12 FRESHWATER AQUATIC RESOURCES

12.1 Introduction

This section examines potential project effects on Freshwater Aquatic Resources. In BC, fish are an important component of the local recreational, commercial, and Aboriginal fisheries and are also important indicators of overall aquatic ecosystem health. For these reasons, Freshwater Aquatic Resources is a valued component (VC).

This assessment addresses project-related effects in the context of the *Fisheries Act*, which establishes the regulatory requirements for the protection of fish and fish habitat. Potential effects on Freshwater Aquatic Resources are considered in terms of changes in habitat availability, food and nutrient content, and fish mortality risk.

The effects on fish in the marine environment are assessed in Section 13 (Marine Resources). Potential effects on Current Use of Land and Resources for Traditional Purposes related to Freshwater Aquatic Resources are assessed in Section 21. Effects from accidents or malfunctions on Freshwater Aquatic Resources are assessed in Section 22.

12.2 Scope of Assessment

The Freshwater Aquatic Resources assessment focuses on the existing fish habitat on Lelu Island, fish presence and fish habitat characterization. The project site contains a number of watercourses draining Lelu Island that will be affected by the construction of the facilities. Fish and fish habitat are important due to their protection under the federal *Fisheries Act.*

12.2.1 Regulatory and Policy Setting

12.2.1.1 Fisheries Act

The Government of Canada is responsible for the management of fisheries resources in Canada through the *Fisheries Act* and its supporting regulations. Fisheries and Oceans Canada (DFO) is the federal agency responsible for administration of the *Fisheries Act* and the policies and programs addressing national interests in marine and fresh waters.

In June 2012, changes to the *Fisheries Act* were introduced to focus the Act on protecting recreational, commercial and Aboriginal fisheries' productivity. Based on the new Act, a risk-based approach will be adopted by the DFO.

The new Act includes prohibitions against causing "serious harm to fish that are part of or support a commercial, recreational or Aboriginal fishery (section 35)" in addition to provisions for flow (section 20) and fish passage (section 21) and a framework for regulatory decision-making (sections 6 and 6.1).

The new *Fisheries Act* defines "*serious harm to fish*" as "*the death of fish or any permanent alteration to, or destruction of, fish habitat*". Serious harm to fish is defined as:

- the death of fish;

- a permanent alteration to fish habitat of a spatial scale, duration or intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes;

- the destruction of fish habitat of a spatial scale, duration, or intensity that fish can no longer rely upon such habitats for use as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes.

When serious harm to fish cannot be avoided or mitigated, a subsection 35(2) authorization would be required. When issuing a subsection 35(2) authorization, the Minister will consider the four factors mentioned in section 6 of the *Act.* These factors are (DFO 2013):

- The contribution of the relevant fish to the ongoing productivity of commercial, recreational or Aboriginal fisheries
- Fisheries management objectives
- Whether there are measures and standards to avoid, mitigate or offset serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or that support such a fishery
- The public interest.

12.2.1.2 Water Act

Section 9 of the *Water Act* requires that on provincial Crown land or private land "changes in and about a stream" occur only under an approval, licence or order, or in accordance with regulations under the Act. Lelu Island is federal land regulated by the PRPA, therefore *Water Act* approvals or notifications will not be required for activities on Lelu Island.

12.2.2 Influence of Consultation on the Assessment

Consultation revealed that Aboriginal people, stakeholders, and the public were concerned about potential effects on juvenile salmon from changes to Lelu Island watercourses. To address this concern, the regional assessment area (RAA) for freshwater fish and fish habitat was expanded to include the waters within Chatham Sound influenced by freshwater from the Skeena and Nass Rivers.

12.2.3 Selection of Potential Effects

Potential project interactions and the effects on Freshwater Aquatic Resources are:

- Change in fish habitat
- Change in food and nutrient content
- Increased fish mortality risk.

12.2.4 Selection of Measurable Parameters

The measurable parameters selected to assess the potential effects of the Project on Freshwater Aquatic Resources are presented in Table 12-1. A brief description of each measurable parameter and the rationale for their selection is included in the table.

Table 12-1: Measurable Parameters for Freshwater Aquatic Resources

Potential Effect	Measurable Parameter(s) for the Effect	Rationale for Selection of the Measurable Parameter
Change in (permanent alteration or destruction of) fish habitat	▪ Area of fish habitat permanently altered or destroyed (measured in square metres) ▪ Areal extent of fish habitat (m^2) affected by acidification of surface waters near the PDA	▪ Area of habitat directly and indirectly affected by the Project is a direct measure of project effects.
Change in food and nutrient content	▪ Relative contribution of freshwater output of the watercourses on Lelu Island compared to the output of the Skeena River (measured indirectly by mean annual flow). ▪ Acidification potential in surface waters near the PDA	▪ Infilling of watercourses on the island may affect food and nutrient availability in the near shore and estuarine environment. ▪ Acidification of surface waters near the PDA may result in reduced production of aquatic invertebrates and therefore reducing the nutrient content.
Increased fish mortality risk	▪ Estimated number of dead or moribund fish that are linked to a commercial, recreational, or aboriginal fishery ▪ Estimated fish mortality as a result of acidification of surface waters near the PDA	▪ Infilling of watercourses may result in fish mortality ▪ Acidification of surface waters near the PDA (in extreme cases) may cause mass mortality of fish

12.2.5 Boundaries

12.2.5.1 Temporal Boundaries

Based on the current project schedule, the temporal boundaries for the effects assessment are:

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

12.2.5.2 Spatial Boundaries

Spatial boundaries are defined partly by watershed areas of affected watercourses and partly by the distribution (area) of fish that use aquatic habitat near and in the LAA. Figure 12-1 illustrates the spatial boundaries.

Project Development Area

The PDA includes Lelu Island to within 30 m of the average high water mark, the bridge abutments and access road corridor, and areas covered by the bridge, pioneer dock, materials off-loading facility (MOF), marine terminal and associated dredging.

Local Assessment Area

The Freshwater Aquatic Resources LAA includes the watercourses on Lelu Island, from their headwaters to their confluence with surrounding estuaries.

Regional Assessment Area

The RAA for Freshwater Aquatic Resources encompasses waters in Chatham Sound that are under the influence of Skeena and Nass Rivers outflow. This area covers the riverine and estuarine plume areas as well as Chatham Sound waters that are under the riverine influence (as defined in Trites 1952).

12.2.5.3 Administrative and Technical Boundaries

Lelu Island is located in DFO Management Area 4, sub-area 4-12, and is within the Skeena-Queen Charlotte Regional District. Lelu Island is also located within the jurisdiction of the Prince Rupert Port Authority.

Lack of data on water chemistry of surface waters near the PDA, where the potential for acidification exists, limits the ability to evaluate the acidification potential with a higher accuracy.

12.2.6 Residual Effects Description Criteria

The criteria used to characterize the predicted residual effects (effects remaining after the application of mitigation measures) on Freshwater Aquatic Resources is presented in Table 12-2.

