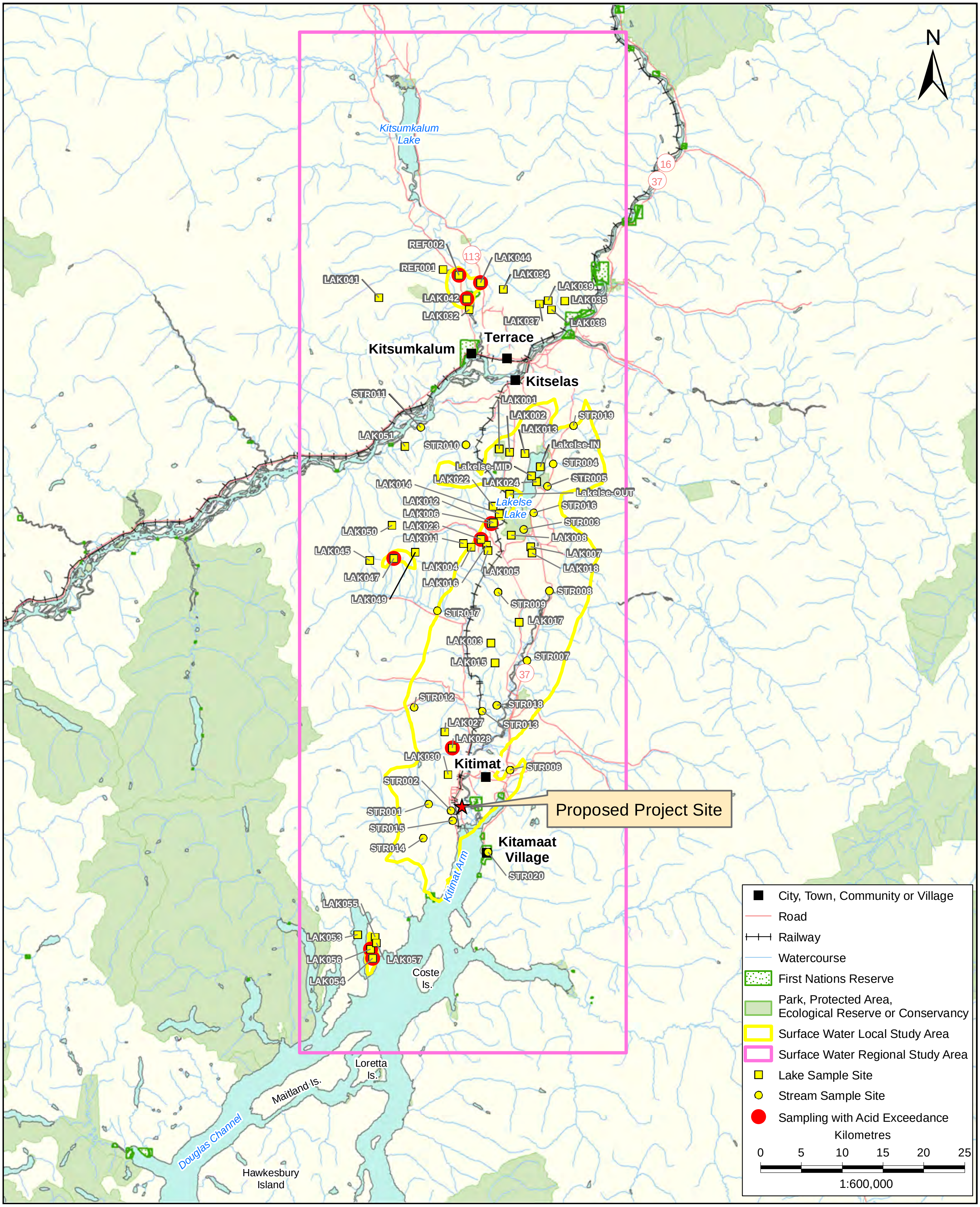
Table 5.9-5: Residual Effects on Acidification Potential for the Base Case and Application Case

Site ID	Waterbody	ANC	Critical Load	Base Case Exceedance Values	Application Case Exceedance Values
		meq/m^3	$meq/m^2/y$	$meq/m^2/y$	$meq/m^2/y$
LAK 01	Hai Lake	1,022.6	786.1	-775.6	-773.0
LAK 02	Herman Lake	125.7	68.5	-57.8	-55.1
LAK 03	Unnamed	285.5	343.6	-316.7	-310.4
LAK 04	Unnamed	194.2	185.1	-174.2	-171.6
LAK 05	Unnamed	93.8	48.4	-36.7	-34.0
LAK 06	End Lake	50.6	9.5	-0.012	2.2
LAK 07	Clearwater Lake	1,477.2	1,437.2	-1,424.9	-1,421.9
LAK 08	Unnamed	1,806	1,589.4	-1,579.5	-1,577.2
LAK 11	Unnamed	85.2	54.3	-45.3	-43.2
LAK 12	Unnamed	96.5	45.2	-35.9	-33.7