Table 12-2: Characterization of Residual Effects for Freshwater Aquatic Resources

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 **M** = Moderate resilience: occurs in a stable ecosystem and/or moderately disturbed environment **H** = High resilience: occurs in viable ecosystem and/or undisturbed environment

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
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 effect on the function or use of the habitat; no measurable reduction in size of the fish population **L** = Measurable effect on habitat function is anticipated but on low quality, marginal or non-critical habitat; anticipated mortality risk to non-sport fish species **M** = Measurable effect on habitat function is anticipated on moderate or high quality or critical habitat; anticipated mortality risk to sport fish species **H** = Measurable effect on habitat function is anticipated on limiting habitat for provincially-listed species or SARA-listed species; anticipated mortality risk to provincially-listed species or SARA-listed species
Extent	Refers to the spatial scale over which the residual effect is expected to occur (i.e., within the PDA, LAA, or RAA)	**PDA** = Residual effects are restricted to the stream within the specific activity area (i.e., construction in project site or temporary workspaces) **LAA** = Residual effects extend beyond the activity area but remain within the LAA **RAA** = Residual effects extend to RAA (watershed/sub-regional level)
Duration	The period of time the residual effect will persist.	**Short-term**—Residual effect occurs for less than one breeding season or generation (e.g., less than one year) **Medium-term**—Residual effect occurs for several breeding seasons or generations, or a project phase (e.g., one to five years, or the project construction phase) **Long-term**—Residual effect is occurs across multiple breeding seasons or generations, or multiple project phases (e.g., 6 to 30 years, or the lifetime of the Project **Permanent**—Residual effect occurs across multiple breeding seasons or generations and is unlikely to recover following project decommissioning and reclamation
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** = Productive capacity will recover (after disruption) through natural process or restoration; loss of an individual or small number of fish that are part of a secure population **I** = Permanent loss of productive capacity and destruction of developing eggs or population is at risk

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
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)	**S** = Residual effect occurs once **MI** = Residual effect occurs sporadically at irregular intervals throughout construction, operation, closure and post-closure **MR** = Residual effect occurs on a regular basis and at regular intervals throughout construction, operation, closure and post-closure **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 **M** = Medium probability of occurrence **H** = High probability of occurrence

NOTES:

[a] For the purpose of this assessment, productive capacity refers to the ability of the watercourse to produce fish and invertebrates measured as total biomass. The productive capacity of fish habitat is affected by two major habitat components: availability of food and nutrients and availability of physical habitat.

[b] In this assessment, ecosystem resilience has been defined as the ability of the aquatic system to support a sustainable fish population. For example, destruction of critical overwintering or unique spawning habitat for a given species may severely interfere with the ability of the aquatic system to sustain a healthy fish population (of that species).

12.2.7 Significance Thresholds for Residual Effects

A significant adverse residual effect is one that reduces the productive capacity of fish habitat or causes injury or mortality to fish, in such a way as to cause an uncompensated net change or decline in the distribution or abundance of a viable fish population, such that the likelihood of the long-term survival of the population is substantially reduced. Table 12-3 summarizes the thresholds used for determination of residual effects significance.

Table 12-3: Significance Thresholds for Freshwater Aquatic Resources

Effect	Threshold
Change in (permanent alteration or destruction of) fish habitat	A net loss of the productive capacity of fish habitat after application of mitigation and offsetting-measures.
Change in food and nutrient content	A reduction in streamflow or riparian cover (or both) in the PDA or acidification of surface waters near the PDA at a level that adversely affects nutrient and food supply in fish-bearing streams and estuarine/near shore environment
Increased fish mortality risk	The likelihood of fish mortality, after mitigation measures are implemented, at a level that interferes with the natural ability of fish populations to recover from the disturbance. Examples include total removal of a resident population, removal of a population with unique genetic pool or region-wide population effects

12.3 Baseline Conditions

12.3.1 Baseline Methods and Data Sources

The information sources used in this assessment include federal and provincial online databases with records of reported fish presence and distribution (e.g., the Fisheries Inventory Summary System [FISS]) and field surveys completed for this assessment.

12.3.1.1 Desktop Assessments

Prior to field survey, existing databases were consulted about freshwater aquatic environments within the LAA; the databases included previous studies in the area, maps, and federal and provincial government websites. The intent was to identify known fish habitat characteristics, fish species composition and distribution and the presence/absence of fish species of management concern. The primary sources of information were the following:

- 1:20,000 terrain resource information mapping (TRIM) for the area
- BC Ministry of Environment's FISS online database (BC MOE 2011a)
- BC Ministry of Environment's EcoCat: The Ecological Reports Catalogue (BC MOE 2011b)
- BC Ministry of Environment's Habitat Wizard Database (BC MOE 2011c).

12.3.1.2 Habitat Assessments

Habitat assessment followed a customized version of field protocols outlined in *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001) established by the BC Ministry of Sustainable Resource Management, Resource Inventory Standards Committee (RISC). This customized protocol included the collection of additional biophysical information such as detailed channel bed material composition and fish habitat descriptions. Associated RISC manuals (BCMSRM 1997), *Forest Practices Code Guidebook* (BC MOF 1998), and relevant field guides were also consulted.

For each watercourse in the LAA, a habitat site card was completed and contained the following information:

- Fish cover (provides hiding, resting or feeding habitat for fish)
- Bankfull and residual pool depths
- Stream stage
- Crown closure
- Bank shape and texture
- Turbidity
- Dominant and subdominant bed materials
- Channel morphology
- Disturbance indicators.

All field data were recorded on RISC site cards. Additional habitat features that were identified and recorded included obstructions to fish passage and any other special features (e.g., culverts, beaver dams, logjams). Watercourse characteristics were documented through upstream, downstream, and stream bank photographs.

Based on the biophysical data collected above, fish habitat quality (for salmonids) was characterized at each site for specific life history functions (rearing, overwintering, spawning, migration, and staging/holding potential). Ratings of nil, poor, moderate, good and excellent were used to rank each function of habitat based on the assessed quality of fish habitat and its potential to support salmonids. Salmonids are used to evaluate freshwater fish habitat because of their ecological and cultural importance and wide distribution in BC.

Table 12-4 summarizes criteria used to evaluate habitat quality for each salmonid life stage.

Table 12-4: Physical Habitat Criteria for the Assessment of Fish Habitat Quality in the LAA

Habitat Type	Assessment Criteria
Spawning	Presence of suitable-sized gravel substrate Presence of cover Presence of ground water seepage Gradient
Overwintering	Presence of deeper pools
Migration	Absence of migration barrier Watercourse continuity Gradient
Staging/holding	Presence of deep pools Presence of cover Gradient

Water Quality

In-situ water quality parameters, that directly affect the quality of fish habitat, were collected during field surveys. A YSI multi parameter water quality meter was used to measure dissolved oxygen (mg/L), temperature (°C), and conductivity (µs/cm). All instruments were calibrated according to the manufacturer's instructions prior to the field program.

Water samples were also collected from Alwyn Lake near Port Edward to study the potential for acidification and eutrophication effects related to project activities in a lake system near the Project. Samples were analyzed for general chemistry, biological and chemical oxygen demands, nutrients, anions, organic carbon, total and dissolved metals and Chlorophyll a. Samples were analyzed by ALS Laboratories (Canadian Association for Laboratory Accreditation [CALA] certified laboratory) in Burnaby, BC.

12.3.2 Overview of Baseline Conditions

No historical information was available for the LAA. All watercourses located on Lelu Island are unnamed. A numbering system was adopted to identify the watercourses, mapped at a scale of 1:20,000, using an alpha-numeric identifier from WC1 to WC17 (see Figure 12-2). A reconnaissance

site visit was conducted in June and a detailed fish habitat field assessment was conducted in August 2013 (results are summarized in Table 12-5).

Most watercourses on Lelu Island were too small to be considered streams and were classified as Non-Classified Drainage (NCD) or No Visible Channel (NVC). Based on guidelines provided in Fish Stream Identification Guidebook (BC MOF 1998) "*a NCD is a watercourse that does not satisfy the definition of reach*". A detailed definition of "reach" is presented in Fish Stream Identification Guidebook (BC MOF 1998). For the purpose of this assessment, a watercourse is considered a stream if each of the following criteria is met:

- The channel bed is at least 100 m in length
- The channel has well-defined banks
- The channel has signs of flow (i.e., scouring)
- It exhibits a permanent channel that provides permanent connection to the near shore waters.

Based on the above criteria, the field survey identified two watercourses (WC 8/9 and WC 11) as streams. Although TRIM data showed two streams named WC8 and WC9 (see Figure 12-2), only one watercourse was identified during the field survey at that location. The remaining mapped watercourses were identified as NCD/NVC.

Figure 12-3 shows the location and habitat characteristics of WC 8/9 and WC 11. A brief description of these watercourses is provided below. Alwyn Lake (near Port Edward) was also sampled to document baseline water quality conditions.

12.3.2.1 Watercourse WC 8/9

This watercourse flows in a southeast direction and has a length of approximately 368 m. No barrier to fish passage was identified on this stream.