Site ID	Waterbody	ANC	Critical Load	Base Case Exceedance Values	Application Case Exceedance Values
		meq/m³	meq/m²/y	meq/m²/y	meq/m²/y
LAK 13	Unnamed	935.5	716.4	-704.9	-701.9
LAK 14	Ena Lake	118.5	70.7	-62.0	-60.0
LAK 15	Unnamed	107.5	87.8	-50.1	-41.0
LAK 16	Unnamed	112.9	65.6	-54.4	-51.7
LAK 17	Unnamed	231.5	210.7	-185.0	-178.8
LAK 18	Clearwater Lakes	1,493	1,453	-1,439.9	-1,436.8
LAK 22	Unnamed	57.5	14	-5.7	-3.7
LAK 23	West Lake	35.8	0	14.7	17.2
LAK 24	Lakelse Lake	322.8	311	-300.7	-297.9
LAK 27	Bowbyes Lake	98.5	99.5	-43.1	-33.5
LAK 28*	Unnamed	0.2	0	154.9	172.4
LAK 30	Unnamed	406.1	659	-560.9	-543.6
LAK 32	Unnamed	1,809.2	1,061.5	-1,055.8	-1,054.4
LAK 34	Unnamed	177.8	96.5	-90.1	-88.5
LAK 35	Unnamed	90.8	45.7	-38.1	-36.3
LAK 37	Unnamed	142.2	102.2	-94.8	-93.0
LAK 38	Unnamed	175	121.5	-113.7	-111.8
LAK 39	Unnamed	107.8	67.8	-60.3	-58.6
LAK 41	Unnamed	52.6	17.7	-13.8	-12.9
LAK 42	Unnamed	6.6	0	13.7	15.2
LAK 44	Unnamed	3.4	0	29.4	30.8
LAK 45	Unnamed	123.6	192.3	-188.2	-187.3
LAK 47	Unnamed	18.6	0	15.6	16.7
LAK 49	Unnamed	117.6	178.6	-172.9	-171.6
LAK 50	Unnamed	71.9	70.2	-65.8	-64.8
LAK 51	Unnamed	279.8	199.3	-193.1	-191.7
LAK 53	Jesse Lake	60.8	37.4	-34.4	-33.8
LAK 54	Unnamed	18.7	0	29.6	30.0
LAK 55	Unnamed	71.5	53.5	-51.0	-50.5
LAK 56*	Unnamed	-11.8	0	69.4	69.8
LAK 57	Unnamed	235.7	332.6	-330.4	-329.9
Lakelse - mid	Lakelse Lake	848.3	889.2	-879.0	-876.2
Lakelse - out	Lakelse Lake	519.8	527.8	-517.2	-514.3
Lakelse - in	Lakelse Lake	510.2	517.2	-510.1	-508.4
REF 01	Unnamed	93.2	35.3	-29.9	-28.6

Site ID	Waterbody	ANC	Critical Load	Base Case	Application Case
				Exceedance Values	Exceedance Values
		meq/m^3	$meq/m^2/y$	$meq/m^2/y$	$meq/m^2/y$
REF 02	Unnamed	-8.2	0	37.5	38.9
Streams					
STR 01	Anderson Creek u/s	104.3	141.4	-105.6	-98.6
STR 02	Anderson Creek d/s	179	333.5	-198.1	-190.3
STR 03	Clearwater Creek	1,646.2	4,015.5	-4,005.1	-4,002.7
STR 04	Furlong Creek	371.3	397.6	-387.4	-384.6
STR 05	Hatchery Creek	360.1	768.2	-756.7	-753.6
STR 06	Hirsch Creek	212.3	361.7	-351.5	-348.3
STR 07	Humphrys Creek	155.8	243.2	-208.8	-200.3
STR 08	Kitimat River u/s	294.4	458	-436.3	-431.0
STR 09	Kitimat River d/s	198.8	254.1	-215.6	-205.1
STR 10	Lakelse River u/s	553.4	975.5	-967.5	-965.6
STR 11	Lakelse River d/s	516.9	906.1	-899.9	-898.4
STR 12	Little Wedeene River u/s	91	107.2	-91.7	-89.2
STR 13	Little Wedeene River d/s	107.5	135.1	-75.9	-59.4
STR 14*	Moore Creek u/s	65.3	48.1	-9.1	-4.3
STR 15	Moore Creek d/s	115.7	196.8	-157.5	-152.8
STR 16	Schulbuckhand Creek	476.9	611.7	-602.1	-599.8
STR 17	Wedeene River u/s	82.9	77.3	-66.0	-63.6
STR 18	Wedeene River	146.2	212.4	-164.7	-151.6
STR 19	Williams Creek	273.8	304	-295.3	-293.0
STR 20	Wathl Creek	324.8	655.1	-650.7	-649.7

NOTE:
Grey highlighting shows critical load exceedances



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Stantec	*SURFACE WATER* *ACIDIFICATION AND EUTROPHICATION ASSESSMENT*	PROJECTION UTM9	DRAWN BY SS
	ACID EXCEEDANCES	DATUM NAD 83	CHECKED BY SW
	LNG CANADA EXPORT TERMINAL KITIMAT, BRITISH COLUMBIA	DATE 25-JUN-14	FIGURE NO. **5.9-3**

The exceedances are related to existing conditions identified in the base case, which includes emissions from RTA Facility and Modernization Project and Kitimat LNG Terminal. The emissions from these existing facilities are anticipated to contribute more than 80% of the total deposition as shown in Figure 5.9-4. The Project only contribution is expected to be less than 20%, minimally contributing to the depositions already present in the area.