Based on physical habitat characteristics observed during the field survey, two reaches were identified on this watercourse. Reach 1 began at the mouth and extended approximately 140 m upstream with an average gradient of 3%. Reach 1 was irregularly meandering with riffle/pool morphology. Dominant substrate material was small cobbles and cover was greater than 20%. Fish (unidentified) were observed in the lower section of this reach at low tide. Appendix I (Freshwater Aquatic Resources Habitat Site Plates and Photo Catalogue) presents site photos and details of habitat measurements in this reach.

Based on criteria specified earlier in this section to identify streams, this watercourse should be ruled out as a stream (because of its lack of permanent connection to the fore shore waters); however, based on the conservative approach adopted for this environmental assessment and the presence of fish in its lower section it was classified as a stream. Reach 1 of this watercourse had a pH of 4.5 at the time of the field assessment. Although this level of pH is not considered lethal, it may have sublethal effects on fish species and may interfere with some critical physiological processes (e.g., reproduction, tolerance to swimming stress) (McKean and Nagpal 1991). The overall habitat quality in this reach is rated as marginal.

Reach 2, irregularly meandering with riffle pool morphology, begins from approximately 140 m upstream of the mouth and extended for approximately 228 m, with an average gradient of

9%, and fines and cobble as the substrate material. The pH of water in this reach was 5.0 at the time of survey. The overall habitat quality in this reach is rated as marginal.

This stream was not connected to the foreshore waters during low tide and no defined channel was present in the intertidal area. Although the field assessment was conducted after a recent rain event, the depth of the water was not appropriate for effective electrofishing or minnow trapping.
This stream is accessible to fish during high tide or heavy rainfall events.

12.3.2.2 Watercourse WC 11

This watercourse flows in a southwest direction and has a length of approximately 248 m.
No barriers to fish passage were identified on this stream. This irregularly meandering watercourse has an average channel width of 1.2 m and an average gradient of 6%, riffle pool morphology, and gravel and fines as the dominant and subdominant substrates respectively. This watercourse had a pH of 3.8 at the time of survey. Although this level of pH is not considered lethal, it may have sublethal effects on fish species and may interfere with some critical physiological processes.
The overall habitat quality in this watercourse is rated as marginal. Appendix I (Freshwater Aquatic Resources Habitat Site Plates and Photo Catalogue) presents site photos and details of habitat measurements in this watercourse.

This stream is not connected to the foreshore waters during low tide. Although the field assessment was conducted after a recent rain event, the depth of the water was not appropriate for effective electrofishing or minnow trapping. The stream is accessible to fish during high tide or heavy rainfall events.

12.3.2.3 Alwyn Lake

Stantec collected surface water samples from Alwyn Lake, near Port Edward in August 2013 to determine baseline water chemistry and to acquire the data required to perform the acidification and eutrophication assessments. Alwyn Lake was selected for study because it is one of the closest lakes to the Project and it provides the drinking water for Port Edward. Results of this sampling program are presented in Appendix I.

Table 12-5: Results of Habitat Assessment of Watercourses on Lelu Island

Watercourse	Channel Length >100 m	Well Defined Banks	Signs of Flow (i.e., scouring)	Permanent Connection to Near Shore Waters	Habitat Quality	Comments
WC1	Yes (102 m)	Yes	Yes	No	Marginal	Minimal flow observed, mostly standing water. Only accessible in high tide.
WC2	No (4 m)	No	No	N/A	None	Classified as NVC
WC3	No (91 m)	No	No	No	None	Classified as NCD. Lower 20 m only accessible during high tide and may provide habitat (brackish water). Poor water quality (pH=4.6).
WC4	No (90 m)	No	Yes	No	Marginal	Classified as NCD. Lower 25 m only accessible during high tide and may provide habitat (brackish water). Channel intermittent in upper sections. Poor water quality (pH=4.5).
WC5	No (87 m)	Yes	Yes	No	None	Classified as NCD. Lower 25 m only accessible during high tide and may provide habitat (brackish water). Channel intermittent in upper sections. Poor water quality (pH=4.3).
WC6	No	No	No	No	None	Classified as NVC
WC7	No (54 m)	No	No	No	None	Classified as NCD. Poor water quality (pH=4.6).
WC 8/9	Yes (368 m)	Yes	Yes	No	Marginal	Only one channel observed at this location. Fish observed in lower section but unlikely to support a resident population. Two reaches identified. Poor water quality (pH=4.5 to 5.0).
WC 10	No (70 m)	No	No	No	None	Classified as NVC/NCD. Poor water quality (pH=4.2).

Watercourse	Channel Length >100 m	Well Defined Banks	Signs of Flow (i.e., scouring)	Permanent Connection to Near Shore Waters	Habitat Quality	Comments
WC 11	Yes (248 m)	Yes	Yes	No	Marginal	May provide marginal habitat for fish but unlikely to support a resident population Poor water quality (pH=3.8).
WC 12	Yes (101 m)	No	Yes	No	Marginal	Classified as NCD. Poor water quality (pH=3.6).
WC 13	No (93 m)	No	No	No	Marginal	Classified as NCD. Poor water quality (pH=3.6).
WC 14	No (48 and 64 m)	No	No	No	None	Classified as NCD. Intermittent channel. Two channels observed. Minimal flow.
WC 15	No (98 m)	No	No	No	None	Classified as NCD.
WC 16	No (9 m)	No	No	No	None	Classified as NCD.
WC 17	No	No	No	No	None	Classified as NVC.

NOTES:
NVC = No Visible Channel
NCD = Non Classified Drainage
Watercourses identified as fish streams are shaded

12.4 Project Interactions with Freshwater Aquatic Resources

The ranking of potential effects that could result from interactions between the environment and project activities are presented in Table 12-6.

Table 12-6: Potential Effects on Freshwater Aquatic Resources

Project Activities and Physical Works	Potential Effects		
	Change in (permanent alteration or destruction of) fish habitat	Change in Food and Nutrient Content	Increased Fish Mortality Risk
Construction			
Site Preparation (land-based)	2	2	2
Onshore Construction	2	2	2
Vehicle Traffic	0	0	0
Dredging	0	0	0
Marine Construction	0	0	0
Waste Management and Disposal	1	1	1
Disposal at Sea	0	0	0
Operational Testing and Commissioning	0	0	0
Site Clean Up and Reclamation	0	0	0
Operations			
Operation of LNG Facility and Supporting Infrastructure on Lelu Island	2	2	2
Marine Terminal Use	0	0	0
Shipping	0	0	0
Waste Management and Disposal	1	1	1
Fish Habitat Offsetting Plan	1	1	1
Wetland Habitat Offsetting	0	0	0
Decommissioning			
Dismantling Facility and Supporting Infrastructure	1	1	1
Dismantling of Marine Terminal	0	0	0
Waste Disposal	1	1	1
Site Clean Up and Reclamation	1	1	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 (BMPs).
2 = Interaction may occur, and resulting effect may exceed acceptable levels without implementation of specified mitigation. Further assessment is warranted.

12.4.1 Justification of Interaction Rankings

The following interactions are ranked 0:

- Vehicle traffic
- Dredging
- Marine construction
- Disposal at sea
- Operational testing and commissioning
- Site clean-up and reclamation
- Operation of LNG facility and supporting infrastructure on Lelu Island
- Marine terminal use
- Shipping
- Dismantling of marine terminal.

Based on the type of activities involved and professional experience, the effects on Freshwater Aquatic Resources from these activities are expected to be non-existent or negligible; therefore, they are not addressed for a detailed assessment.

Interactions between a number of project activities (waste management and disposal, dismantling of the facility and related infrastructure, and site clean-up and reclamation) and Freshwater Aquatic Resources have all been ranked as 1, therefore requiring some mitigation. These interactions are considered here. These potential interactions can be managed through the adoption of industry standards and best management practices. These industry standards include best management practices such as conventional erosion and sediment control measures and adoption of DFO's guidelines. Because these potential effects are well known and can be managed through conventional control measures, no additional analysis is required.

Activities ranked as a 2 have the potential to affect Freshwater Aquatic Resources if unmanaged or uncompensated. Potential effects of these types of activities generally include effects on fish habitat structure, quality and availability and fish populations. These activities and interactions with fish habitat are addressed further in Section 12.5.

12.5 Effects Assessment

12.5.1 Analytical Methods

12.5.1.1 Analytical Assessment Techniques

The two major determinants of the productive capacity of fish habitat are habitat availability; and food and nutrient content. For both aspects of fish habitat productive capacity, qualitative and quantitative analyses, supported by baseline data and the literature, are used to assess the potential effects of the Project on fish habitat productive capacity.

Project activities ranked as 2 in Table 12-6 relate to the areal extent of project effects on fish habitat, change in food and nutrient content of near shore waters and potential for fish mortality as a result of the construction and operations of the plant facilities. Average channel widths and the length of the watercourse sections directly affected by construction are used to calculate the areal extent of altered fish habitat.

Emissions of SO_2 and NO_x can also affect health of freshwater aquatic ecosystems. These compounds have the potential to cause acid deposition (as acid rain) by reacting with water and oxygen in the atmosphere and precipitating as sulfate (SO_4) and NO_x. Acid rain is rain, or any other form of precipitation, that is acidic and contains elevated levels of hydrogen ions (low pH). Over time, acid rain could lead to the acidification and eutrophication of surface waters, which can adversely affect fish and other aquatic biota, such as aquatic invertebrates. Air emissions modelling results (see Section 6: Air Quality) are used to assess the potential for acidification of surface waters and eutrophication of aquatic systems near the PDA from emissions during operation of the LNG facility. Acidification and eutrophication may air quality dispersion modelling affect the areal extent of available fish habitat and in extreme cases may result in fish mortality. A critical load assessment using a Steady State Water Chemistry model was conducted to determine whether modelled atmospheric deposition of SO_4 and NO_x exceeds the critical load of acidity determined for Alwyn Lake (Appendix J).

12.5.1.2 Assumptions and the Conservative Approach

The assessment of Freshwater Aquatic Resources in watercourses on Lelu Island follows a conservative approach so that relevant aspects of Freshwater Aquatic Resources are considered in the assessment. This includes the identification of two watercourses as fish-bearing streams. Although these watercourses do not meet some of the criteria of fish-bearing watercourses (i.e., the presence of permanent connection to downstream foreshore habitat and flow) and may be classified as NCDs, this assessment is based on their classification as fish-bearing streams as a conservative measure.

12.5.2 Change in Fish Habitat

12.5.2.1 Potential Effects

Project construction will remove watercourses on the island and therefore affect fish habitat availability in these watercourses. Watercourses will be infilled and removed to accommodate the Project's components. Watercourses on Lelu Island originate from the center of the island and drain into the surrounding intertidal area in Chatham Sound.

Only two watercourses on Lelu Island are classified as fish streams (WC 8/9 and WC 11). Total loss of instream habitat from infilling and removal of fish habitat watercourses on Lelu Island is 740 m^2 (Table 12-7).

Table 12-7: Estimated Freshwater Fish Habitat Loss Resulting from the Construction of Project Facilities

Estimated Instream Habitat Loss				Estimated Riparian Habitat Loss			Total Habitat Loss (m^2)
Watercourse	Length (m)	Average Channel Width (m)	Area (m^2)	Stream Class	Riparian Setback Width (m)	Area (m^2)	
WC 8/9	368	1.2	442	S4	15	11,040	-
WC 11	248	1.2	298	S4	15	7,440	-
Total			**740**			**18,480**	**19,220**

Air emissions from the project operations will result in the deposition of substances that have the potential to cause acidification and eutrophication of water bodies, thereby affecting fish habitat availability. Air quality dispersion modelling for the Project identified the critical load for sulfate and nitrogen deposition (greater than 150 eq/ha/year= greater than 150,000 meq/ha/year= greater than 15 meq/m^2/year) based on BC MOE criteria.

12.5.2.2 Mitigation

Only two watercourses on Lelu Island are classified as fish streams (WC 8/9 and WC 11). The remaining watercourses are classified as NCDs or NVCs, or do not meet the criteria to be considered as fish streams.

Where practical, effects to the lower sections of these watercourses will be avoided, and extent of infilling of water courses will be reduced, where practical. A sedimentation and erosion control plan will be in place to avoid downstream effects. PNW LNG will maintain a vegetated buffer that extends 30 m inland from the high-water mark around Lelu Island.

A Conceptual Fish Habitat Offsetting Strategy (see Appendix K) has been proposed for the Project. Implementation of the fish habitat offsetting strategy will mitigate the loss of freshwater fish habitat as a result of construction of the Project to achieve no net loss of the productive capacity of the fish habitat.

12.5.2.3 Characterization of Residual Effects

As the habitat quality of watercourses WC 8/9 and WC 11 is rated marginal, the residual effects of the Project on the freshwater fish habitat availability in the LAA are characterized as, low in magnitude, limited to the PDA, single event, long-term, and irreversible. The Conceptual Fish Habitat Offsetting Strategy (see Appendix K) for the Project will mitigate the loss of fish habitat as a result of construction.

Acidification of surface waters on Lelu Island is not expected as both watercourses on the island will be infilled during the construction phase of the Project. A detailed assessment of the potential for surface water acidification and eutrophication for Alwyn Lake, Port Edward, near the PDA, is presented in Appendix J. Overall, the eutrophication or acidification of Alwyn Lake as a result of contributions of nitrates and sulfates (NO_x and SO_4) is not expected to occur.

Fish habitat in the LAA is considered to be of high resilience as it is relatively undisturbed by human activity and other developments.

12.5.2.4 Likelihood

Likelihood of a residual effect is low, as it is highly unlikely that that these watercourses support any resident or anadromous fish species. Also, the measures outlined in the conceptual Fish Habitat Offsetting Strategy will mitigate loss of potential fish habitat.

12.5.2.5 Determination of Significance

The loss of the instream and riparian habitat, as a result of the infilling of these watercourses, will be mitigated through a fish habitat offsetting plan, to achieve no net loss of the productive capacity. The framework for the fish habitat offsetting strategy is presented in Appendix K. Watercourses affected by the Project do not provide critical habitat for any resident or anadromous species. Therefore, project effects on freshwater fish habitat availability are expected to be not significant.

12.5.2.6 Confidence and Risk

The prediction confidence for change in fish habitat availability is high. The assessment uses detailed field assessment methods, professional opinion and past experience with similar projects in the area. Only two watercourses are identified as potential fish streams. Habitat quality in these watercourses is rated as marginal, following the conservative approach. It is highly unlikely that these watercourses support any resident or anadromous fish species.

Overall, the likelihood of a residual effect is low and the project effects on freshwater fish habitat availability are expected to be not significant. Since the confidence in this prediction is not low, no additional risk analysis has been conducted.

12.5.3 Change in Food and Nutrient Content

12.5.3.1 Potential Effects

The infilling and removal of freshwater watercourses on Lelu Island will remove the input of food and nutrients to the surrounding near shore waters around the island from the freshwater streams and may result in the loss of productive capacity.

12.5.3.2 Mitigation

PNW LNG will generally maintain a vegetated buffer that extends 30 m inland from the high-water mark around Lelu Island. The proposed Conceptual Fish Habitat Offsetting Strategy (Appendix K) will mitigate the potential loss of productive capacity as a result of the removal of food and nutrient contribution of watercourses on Lelu Island.

12.5.3.3 Characterization of Residual Effects

The contribution of food and nutrients from the freshwater watercourses on Lelu Island to the near shore estuarine habitat is expected to be negligible based on the physical characteristics and small sizes of these watercourses.

Lelu Island is located in Chatham Sound. Chatham Sound receives freshwater, including food and nutrients from the Skeena and Nass Rivers and sea water from Hecate Strait. The near shore habitat surrounding Lelu Island is heavily influenced by organic material (i.e., food and nutrient) input from the Skeena and Nass rivers (Trites 1952).