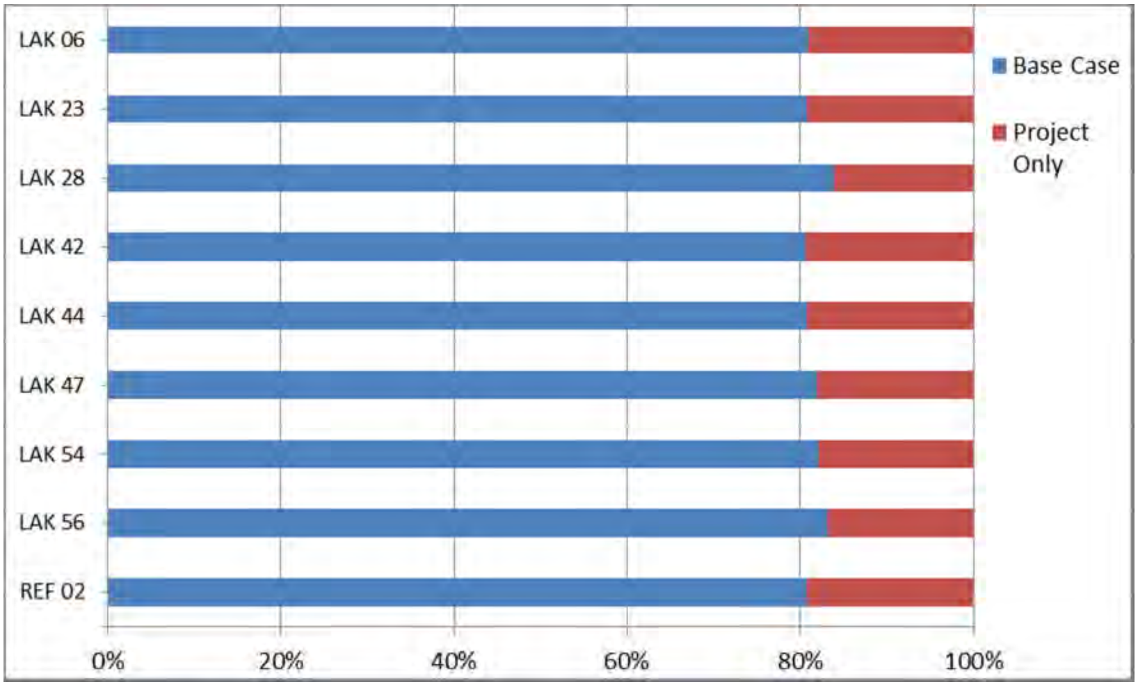

Figure 5.9-4: Base Case and Project only Nitrogen and Sulphate Deposition

NOTE: Only the sites with critical load exceedances are shown

The effects on water quality will not result in exceedances to the critical load for most freshwater systems located in the LSA. Most of the base case and application case exceedances to the critical load are recorded for acidic or highly acid sensitive lakes, ranging in pH from 4.50 to 6.24. These lakes have observed or inferred fish habitat based on lake characteristics (ESSA Technologies 2013), despite the low pH values. This situation indicates that that biota inhabiting these systems may have adapted to low pH conditions. Thus, residual effects are not anticipated to impair the ability of these watercourses to sustain aquatic life.

Residual effects resulting in acidification, with mitigation, are anticipated to be low to moderate in magnitude (86% of the lakes and streams have a low magnitude effect with no critical load exceedances, and 14% have a moderate magnitude effect with exceedances), in the LSA, continuous (to occur throughout the operation phase), and reversible. The lakes and streams are anticipated to have a high capacity to recover; however, nine of the lakes that identified as acidic or highly acid sensitive at the base case are expected to have a low to moderate resilience, given that they are already classified as highly sensitive to acid inputs.

5.9.5.2.4 Determination of Significance for Change in Acidification Potential

With mitigation and environmental protection measures, changes in acidification potential are not significant.

Residual effects during operation have the following characteristics:

- Exceedances are localized in geographic extent (limited to a few acid-sensitive waterbodies within the LSA), continuous during Project operation and reversible after cessation of emissions at closure.
- Residual effects are low to moderate in magnitude, with less than 14% of freshwater systems located in the LSA modelled as having exceedances to the critical load; all of the sites with exceedances are acid sensitive or acidic, as defined by measurable parameters at base case, and all but one of the sites already has an exceedance for the base case.

There is a high degree of confidence that these conclusions will be no worse than predicted given the conservative approach adopted in the acidification assessment, the conservative approach used in the air modelling, and the confidence in the effectiveness of the mitigation measures.

5.9.5.3 Assessment of Change in Trophic Status Causing Eutrophication

To assess the change in trophic status for lakes and streams resulting from atmospheric deposition of NO_x, the following steps are used:

1. Baseline trophic status (pre-Project) is determined using total nitrogen concentrations provided in Stantec 2013 water chemistry data.
2. Predicted total nitrogen, estimated from modelled atmospheric deposition of NO_X, is used to predict future trophic status.
3. Baseline trophic status (pre-Project) is compared to predicted trophic status.

5.9.5.3.1 Description of Project Effect Mechanisms for Change in Trophic Status Causing Eutrophication

The total nitrogen estimated from modelled atmospheric deposition of NO_x (base case, Project-alone case, application case, and cumulative case) is determined by calculating the increase in total nitrogen between the base case and the Project-alone case and adding the increase to the total nitrogen concentration for the baseline water chemistry data. The methods used to assess eutrophication potential are described in detail in the Surface Water Quality TDR (Stantec 2014c). Results from Section 5.2 for the base case and the application case (as defined in that section) are used. The cumulative effects case is discussed in Section 5.9.8.

During the operation phase, the Project facility will emit NO_x during LNG production. These emissions have the potential to be deposited into freshwater systems, causing increases in the level of nitrogen that have the potential to cause eutrophication effects. Nitrogen is a nutrient for aquatic plants. Excessive nutrient levels can cause dense aquatic plant growth, which can deplete dissolved oxygen in the water when the plants decompose and can decrease diversity in the affected aquatic system.

The spatial extent of nitrogen deposition (mechanism for eutrophication) is defined by modelled nitrogen depositional data described in the Air Quality TDR (Stantec 2014b). As mentioned in Section 5.9.5.3, in order to assess residual effects, the increase in total nitrogen between the base case and the application case is evaluated. The trophic status is not anticipated to change between the base case and the application case for any of the assessed sites. However, the total nitrogen concentration from base case to application case is expected to increase throughout the RSA, according to air quality modelling.

5.9.5.3.2 Mitigation for Change in Trophic Status Causing Eutrophication

The following mitigation measure will be implemented to limit the Project NO_x emissions and subsequent deposition into surface water: manage, through Project engineering design and operational procedures, the continuous NO_x emissions associated with the gas turbine exhaust to meet regulatory requirements (Mitigation 5.2-5).

Through engineering design and management plans aimed at managing emissions of NO_x, the amount of acid deposition introduced into surface water will be decreased.

5.9.5.3.3 Characterization of Change in Trophic Status Causing Eutrophication

Residual effects for the base case and application case are shown in Table 5.9-6. The predicted increase in total nitrogen related to Project emissions ranges from 0.001 g/m^3 (for LAK 54, from 0.386 g/m^3 to 0.387 g/m^3) to 0.007 g/m^3 (for STR 18, from 0.130 g/m^3 to 0.137 g/m^3), or 0.1% to 5.3% compared to the base case.

With mitigation, Project-related nitrogen deposition will result in a low-magnitude effect in the LSA, and will be continuous in frequency, long term in duration (throughout operation), and reversible after operation ceases. Most lakes and streams are anticipated to have a high capacity to recover; however, the two lakes identified as eutrophic at base case are expected to have a low to moderate resilience because of their already eutrophic state. The effects are not anticipated to result in a change of trophic status for any of the aquatic systems in the LSA.