Skeena and Nass rivers provide nutrients to the intertidal areas around Lelu Island. Watershed areas for the Nass and Skeena rivers are 18,400 and 42,300 km^2 respectively (EC 2013). Both of these watersheds are much larger than Lelu Island (with a watershed area of 1.95 km^2). The nutrients provided to Chatham Sound by the Skeena and Nass Rivers greatly exceed those potentially provided by Lelu Island's watercourses. The loss of nutrient input into the estuarine areas from infilled watercourses on Lelu Island is not expected to have any measurable effect on the total nutrient content of waters surrounding the island.

Residual effects of the Project on food and nutrient availability in foreshore intertidal area are characterized as low in magnitude, limited to the PDA, single event, long-term and irreversible. The freshwater environment surrounding Lelu Island is considered to be of high resilience and removal or infilling of the freshwater watercourses on Lelu Island is not expected to have any measurable effect on food and nutrient availability in near shore waters, as the waters surrounding Lelu Island is heavily influenced by two large rivers (Skeena and Nass rivers).

12.5.3.4 Likelihood

The likelihood of a residual effect is low. Considering that food and nutrient content of waters surrounding Lelu Island is heavily influenced by two large rivers (Skeena and Nass rivers). It is highly unlikely that infilling of watercourses on Lelu Island would have any measurable effect on the food and nutrient content of the surrounding waters.

12.5.3.5 Determination of Significance

Residual effects of the Project on food and nutrient availability in near shore waters around Lelu Island are not significant, based on the relative magnitude of watershed areas of Lelu Island, that of the Skeena River and the Nass River.

12.5.3.6 Confidence and Risk

The prediction confidence for change in food and nutrient content is high. The assessment results are based on detailed field assessments and a quantitative comparison of watershed basins providing food and nutrients to the Chatham Sound. Since the confidence in this prediction is not low, no additional risk analysis is conducted.

12.5.4 Change in Fish Mortality Risk

12.5.4.1 Potential Effects

Infilling of freshwater watercourses on Lelu Island may cause mortality of fish species present in these watercourses during project construction; therefore, there may be an increase in fish mortality risk.

Emissions from the operation of the LNG facility have the potential to affect surface water quality of lakes and streams near the LAA because of acidification and eutrophication through deposition, thereby causing fish mortality in extreme cases. Air quality dispersion modelling for the Project identified the critical load for sulfate and nitrogen deposition (greater than 150 eq/ha/year= greater than 150,000 meq/ha/year= greater than 15 $meq/m^2/year$) based on BC MOE criteria.

12.5.4.2 Mitigation

Mitigation of potential effects on change in fish mortality from project activities will be achieved by implementing a fish salvage program. Before the infilling of any watercourses, fish salvages will be conducted in WC 8/9 and WC 11 to avoid potential fish mortality. Any captured fish will be released in downstream reaches or nearby watercourses with similar habitat conditions.

12.5.4.3 Characterization of Residual Effects

Residual effects of the Project on fish mortality risk in watercourses on Lelu Island are considered as occurring in a highly resilient context, with no measueable effect, limited to the PDA, occurring once, short-term and irreversible. By following the mitigation measure suggested (i.e., fish salvage prior to infilling of watercourses), no fish mortality is expected to occur.

As acidification and eutrophication of Alwyn Lake is not expected (see Section 12.5.2.3), no fish mortality is expected.

12.5.4.4 Likelihood

The likelihood of a residual effect is low. It is unlikely that watercourses on Lelu Island support any resident or anadromous species. Additionally, mitigation measures (i.e., fish salvage prior to infilling) will be efficient; therefore, no fish mortality is expected as a result of the Project.

12.5.4.5 Determination of Significance

Residual effects on freshwater fish mortality risk are expected to be not significant.

12.5.4.6 Confidence and Risk

Prediction confidence for change in fish mortality risk is high. The assessment uses detailed field assessment methods. Only two watercourses are identified as potential fish streams. Habitat quality in these watercourses is rated as marginal at best and it is highly unlikely that these watercourses support any resident or anadromous fish species. Since the confidence in this prediction is not low, no additional risk analysis has been conducted.

12.5.5 Summary of Residual Effects

The residual effects of the Project on the Freshwater Aquatic Resources are summarized in Table 12-8. Residual effects on Freshwater Aquatic Resources are predicted to be not significant.

Construction of the Project will result in infilling of two watercourses on Lelu Island that provide fish habitat. This will result in a reduction in freshwater fish habitat availability. The habitat quality in these watercourses is rated as marginal and the loss of habitat will be compensated through implementation of a fish habitat offsetting plan. No net reduction in productive capacity is expected as a result of the Project.

Infilling of the watercourses on Lelu Island will remove their food and nutrient contribution to the near shore estuarine areas; however, the near shore waters around Lelu Island are under heavy influence of Skeena and Nass rivers and removal of freshwater streams on Lelu Island is not expected to cause any measurable reduction in food and nutrient content in near shore waters around the island.

Infilling of the freshwater streams on Lelu Island may cause an increase in fish mortality risk. Fish salvage will be conducted prior to infilling of the watercourses and any fish that are captured will be released in downstream reaches or nearby watercourses with similar habitat conditions.

Assessment of the potential for surface water acidification and eutrophication in Alwyn Lake showed that the eutrophication or acidification of Alwyn Lake, as a result of nitrogen and sulfate contributions from the Project, is not expected to occur.

Based on the assessment results, the Project is expected to have not significant adverse residual effects on Freshwater Aquatic Resources.

Table 12-8: Summary of Residual Effects on Freshwater Aquatic Resources

Project Phase	Mitigation Measures	Residual Effects Characterization						Likelihood	Significance	Confidence	Follow-up and Monitoring
		Context	Magnitude	Extent	Duration	Reversibility	Frequency				
Change in (permanent alteration or destruction of) Fish Habitat											
Construction	▪ The extent of infilling of water courses will be reduced, where practical. ▪ Infilling lower sections of watercourses (near the intertidal area) will be avoided, where practical. ▪ Sedimentation and erosion control plan will be in place to avoid downstream effects. ▪ Undertake fish habitat offsetting. ▪ A 30 m vegetation buffer will be maintained around Lelu Island.	H	L	PDA	L	I	S	L	N	H	Monitoring as part of the Fish Habitat Offsetting Strategy Monitoring of effects of acidification or eutrophication of freshwater systems on fish habitat, if acidification or eutrophication occurs
Operation		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				
Residual effects for all phases		H	L	PDA	L	I	S				
Change in Food and Nutrient Content											
Construction	▪ A 30 m vegetation buffer will be maintained around Lelu Island. ▪ Undertake fish habitat offsetting.	H	L	PDA	L	I	S	L	N	H	Monitoring of effects of acidification or eutrophication of freshwater systems on fish habitat, if acidification or eutrophication occurs
Operation		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				
Residual effects for all phases		H	L	PDA	L	I	S				

Project Phase	Mitigation Measures	Residual Effects Characterization						Likelihood	Significance	Confidence	Follow-up and Monitoring
		Context	Magnitude	Extent	Duration	Reversibility	Frequency				
Increased Fish Mortality Risk											
Construction	▪ Fish salvage program during construction	H	N	PDA	S	I	S	L	N	H	Monitoring of effects of acidification or eutrophication of freshwater systems on fish, if acidification or eutrophication occurs
Operation		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				
Residual effects for all phases		H	N	PDA	S	I	S				

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** = No measurable adverse effect on the function or use of the habitat; no measurable reduction in size of the fish population **L** = Measurable effect on habitat function is anticipated but on low quality, marginal or non-critical habitat; anticipated mortality risk to non-sport fish species **M** = Measurable effect on habitat function is anticipated on moderate or high quality or critical habitat; anticipated mortality risk to sport fish species **H** = Measurable effect on habitat function is anticipated on limiting habitat for provincially-listed species or SARA-listed species; anticipated mortality risk to provincially-listed species or SARA-listed species **EXTENT:** **PDA**—residual effects are restricted to the stream within the specific activity area (i.e., construction in project site or temporary workspaces) **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** = Measurable effect restricted to one day to a maximum of one week. **MT** = Measureable effect extends from one week to a year **LT =** Measurable effect extends from 1 to 5 years, but not permanent **P** = Measurable effect is permanent and unlikely to recover to baseline level **FREQUENCY:** **S** = Residual effect occurs once **MI** = Residual effect occurs sporadically at irregular intervals throughout construction, operation, closure and post-closure **MR** = Residual effect occurs on a regular basis and at regular intervals throughout construction, operation, closure and post-closure **C** = Residual effect occurs continuously **REVERSIBILITY:** **R** = Productive capacity a will recover (after disruption) through natural process or restoration; loss of an individual or small number of fish that are part of a secure population **I** = Permanent loss of productive capacity and destruction of developing eggs or population is at risk							**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				

12.6 Cumulative Effects

12.6.1 Context for Cumulative Effects

The assessment of cumulative effects on Freshwater Aquatic Resources considers potential effects of the Project in the broader regional context. This is achieved through the consideration of the general trends affecting the Freshwater Aquatic Resources and other activities within the RAA that may affect Freshwater Aquatic Resources with potential to act cumulatively on freshwater fish species and fish habitat.

For Freshwater Aquatic Resources, cumulative effects are considered in the context of past, present and foreseeable future developments and their effects on watersheds, the areal extent of available habitat for any given fish species, the ability of fish populations to sustain their viability and the production of food and nutrients.

Cumulative effects on Freshwater Aquatic Resources resulting from various anthropogenic disturbances may result in:

- Disturbances in instream flows, flow regime, water temperature and other physical attributes that are critical components of fish habitat
- Reduction of areal extent of available habitat required by fish species to complete their life cycles and adverse effects on limiting habitat types
- Reduction in the production of food and nutrients that are critical for fish growth, particularly in higher order streams and estuarine environment
- Cumulative effects of anthropogenic disturbances on fish populations may interfere with their ability to maintain a viable population through the removal of critical habitat types such as spawning and overwintering habitat.

12.6.2 Cumulative Effects Assessment

The cumulative effects assessment is conducted for each residual effect identified above according to a two-step process to determine the potential for cumulative effects on Freshwater Aquatic Resources. In conducting the cumulative effects assessment, the residual effects arising from interactions that scored either a 1 or a 2 in Table 12-6 are considered. The first step consists of a 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 12-9 indicates that there is potential for the Project to contribute to cumulative effects on Freshwater Aquatic Resources. 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 quality or sustainability of the VC?

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

Table 12-9: Potential Cumulative Effects on Freshwater Aquatic Resources

Other Projects and Activities with Potential for Cumulative Effects	Potential Cumulative Effects		
	Change in fish habitat	Change in food and nutrient content	Increased fish mortality risk
Atlin Terminal			
Canpotex Potash Export Terminal	✓	✓	✓
CN Rail Line	✓	✓	✓
Douglas Channel LNG			
Enbridge Northern Gateway Project			
Fairview Container Terminal Phase I	✓	✓	✓
Fairview Container Terminal Phase II	✓	✓	✓
Kitimat LNG Terminal Project			
LNG Canada Project			
Mount McDonald Wind Power Project			
NaiKun Wind Energy Project			
Northland Cruise Terminal	✓	✓	✓
Odin Seafood			
Pinnacle Pellet Inc.			
Prince Rupert LNG Facility	✓	✓	✓
Prince Rupert Gas Transmission Project			
Prince Rupert Ferry Terminal	✓	✓	✓
Prince Rupert Industrial Park			
Prince Rupert Grain Limited	✓	✓	✓
Ridley Island Log Sort			
Ridley Terminals Inc.	✓	✓	✓
Rio Tinto Alcan Aluminium Smelter and Modernization Project			
WatCo Pulp Mill			
Westcoast Connector Gas Transmission Project			

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

12.6.2.1 Change in Fish Habitat Availability

The Project will result in the removal of 739.2 m^2 of instream fish habitat in watercourses WC 8/9 and WC 11. A fish habitat offsetting strategy has been proposed for the Project to mitigate habitat losses. The habitat quality in WC 8/9 and WC11 is rated marginal; however, PNW LNG will take a conservative approach and offset the area of those watercourses affected by creating new habitat through implementation of the fish habitat offsetting strategy.

Results of air quality dispersion modelling (Section 6.5 and Section 6.6) for the application case showed that potential effects are limited to Lelu Island. Because the existing streams on the island will be infilled during the construction case, no cumulative effects on freshwater habitat availability on Lelu Island are expected. The air quality dispersion modelling for the cumulative case identified two areas in the RAA (Figure 12-4) that may exceed the BC MOE critical load for sulfate and nitrogen deposition (greater than 15 eq/ha/year = greater than 150 meq/ha/year = greater than 0.015 meq/m^2/year):

- Ridley Island
- Northwest of Kaien Island (west of Prince Rupert).

A desktop review conducted to determine the presence of sensitive fish habitat showed that in the Ridley Island area there are six mapped watercourses, one wetland and a drainage ditch. Watercourses in this area are first order and drain into the foreshore area with lengths that range from approximately 313 m to 638 m and gradients of 5% to 11%. Although these watercourses are potentially accessible to fish, it is unlikely that they support any resident or anadromous fish populations.

Based on the results of the desktop review, in the potential exceedance area west of Prince Rupert there are a number of first order high gradient streams. These watercourses are considered high gradient and unlikely to support any resident or anadromous fish populations. This area also overlaps with the headwaters of Hays Creek (Watershed Code: 915-789100-27000). Hays Creek is considered fish-bearing. Anadromous salmon, Dolly Varden, rainbow trout and cutthroat trout have been reported from this creek. Further studies should be completed to determine the accuracy of the desktop review of potentially sensitive fish and fish habitat and potential effect of the acidification on fish habitat availability in these areas.

Because of offsetting through the fish habitat offsetting strategy, and because most of the watercourses potentially affected by acidification and eutrophication are unlikely to support any resident or anadromous fish populations (based on a desktop review), the Project is not expected to have any net change in fish habitat availability. Thus, the Project is not expected to have any residual cumulative effects on fish habitat availability.

12.6.2.2 Change in Food and Nutrient Content

The contribution of Lelu Island freshwater streams to the food and nutrient content in Chatham Sound is negligible. Infilling of WC 8/9 and WC 11 is not expected to have any measurable effect on food and nutrient availability in the near shore habitat around the island. Any potential reduction of food and nutrients in Chatham Sound as a result of infilling of WC 8/9 and WC 11 are not measurable because of the heavy influence of from Skeena and Nass rivers on the Chatham Sound waters.

As mentioned in Section 12.5.1.1 the potential for acid deposition in surface waters, may reduce production of aquatic invertebrates, important food and nutrient sources for aquatic ecosystems. The potential for acidification noted in Section 12.6.2.1 may reduce the production of aquatic invertebrates

and therefore cause a reduction in the available food and nutrient content of freshwaters. A follow-up and monitoring program would be completed to determine the accuracy of the desktop review and identify potentially sensitive fish and fish habitat and potential effect of acidification on freshwater aquatic resources.

The reduction in food and nutrient input from watercourses on Lelu Island is not measurable as a result of the small watershed area of the island. Therefore, there is no expectation that the Project will have adverse residual effects on food and nutrient availability in the near shore and estuarine habitat and thus no cumulative effects are anticipated.

12.6.2.3 Change in Fish Mortality Risk

With the adoption of fish salvage as mitigation, no direct residual effects are expected from the Project on fish mortality risk. Watercourses in areas that may exceed the BC MOE critical load for sulfate and nitrogen deposition (see Section 12.6.2.1) are unlikely to support any resident or anadromous fish except headwaters of Hays Creek (Figure 12-4); however, further studies should be completed to determine the accuracy of the desktop review of potentially sensitive fish and fish habitat and potential effect of the acidification on fish habitat availability in these areas.