Table 5.9-6: Residual Effects on Trophic Status for the Base Case and the Application Case

Site ID	Waterbody	Base Case	Application Case	Percent Increase	Predicted - Trophic Status
		Predicted Total Nitrogen	Predicted Total Nitrogen		
		g/m^3	g/m^3	%	
LAK 06	End Lake	0.218	0.221	1.2	Oligotrophic
LAK 12	Unnamed	0.679	0.682	0.4	Mesotrophic
LAK 22	Unnamed	0.225	0.228	1.2	Oligotrophic
LAK 23	West Lake	0.906	0.909	0.4	Eutrophic
LAK 42	Unnamed	0.502	0.504	0.4	Mesotrophic
LAK 44	Unnamed	0.168	0.170	1.3	Oligotrophic
LAK 47	Unnamed	0.025	0.026	3.5	Oligotrophic
LAK 51	Unnamed	0.551	0.553	0.4	Mesotrophic
LAK 54	Unnamed	0.386	0.387	0.1	Mesotrophic
Lakelse in	Lakelse Lake	0.123	0.125	2.3	Oligotrophic
Lakelse mid	Lakelse Lake	0.097	0.100	3.0	Oligotrophic
Lakelse out	Lakelse Lake	0.095	0.097	1.8	Oligotrophic
REF 01	Unnamed	0.579	0.581	0.3	Mesotrophic
REF 02	Unnamed	1.031	1.033	0.2	Eutrophic
Streams					
STR 02	Anderson Creek d/s	0.401	0.404	0.9	Oligotrophic
STR 03	Clearwater Creek	0.051	0.052	2.1	Oligotrophic
STR 05	Hatchery Creek	0.071	0.073	1.9	Oligotrophic
STR 08	Kitimat River u/s	0.159	0.162	2.0	Oligotrophic
STR 10	Lakelse River u/s	0.502	0.503	0.2	Oligotrophic
STR 11	Lakelse River d/s	0.854	0.855	0.1	Mesotrophic
STR 15	Moore Creek d/s	0.342	0.344	0.6	Oligotrophic
STR 18	Wedeene River	0.130	0.138	5.3	Oligotrophic

5.9.5.3.4 Determination of Significance for Change in Trophic Status Causing Eutrophication

With mitigation, eutrophication is not significant. No freshwater systems are anticipated to have a change in trophic status compared to base case, and the two lakes in the LSA that are currently considered eutrophic will have negligible changes in nitrogen loading (0.2% to 0.4% increase).

There is a high degree of confidence that these conclusions will be no worse than predicted, given the conservative approach used with respect to the eutrophication assessment and air model, and confidence in the effectiveness of the mitigation measures.

5.9.5.4 Summary of Residual Effects from the LNG Facility

Overall, residual effects are expected to be low to moderate in magnitude, in the LSA, and long term in duration. Project contributions to acidification or eutrophication effects are considered to be reversible after Project emissions cease. Residual effects on surface water quality from Project emissions are assessed as not significant.

5.9.6 Assessment of Residual Effects from Shipping

No effects on surface water quality are anticipated from marine shipping. (Potential effects due to air emissions related to marine shipping have been incorporated into the dispersion modelling used as a basis to assess effects on lakes and streams in the RSA.)

5.9.7 Summary of Project Residual Effects

Residual effects on surface water quality are summarized in Table 5.9-7.

Table 5.9-7: Summary of Project Residual Effects: Surface Water Quality

Project Phase	Mitigation Measures	Residual Effects Rating Criteria: Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context	Likelihood of Residual Effects	Significance	Prediction Confidence	Follow-up and Monitoring
Facility Works and Activities											
Change in Acidification Potential: *emissions of the LNG facility during operation will contribute to acidification of lakes and streams*											
Construction	Mitigation 5.2-5 Mitigation 5.2-7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Operation		L-M	LSA	LT	C	R	L-M	M	N	H	N/A
Decommissioning		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Residual effects for all phases		L-M	LSA	LT	C	R	L-M	M	N	M	N/A
Change in Trophic Status Causing Eutrophication: *emissions of the LNG facility during operation will contribute to nutrient loading into lakes and streams*											
Construction	Mitigation 5.2-5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Operation		L	LSA	LT	C	R	L-M	L	N	H	N/A
Decommissioning		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Residual effects for all phases		L	LSA	LT	C	R	L-M	L	N	H	N/A
Shipping Activities											
Change in Acidification Potential and Trophic Status: *no effects from marine shipping are expected on surface water quality*											
Construction		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Operation		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Decommissioning		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Project Phase	Mitigation Measures	Residual Effects Rating Criteria						Likelihood of Residual Effects	Significance	Prediction Confidence	Follow-up and Monitoring
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context				
Residual effects for all phases		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

KEY

MAGNITUDE:

N = Negligible—no measurable change from baseline conditions

L = Low—a measurable change from baseline but no critical load exceedance (acidification), or no change in trophic status (eutrophication)

M = Moderate—a measurable change from baseline conditions resulting in a critical load exceedance, and sites are considered acid sensitive or acidic at baseline (acidification), or a change in trophic status from oligotrophic to mesotrophic (eutrophication)

H = High—a measurable change from baseline conditions resulting in a critical load exceedance, and sites are considered to have moderate to low acid sensitivity at baseline (acidification), or a change in trophic status to eutrophic (eutrophication)

GEOGRAPHIC EXTENT:

PF = Project footprint—residual effects are restricted to the Project footprint

LSA—residual effects extend into the LSA

RSA—residual effects extend into the RSA

DURATION:

ST = Short-term—residual effect restricted to the construction phase

MT = Medium-term—residual effect extends through operation phase

LT = Long-term—residual effect extends beyond closure

P = Permanent—residual effect unlikely to recover to baseline

FREQUENCY:

S = Single event—occurs once

I = Multiple irregular event)—occurs sporadically at irregular intervals throughout operation

R = Multiple regular event—occurs on a regular basis and at regular intervals throughout operation

C = Continuous—occurs continuously throughout operation.

REVERSIBILITY:

R = Reversible—residual effect will recover to existing baseline conditions after Project closure and reclamation

I = Irreversible—residual effect is permanent.

CONTEXT:

L = Low resilience—low capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

M = Moderate resilience—moderate capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

H = High resilience—high capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

SIGNIFICANCE:

S = Significant

N = Not Significant

PREDICTION CONFIDENCE:

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

LIKELIHOOD OF RESIDUAL EFFECT OCCURRING:

Based on professional judgment

L = Low likelihood that there will be a residual effect

M = Moderate likelihood that there will be a residual effect

H = High likelihood that there will be a residual effect

N/A = Not Applicable

5.9.8 Assessment of Cumulative Effects

Cumulative effects are considered for each Project-specific residual effect. Three stages are involved: (1) establishing context by providing an overview of the cumulative effects of other projects and activities on surface water; (2) determining the potential for Project-specific residual effects to interact with the effects of other projects and activities; and, if the Project does interact cumulatively with other actions, (3) assessing the significance of the resulting overall cumulative effect and characterizing the Project's contribution to the change in cumulative effects.

5.9.8.1 Stage 1, Cumulative Effects Context

Qualitative classification of acid sensitivity based on water chemistry data (Section 5.9.3) indicates that the nine lakes (with exceedances for the application case) studied in the LSA are already acidic or highly sensitive to acid inputs due to existing emissions from other operations, natural lake conditions, or a combination of factors. Although the pH of these nine lakes ranges from 4.50 to 6.24, fish habitat has been observed, indicating that they should be capable of sustaining healthy aquatic communities. Two of the lakes in the LSA are considered eutrophic at base case, which can also be related to natural conditions or anthropogenic activities.

The Project's contribution to cumulative effects on surface water quality is assessed by evaluating the base case and cumulative case modelling scenarios. Projects that are not expected to have nitrogen and sulphur emissions during operations are not considered in the cumulative effects assessment (e.g., pipeline projects). Past, present, and reasonably foreseeable future-project works included in the cumulative case are:

- RTA Facility and Modernization Project. The modernized facility is to be updated and expanded from 280,000 tonnes to 420,000 tonnes per annum by 2015, with operations continuing throughout the modernization program.
- Kitimat LNG Terminal. The LNG facility and marine loading facilities is to be located at Bish Cove, south of Kitimat, with a 10 million tonnes per annum capacity. Construction is underway and is expected to be finished in 2015/2016; operation is planned for 2015/2016 to 2040/2041. The project includes a 14 km natural gas pipeline to connect with Pacific Trail Pipeline near Minette substation. Also, the project includes redeveloping the former Eurocan mill site as a project lay down and construction camp. Certified by the EAO in June 2006.
- Douglas Channel LNG Terminal. The proposed small-scale LNG facility is located on the west side of Douglas Channel, south of Moon Bay. Using existing capacity from Pacific Northern Gas' pipeline, the facility will produce approximately 900,000 tonnes of LNG per annum. The gas export licence was granted February 2012.

- Enbridge Northern Gateway. The proposed oil export terminal is in Kitimat. The project includes two parallel pipelines; one to transport bitumen from Edmonton to Kitimat (for export) and the other to transport imported condensate from Kitimat back to Edmonton. The Project is currently waiting for a decision from Cabinet.
- Kitimat Clean Ltd. The proposed oil refinery is located approximately 25 km north of Kitimat, BC that is proposing to import diluted bitumen by rail or pipeline for the purpose of processing approximately 87,445 m^3 of refined bitumen/d.

5.9.8.2 Stage 2, Determination of Potential Cumulative Interactions

The potential for interactions between past, present, and future activities with the Project-related effects is shown in Table 5.9-8. The potential for cumulative effects is identified through spatial and temporal overlaps of emissions effects. Projects that are not expected to have nitrogen and sulphur emissions during operations are not considered in the cumulative effects assessment (e.g., pipeline projects).

Table 5.9-8: Potential for Cumulative Effects on Surface Water Quality

Other Projects and Activities with Potential for Cumulative Effects	Potential Cumulative Effects	
	Surface water acidification from the facility	Surface water eutrophication from the facility
Kitimat Area Project/Facility		
Douglas Channel LNG Project (also known as BC LNG)	✓	✓
Enbridge Northern Gateway Project	✓	✓
Kitimat Clean	✓	✓
Kitimat LNG Terminal Project	✓	✓
Rio Tinto Alcan Facility and Modernization Project	✓	✓

NOTES:
✓ = those ‘other projects and activities’ whose effects have potential to interact cumulatively with the Project’s residual effects.

Residual effects from the Project spatially and temporally overlap with effects of past, present, and reasonably foreseeable projects identified in Table 5.9-8; therefore, cumulative effects are discussed further.

5.9.8.3 Stage 3, Determining Significance of Cumulative Effects

5.9.8.3.1 Change in Acidification Potential

Modelled acid deposition is compared between the application case (Project emissions plus base case conditions) and the cumulative effects case (Table 5.9-9); there will be a small but measurable increase in emissions of SO_2 and NO_X that will contribute to the acid deposition over the LSA and RSA. Trends are similar to those noted in Section 5.9.5 for the application case, with nine lakes showing critical load exceedances. The emissions from past, present, and reasonably foreseeable projects are expected to contribute more than 80% of the total acid deposition as shown in Figure 5.9-5.