12.6.2.4 Summary of Cumulative Effects

The Project is not expected to result in a net loss of the productive capacity of freshwater environment, although cumulative emissions of SO_2 and NO_x may affect habitat quality and availability for freshwater fish and in extreme cases may cause fish mortality. Further studies are required to confirm the potential for this effect.

The expectation is that the Project will not result in direct cumulative effects on freshwater aquatic resources. Prediction confidence for cumulative effects is moderate. Only two watercourses on Lelu Island are identified as potential fish streams. Habitat quality in these watercourses is rated as marginal, at best. It is highly unlikely that these watercourses support any resident or anadromous fish species.

A follow-up program is recommended to determine the sensitivity of fish habitat to acidification and eutrophication in areas where an exceedance of critical load is expected.

12.7 Follow-up and Monitoring

A monitoring program is proposed as a part of the Conceptual Fish Habitat Offsetting Strategy (see Appendix K) to ensure that habitat offsetting plans are successful in achieving their goals.

A follow up program is recommended to characterize fish habitat and their sensitivity to potential acidification and eutrophication in areas with potential for PAI exceedances (i.e., Ridley Island and northwest of Kaien Island).

12.8 Conclusion

No residual effects on Freshwater Aquatic Resources are expected as a result of the Project. Only two streams are classified as fish streams on Lelu Island. Following the conservative approach, fish habitat in these streams is rated as marginal. These streams will be infilled during the construction of project facilities. Any potential loss of fish habitat will be mitigated through the Project's Conceptual Fish Habitat Offsetting Strategy (Appendix K). No loss of productive capacity is expected as a result of the Project.

Cumualtive effects on freshwater aquatic resources are not anticipated; however, further studies are required to characterize potential cumulative effects of the Project on acidification and eutrophication of surface waters near the PDA, with potential for PAI exceedances (i.e., Ridley Island and northwest of Kaien Island).

The confidence level for the assessment of project effects on Freshwater Aquatic Resources is high, based on 1) the conservative approach adopted for the Project, 2) marginal quality of fresh water streams identified on Lelu Island, 3) professional opinion and 4) past projects with similar effects.

12.9 References

BC Ministry of Environment (BC MOE). 2011a. *Fisheries Information Summary System (FISS) online database*. Available at: http://a100.gov.bc.ca/pub/fidq/main.do;jsessionid=90f9130bc034b21ab59da1cdbf6341111d7963 7821331d336b2483aa817d8b50. e3uMah8KbhmLe3mNaN4Kb3eLe6fznA5Pp7ftolbGmkTy

BC Ministry of Environment (BC MOE). 2011b. *EcoCat: The Ecological Reports Catalogue*.

BC Ministry of Environment (BC MOE), 2011c. Habitat Wizard Online Database. Available at: http://webmaps.gov.bc.ca/imf5/imf.jsp?site=moe_habwiz.

BC Ministry of Sustainable Resource Management (BCMSRM). 1997. *Fish Collection Methods and Standards*. Version 4. 0. Resources Inventory Standards Committee (RISC), Victoria, BC. 64 pp.

Boynton, W. R. and W. M. Kemp. 2000. Influence of river flow and nutrient loads on selected ecosystem processes: A synthesis of Chesapeake Bay data. Pp. 269-298. In J. E. Hobbie (ed.) Estuarine Science: A synthetic approach to research and practice, Island press, Washington, DC.

Environment Canada (EC). 2013. Water Survey of Canada. Available at: http://www.ec.gc.ca/rhc-wsc/. Accessed August 2013

Fisheries and Oceans Canada (DFO). 2013. Fisheries Protection Policy Statement. October 2013. Available at: http://www.dfo-mpo.gc.ca/habitat/cg2/pol/index-eng.html. Accessed: November 8, 2013.

McKean, C. J. P. and N. K. Nagpal. 1991. Ambient Water Quality Criteria for pH Technical Appendix. Ministry of Environment, Water Quality Branch, Water Management Division, Victoria, BC http://www.env.gov.bc.ca/wat/wq/BCguidelines/phtech.pdf. Accessed: June 26, 2013

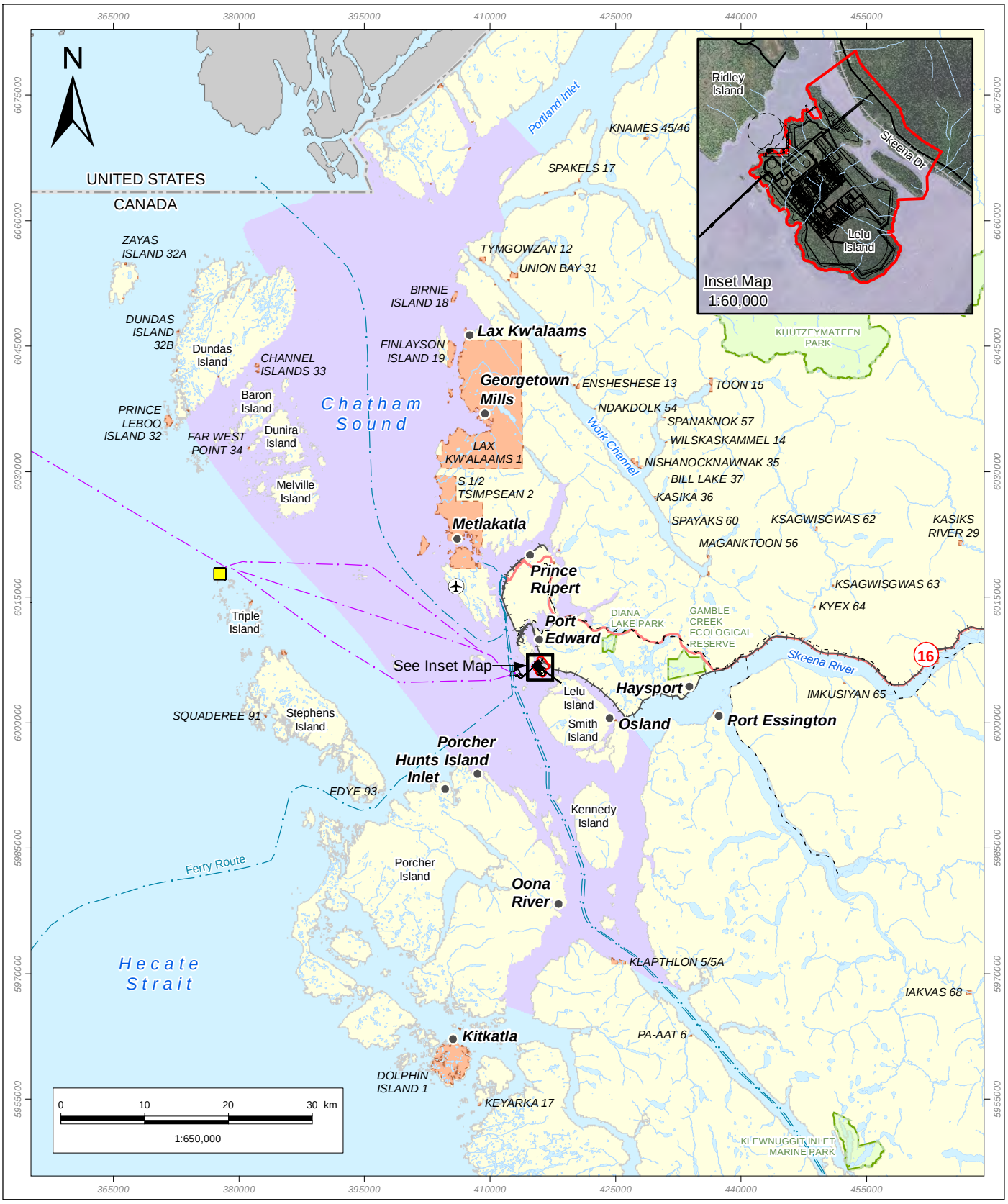
Ministry of Forests (BC MOF). 1998. *Fish-stream Identification Guidebook*. Version 2. 1. Available at: https://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/FISH/FishStream.pdf

Resources Inventory Committee (RIC). 2001. *Reconnaissance (1:20 000) Fish and Fish Habitat Inventory.* Standards and Procedures. British Columbia

Trites, R. W. 1952. The Oceanography of Chatham Sound. M. A. Thesis. Department of Physics, University of British Columbia. In: Gottesfeld, A. S., C. Carr-Harris, B. Proctor and D. Rolston. 2008. *Sockeye Salmon Juveniles in Chatham Sound*. 2007. Skeena Fisheries Commission.