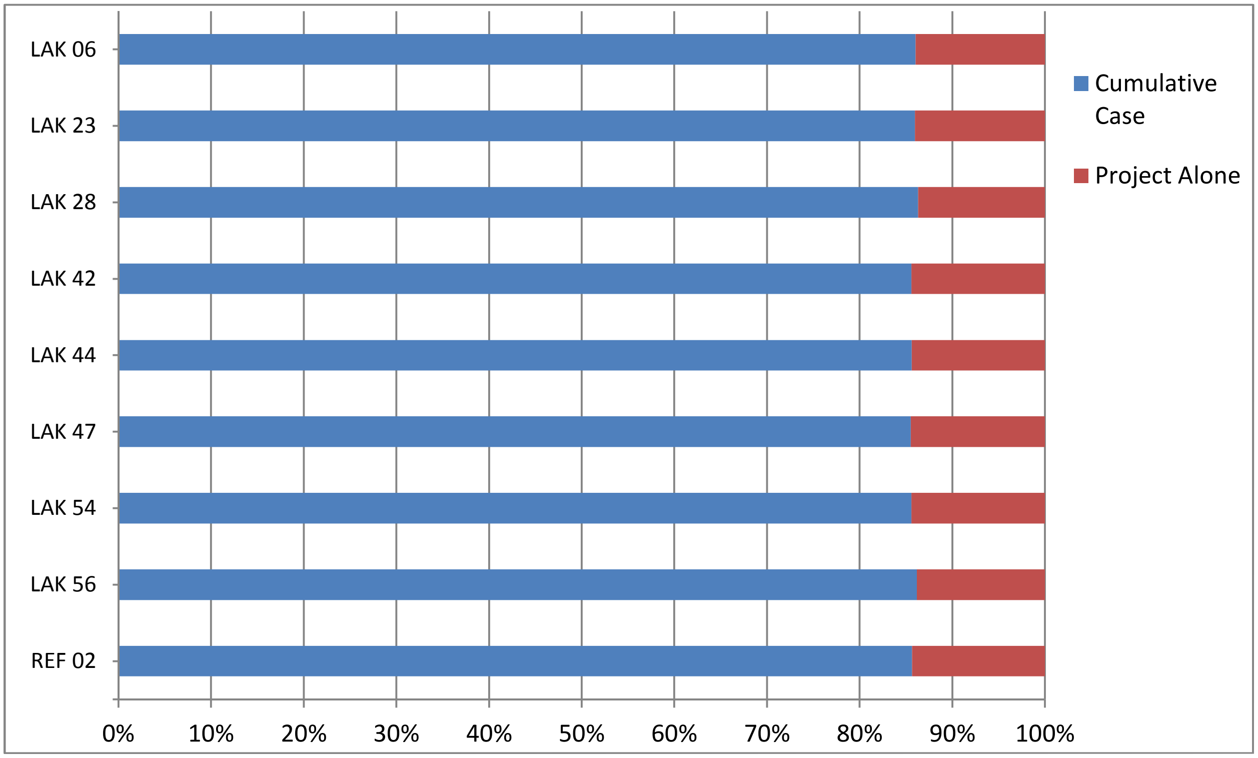

Figure 5.9-5: Cumulative Case and Project-alone Nitrogen and Sulphate Deposition

NOTE: Shown for sites with critical load exceedances only

The significance threshold for cumulative effects on surface water quality is defined as an exceedance to the critical load (defined as the maximum acid input level to protect aquatic biota) relative to the base case, geographical extent, and the frequency of the predicted exceedances (Section 5.9.2.8). As shown in Table 5.9-9, there are no anticipated changes from the base case in the number of exceedances, or to the geographic extent.

There is a high degree of confidence that cumulative effects on water quality with the potential to lead to acidification of freshwater systems will be not significant and that the number of acidification exceedances in freshwater systems will not increase above the application case (base case and Project-alone effects). Furthermore, Figure 5.9-5 shows the Project nitrogen and sulphate deposition compared with those of nearby facilities and illustrates the low incremental loading attributable to Project emissions in the LSA and RSA.

Table 5.9-9: Cumulative Effects on Acidification Potential (Critical Load Exceedances)

Site ID	Waterbody	ANC	Critical Load	Application Case Exceedance Values	Cumulative Case Exceedance Values
		meq/m^3	meq/m^2/y	meq/m^2/y	meq/m^2/y
LAK 01	Hai Lake	1,022.6	786.1	-773.0	-770.2
LAK 02	Herman Lake	125.7	68.5	-55.1	-52.4
LAK 03	Unnamed	285.5	343.6	-310.4	-309.1
LAK 04	Unnamed	194.2	185.1	-171.6	-168.8
LAK 05	Unnamed	93.8	48.4	-34.0	-31.5
LAK 06	End Lake	50.6	9.5	2.2	4.3
LAK 07	Clearwater Lake	1,477.2	1,437.2	-1,421.9	-1,404.4
LAK 08	Unnamed	1,806	1,589.4	-1,577.2	-1,572.0
LAK 11	Unnamed	85.2	54.3	-43.2	-41.5
LAK 12	Unnamed	96.5	45.2	-33.7	-31.4
LAK 13	Unnamed	935.5	716.4	-701.9	-698.3
LAK 14	Ena Lake	118.5	70.7	-60.0	-57.7
LAK 15	Unnamed	107.5	87.8	-41.0	-39.6
LAK 16	Unnamed	112.9	65.6	-51.7	-49.4
LAK 17	Unnamed	231.5	210.7	-178.8	-176.3
LAK 18	Clearwater Lakes	1,493	1,453	-1,436.8	-1,416.5
LAK 22	Unnamed	57.5	14	-3.7	-2.1
LAK 23	West Lake	35.8	0	17.2	19.7
LAK 24	Lakelse Lake	322.8	311	-297.9	-293.2
LAK 27	Bowbyes Lake	98.5	99.5	-33.5	-32.5
LAK 28*	Unnamed	0.2	0	172.4	173.9
LAK 30	Unnamed	406.1	659	-543.6	-542.1
LAK 32	Unnamed	1,809.2	1,061.5	-1,054.4	-1,053.3
LAK 34	Unnamed	177.8	96.5	-88.5	-87.3
LAK 35	Unnamed	90.8	45.7	-36.3	-34.5
LAK 37	Unnamed	142.2	102.2	-93.0	-91.4
LAK 38	Unnamed	175	121.5	-111.8	-110.0
LAK 39	Unnamed	107.8	67.8	-58.6	-56.9
LAK 41	Unnamed	52.6	17.7	-12.9	-12.3
LAK 42	Unnamed	6.6	0	15.2	16.3
LAK 44	Unnamed	3.4	0	30.8	31.9
LAK 45	Unnamed	123.6	192.3	-187.3	-187.0
LAK 47	Unnamed	18.6	0	16.7	17.0
LAK 49	Unnamed	117.6	178.6	-171.6	-171.1