12.10 Figures

Please see the following pages.



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

Pacific NorthWest LNG

Freshwater Aquatic Resources 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: 11-FEB-14
FIGURE ID: 123110537-400
DRAWN BY: K. POLL
PROJECTION: UTM - ZONE 9
DATUM: NAD 83
CHECKED BY: B. BYRD

PREPARED BY: Stantec
PREPARED FOR: Pacific NorthWest LNG
FIGURE NO: **12-1**

2/11/2014 - 9:45:59 AM V:\active\123110537\gis\figures\general\mxd\english\g_123110537-400_freswater_laa_raa.mxd

- City or Town
- Confluence of Watercourse
- Railway
- Road
- Project Component
- Turning Basin
- Watercourse

Pacific NorthWest LNG

Mapped Watercourses on Lelu Island

Sources: Government of British Columbia; Government of Canada, Natural Resources Canada, Centre for Topographic Information; Progress Energy Canada Ltd.; WorldView-2 Imagery. Imagery date: 2011.

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: 11-FEB-14	PROJECTION: UTM - ZONE 9
FIGURE ID: 123110537-192	DATUM: NAD 83
DRAWN BY: K. POLL	CHECKED BY: A. PARSAMANESH

PREPARED BY: Stantec

PREPARED FOR: Pacific NorthWest LNG

FIGURE NO: **12-2**

2/11/2014 - 9:45:31 AM V:\active\123110537\gis\figures\general\mxd\english\fig_123110537-192_freshwater_fish_surveys.mxd

Confluence of Watercourse

Reach Break

Potentially Fish-bearing

Project Component

Railway

Road

Watercourse

Pacific NorthWest LNG

Potential Fish-bearing Streams on Lelu Island

Sources: Government of British Columbia; Government of Canada, Natural Resources Canada, Centre for Topographic Information; Progress Energy Canada Ltd.; WorldView-2 Imagery. Imagery date: 2011.

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.

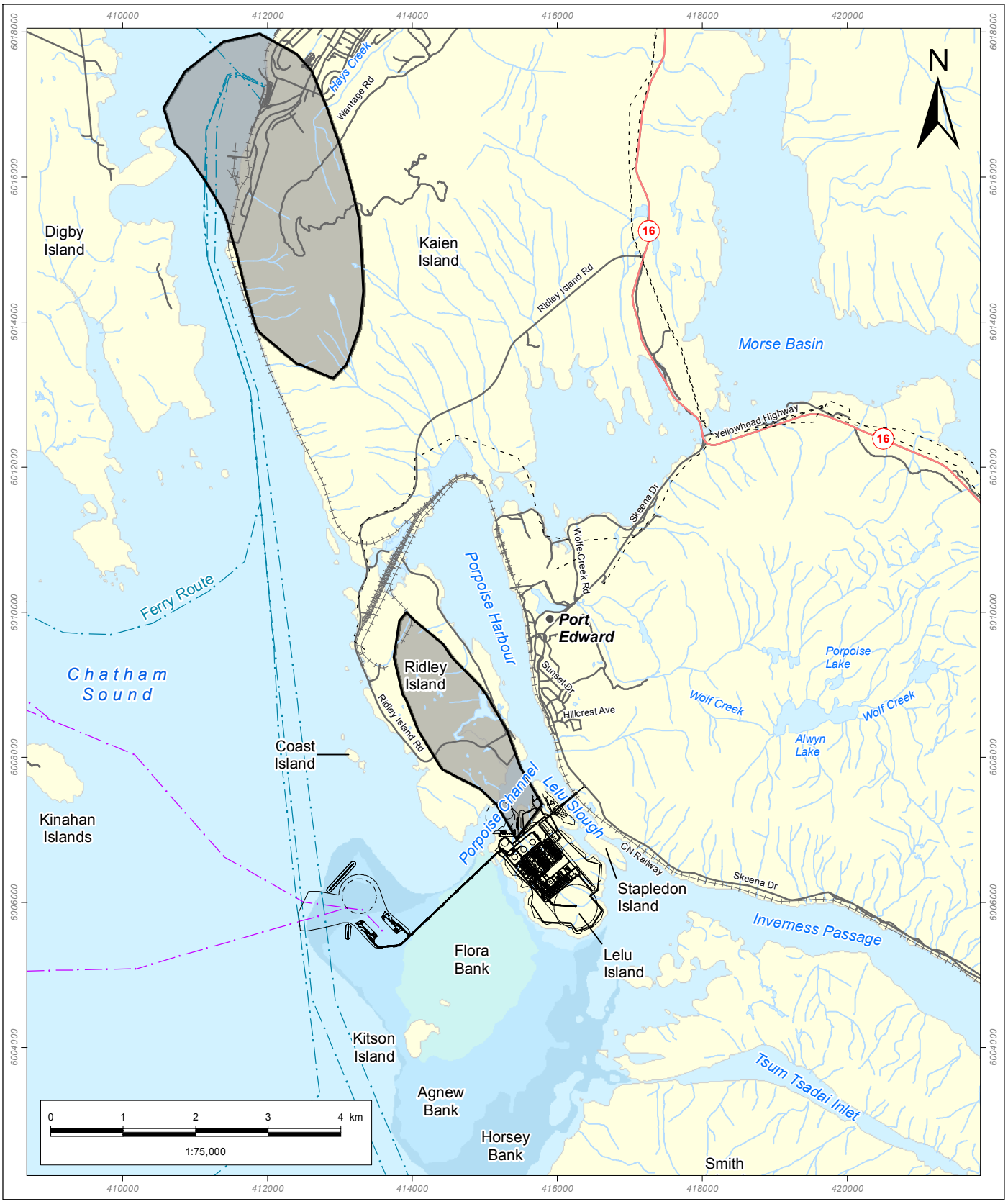
DATE: 11-FEB-14	PROJECTION: UTM - ZONE 9
FIGURE ID: 123110537-290	DATUM: NAD 83
DRAWN BY: L.HOPPER	CHECKED BY: A. PARSAMANESH

PREPARED BY: Stantec

PREPARED FOR: Pacific NorthWest LNG

FIGURE NO: **12-3**

2/11/2014 - 9:45:06 AM V:\active\123110537\gis\figures\general\mxd\english\fig_123110537-290_potential_fish_bearing.mxd



Exceedance Area for Acid Deposition Critical Load (PAI ≥ 15 meq/m²/yr)
Potential Shipping Route
Project Component
Turning Basin
City or Town
Electrical Power Transmission Line
Ferry Route
Railway
Road
Secondary Road
TRIM Watercourse
Waterbody

Shoals
Agnew Bank
Flora Bank
Horsey Bank

Pacific NorthWest LNG

Mapped Watercourses (TRIM) within PAI Exceedance Areas

Sources: Government of British Columbia; Government of Canada, Natural Resources Canada, Centre for Topographic Information; Canadian Hydrological Service (CHS), 1995.

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

DATE: 21-FEB-14	PROJECTION: UTM - ZONE 9
FIGURE ID: 123110537-542	DATUM: NAD 83
DRAWN BY: K. POLL	CHECKED BY: A. PARSAMANESH

PREPARED BY: Stantec

PREPARED FOR: Pacific NorthWest LNG

FIGURE NO: **12-4**

2/21/2014 - 10:59:38 AM V:\active\123110537\gis\figures\general\mxds\english\fig_123110537-542_fisheries_trim_pai_exceedance.mxd