Site ID	Waterbody	ANC	Critical Load	Application Case	Cumulative Case
				Exceedance Values	Exceedance Values
		meq/m^3	meq/m^2/y	meq/m^2/y	meq/m^2/y
LAK 50	Unnamed	71.9	70.2	-64.8	-64.4
LAK 51	Unnamed	279.8	199.3	-191.7	-190.6
LAK 53	Jesse Lake	60.8	37.4	-33.8	-33.7
LAK 54	Unnamed	18.7	0	30.0	30.1
LAK 55	Unnamed	71.5	53.5	-50.5	-50.4
LAK 56*	Unnamed	-11.8	0	69.8	70.0
LAK 57	Unnamed	235.7	332.6	-329.9	-329.8
Lakelse - mid	Lakelse Lake	848.3	889.2	-876.2	-871.5
Lakelse - out	Lakelse Lake	519.8	527.8	-514.3	-509.4
Lakelse - in	Lakelse Lake	510.2	517.2	-508.4	-505.4
REF 01	Unnamed	93.2	35.3	-28.6	-27.7
REF 02	Unnamed	-8.2	0	38.9	39.9
Streams					
STR 01	Anderson Creek u/s	104.3	141.4	-98.6	-97.8
STR 02	Anderson Creek d/s	179	333.5	-190.3	-188.2
STR 03	Clearwater Creek	1,646.2	4,015.5	-4,002.7	-3,993.4
STR 04	Furlong Creek	371.3	397.6	-384.6	-380.4
STR 05	Hatchery Creek	360.1	768.2	-753.6	-747.6
STR 06	Hirsch Creek	212.3	361.7	-348.3	-347.7
STR 07	Humphrys Creek	155.8	243.2	-200.3	-198.9
STR 08	Kitimat River u/s	294.4	458	-431.0	-427.9
STR 09	Kitimat River d/s	198.8	254.1	-205.1	-204.1
STR 10	Lakelse River u/s	553.4	975.5	-965.6	-963.7
STR 11	Lakelse River d/s	516.9	906.1	-898.4	-897.3
STR 12	Little Wedeene River u/s	91	107.2	-89.2	-88.8
STR 13	Little Wedeene River d/s	107.5	135.1	-59.4	-58.0
STR 14*	Moore Creek u/s	65.3	48.1	-4.3	-3.9
STR 15	Moore Creek d/s	115.7	196.8	-152.8	-150.3
STR 16	Schulbuckhand Creek	476.9	611.7	-599.8	-592.7
STR 17	Wedeene River u/s	82.9	77.3	-63.6	-62.6
STR 18	Wedeene River	146.2	212.4	-151.6	-150.3
STR 19	Williams Creek	273.8	304	-293.0	-290.3
STR 20	Wathl Creek	324.8	655.1	-649.7	-649.3

Determination of significance of cumulative effects uses the thresholds identified in Section 5.9.2.8. Cumulative effects on water quality that could lead to acidification are assessed as not significant because no changes to potential acidification are anticipated with the addition of the Project. The effects will be continuous and reversible in an area already disturbed by emissions generated by other operating facilities.

5.9.8.3.2 Change in Trophic Status Causing Eutrophication

The comparison of predicted nitrogen loads in the application case (Project emissions plus base case conditions) with the cumulative effects case shows an increase in nitrogen load that will contribute to the total nitrogen concentrations in freshwater systems located in the LSA and RSA (Table 5.9-10). The highest percentage increase between the two cases is predicted to occur at STR 03 (3.8%). However, the magnitude of change is expected to be low because the increase of total nitrogen is not anticipated to change the trophic status of any of the studied watercourses.

Table 5.9-10: Cumulative Effects on Trophic Status Causing Eutrophication

Site ID	Waterbody	Application Case	Cumulative Case	Percentage Increase	Trophic status
		Predicted Total Nitrogen	Predicted Total Nitrogen		
		g/m^3	g/m^3	%	
LAK 06	End Lake	0.22	0.22	0.7	Oligotrophic
LAK 12	Unnamed	0.68	0.68	0.3	Mesotrophic
LAK 22	Unnamed	0.23	0.23	0.5	Oligotrophic
LAK 23	West Lake	0.91	0.91	0.2	Eutrophic
LAK 42	Unnamed	0.50	0.51	0.2	Mesotrophic
LAK 44	Unnamed	0.17	0.17	0.5	Oligotrophic
LAK 47	Unnamed	0.03	0.03	0.6	Oligotrophic
LAK 51	Unnamed	0.55	0.55	0.1	Mesotrophic
LAK 54	Unnamed	0.39	0.39	0.0	Mesotrophic
Lakelse in	Lakelse Lake	0.13	0.13	1.6	Oligotrophic
Lakelse mid	Lakelse Lake	0.10	0.10	2.2	Oligotrophic
Lakelse out	Lakelse Lake	0.10	0.10	1.6	Oligotrophic
REF 01	Unnamed	0.58	0.58	0.1	Mesotrophic
REF 02	Unnamed	1.03	1.03	0.1	Eutrophic
Streams					
STR 02	Anderson Creek d/s	0.40	0.41	0.3	Oligotrophic
STR 03	Clearwater Creek	0.05	0.05	3.8	Oligotrophic
STR 05	Hatchery Creek	0.07	0.07	1.5	Oligotrophic
STR 08	Kitimat River u/s	0.16	0.16	0.3	Oligotrophic

Site ID	Waterbody	Application Case	Cumulative Case	Percentage Increase	Trophic status
		Predicted Total Nitrogen	Predicted Total Nitrogen		
		g/m^3	g/m^3	%	
STR 10	Lakelse River u/s	0.50	0.50	0.1	Oligotrophic
STR 11	Lakelse River d/s	0.86	0.86	0.0	Mesotrophic
STR 15	Moore Creek d/s	0.34	0.35	0.3	Oligotrophic
STR 18	Wedeene River	0.14	0.14	0.5	Oligotrophic

The significance threshold for cumulative effects on surface water quality is defined as a change in trophic status from the baseline, with a high likelihood of the waterbody becoming eutrophic (Section 5.9.2.8). With mitigation and environmental protection measures, the cumulative effect of nitrogen emissions from the Project and from other past, present, and reasonably foreseeable projects on eutrophication is assessed as not significant for all lakes and streams in the LSA and RSA.

Determination of significance of cumulative effects is based on the thresholds provided in Section 5.9.2.8. Cumulative effects on water quality that could lead to eutrophication are assessed as not significant, given the low magnitude and regional extent of the effects identified.

5.9.8.4 Summary of Cumulative Effects

Cumulative change in acidification potential and change in trophic status from past, present, and foreseeable future projects are low in magnitude, restricted to the LSA, continuous (throughout the operation), and reversible. As such, cumulative effects are assessed as not significant (Table 5.9-11).

Table 5.9-11: Summary of Cumulative Effects on Surface Water Quality

Effect	Other Projects, Activities and Actions	Cumulative Effects Characterization					
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context
Facility Works and Activities							
Cumulative change in the acidification potential of streams and lakes							
Cumulative effect with the Project and other projects, activities, and actions ▪ Change in the acidification potential of streams and lakes related to SO_2 and NO_X emissions	▪ Douglas Channel LNG Project (also known as BC LNG) ▪ Enbridge Northern Gateway Project ▪ Kitimat Clean ▪ Kitimat LNG Terminal Project ▪ Rio Tinto Alcan Facility and Modernization Project	M	LSA	LT	C	R	M
Contribution from the Project to the overall cumulative effect ▪ Change in the acidification potential of streams and lakes related to emissions of SO_2 and NO_X during operation		L/M	LSA	LT	C	R	M
Cumulative change in trophic status resulting in eutrophication of lakes and streams							
Cumulative effect with the Project and other projects, activities, and actions ▪ Change in trophic status resulting in eutrophication of lakes and streams related to nitrogen emissions	▪ Douglas Channel LNG Project (also known as BC LNG) ▪ Enbridge Northern Gateway Project ▪ Kitimat Clean ▪ Kitimat LNG Terminal Project ▪ Rio Tinto Alcan Facility and Modernization Project	L	LSA	LT	C	R	M
Contribution from the Project to the cumulative effect ▪ Change in trophic status resulting in eutrophication of lakes and streams related to nitrogen emissions during operation		L	LSA	LT	C	R	M

KEY

MAGNITUDE:

N = Negligible—no measurable change from baseline conditions

L = Low—a measurable change from baseline but no critical load exceedance (acidification), or no change in trophic status (eutrophication)

M = Moderate—a measurable change from baseline conditions resulting in a critical load exceedance, and sites are considered acid sensitive or acidic at baseline (acidification), or a change in trophic status from oligotrophic to mesotrophic (eutrophication)

H = High—a measurable change from baseline conditions resulting in a critical load exceedance, and sites are considered to have moderate to low acid sensitivity at baseline (acidification), or a change in trophic status to eutrophic (eutrophication)

GEOGRAPHIC EXTENT:

PF = Project footprint—residual effects are restricted to the Project footprint

LSA—residual effects extend into the LSA

RSA —residual effects extend into the RSA

DURATION:

ST = Short-term—residual effect restricted to the construction phase

MT = Medium-term—residual effect extends through operation phase

LT = Long-term—residual effect extends beyond closure

P = Permanent—residual effect unlikely to recover to baseline

FREQUENCY:

S = Single event—occurs once

I = Multiple irregular event)—occurs sporadically at irregular intervals throughout operation

R = Multiple regular event—occurs on a regular basis and at regular intervals throughout operation

C = Continuous—occurs continuously throughout operation.

REVERSIBILITY:

R = Reversible—residual effect will recover to existing baseline conditions after Project closure and reclamation

I = Irreversible—residual effect is permanent.

CONTEXT:

L = Low resilience—low capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

M = Moderate resilience—moderate capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

H = High resilience—high capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

SIGNIFICANCE:

S = Significant

N = Not Significant

PREDICTION CONFIDENCE:

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

LIKELIHOOD OF RESIDUAL EFFECT OCCURRING:

Based on professional judgment

L = Low likelihood that there will be a residual effect

M = Moderate likelihood that there will be a residual effect

H = High likelihood that there will be a residual effect

N/A = Not Applicable

5.9.9 Prediction Confidence and Risk

There is a high degree of confidence that Project residual effects and cumulative effects on surface water quality will be not significant and that they will be no worse than predicted. Confidence in these conclusions relies on the quality of baseline data, understanding of Project mechanisms, effectiveness of mitigation measures, and assumptions made. Uncertainties are addressed by using conservative assumptions in both the acidification and eutrophication assessments and in air quality modelling, and by implementing mitigation measures aimed at reducing the magnitude and geographic extent of effects.

5.9.10 Follow-up Program and Compliance Monitoring

As described in Section 21, a follow-up monitoring program will be developed in consultation with MOE and will most likely include lakes identified as acid sensitive (nine lakes).

5.9.11 Summary of Mitigation Measures

LNG Canada will implement the following mitigation measures to limit Project residual effects and cumulative effects on surface water quality:

- Diesel fired equipment will be powered by low sulphur fuel (Mitigation 5.2-7).
- Manage, through Project engineering design and operational procedures, the continuous NOx emissions associated with the gas turbine exhaust to meet regulatory requirements. (Mitigation 5.2-5).

5.9.12 Conclusion

Project residual effects on surface water quality are assessed as not significant. The conservative approach adopted in this assessment provides confidence in the following conclusions:

- Acidification: Residual effects will be low to moderate in magnitude for acidification and mostly limited to already acid sensitive lakes. No significant exceedances to the critical load relevant to the base case are expected to occur because of Project emissions.
- Eutrophication: Residual effects will be low in magnitude for eutrophication and mostly associated with small incremental increases in the nitrogen loads in lakes compared with the base case. No changes in trophic status are expected to occur in lakes and streams located in the LSA and RSA.

Residual effects are expected to be long term, to occur only during operation, and to be reversible after operation ceases.