13.0 MARINE RESOURCES

The assessment of potential effects of the Project on marine resources was provided in Section 13 of the EIS. A replacement chapter of Section 13 is included in Appendix A of this EIS Addendum.

This section of the EIS Addendum provides:

- Responses to requests for additional information from the federal government (August 14, 2014 and September 11, 2014)
- An updated list of mitigation measures for the Marine Resources VC
- Updated conclusions on the assessment of effects on the Marine Resources VC, taking into account project changes and the requested additional information.

Table 13-1 lists the documents applicable to Marine Resources submitted by PNW LNG as part of the environmental assessment process to date and identifies if information is either *updated by EIS Addendum, superseded*, *not relevant*, or *not affected* by information in the EIS Addendum. The updated Section 13 (see Appendix A of this EIS Addendum) contains information that updates the documents classified as *updated by EIS Addendum* or *superseded* in Table 13-1.

Table 13-1 Status of Previously Submitted Documents

Document Name	Status
Section 13 of the EIS (February 2014)	Superseded
Appendix K: Conceptual Fish Habitat Offsetting Strategy	Superseded
Appendix L: Technical Data Report - Marine Sediment and Water Quality	Not Affected
Appendix M: Technical Data Report - Marine Resources	Not affected
Appendix N: Modelling of Underwater Noise for Pacific NorthWest LNG Marine Construction and Shipping Scenarios	Not affected
Appendix O: Sediment Modelling of Dredging off Lelu Island, Prince Rupert, BC Canada, and Disposal of Dredgate at Brown Passage	Updated by EIS Addendum
Technical Memorandum: Response to Aboriginal Independent Science Review Team (AISRT) Review (June 2014)	Not affected
Technical Memorandum: Sediment Transport into the Project Development Area from the Skeena River (June 2014)	Not affected
Technical Memorandum: Effects of Dredging and Disposal at Sea (June 2014) • Sections relating to the marine terminal berth • Sections relating to the materials off-loading facility (MOF).	 Not relevant Updated by EIS Addendum
Technical Memorandum: Fish Habitat Offsetting (June 2014)	Superseded

Document Name	Status
Technical Memorandum: Contaminants of Concern in Sediment Proposed to be Dredged from the Materials Offloading Facility and Marine Terminal Berth Area (June 2014)	
• Sections relating to the marine terminal berth	Not relevant
• Sections relating to the MOF.	Updated by EIS Addendum
Technical Memorandum: Effects of Underwater Noise on Marine Mammals and Fish (June 2014)	Not affected
Technical Memorandum: Trenching Utility Lines through Lelu Slough (June 2014)	Not relevant
Technical Memorandum: Mitigation Measures for Effects of Underwater Construction Noise (June 2014)	Not affected
Technical Memorandum: Species Use of Marine Habitats in the Local Assessment Area (June 2014)	Not affected
Follow-up Report on Sediment and Water Quality Associated with Construction of the Terminal Berth Area (June 2014)	
• Appendix D (PNW LNG Proposed MOF – Review of Dioxin and Furan Data from the Proposed Dredge Site According to Environment Canada [2014] Guidance)	Updated by EIS Addendum
• Remainder of the report.	Not relevant
Responses to Working Group Comments (June 2014)	
• Responses relating to the marine terminal berth area	Not relevant
• Responses relating to the MOF	Updated by EIS Addendum
• Responses relating to marine fish and marine mammals	Not affected
• Reponses relating to fish habitat offsetting.	Updated by EIS Addendum

13.1 PROJECT EFFECTS ASSESSMENT UPDATE

See Appendix A of this EIS Addendum.

13.2 CUMULATIVE EFFECTS ASSESSMENT UPDATE

See Appendix A of this EIS Addendum.

13.3 RESPONSES TO THE OUTSTANDING INFORMATION REQUESTS

Responses to outstanding information requests for Marine Resources are provided in Appendix G (see Table 13-2).

Table 13-2 Outstanding Information Request Responses

Outstanding Information Request	Location/Response
Marine Resources Information Request #1	Appendix G.1
Marine Resources Information Request #2	Appendix G.1
Marine Resources Information Request #3	Appendix G.1
Marine Resources Information Request #4	Appendix G.2 & G.3
Marine Resources Information Request #5	Appendix G.2 & G.3
Marine Resources Information Request #6	Appendix G.2 & G.3
Marine Resources Information Request #7	Appendix G.2 & G.3
Marine Resources Information Request #10	Appendix G.4 & G.19
Marine Resources Information Request #11	Appendix G.5
Marine Resources Information Request #12	Appendix G.5
Marine Resources Information Request #13	Appendix G.5
Marine Resources Information Request #15	Appendix G.5
Marine Resources Information Request #16	Appendix G.5
Marine Resources Information Request #17	Appendix G.5
Marine Resources Information Request #18	Appendix G.6
Marine Resources Information Request #19	Appendix G.7
Marine Resources Information Request #20	Appendix G.7
Marine Resources Information Request #21	Appendix G.5
Marine Resources Information Request #23	Appendix G.8
Marine Resources Information Request #24	Appendix G.8
Marine Resources Information Request #25	Appendix G.9 & G.10
Marine Resources Information Request #26B	Appendix G.9 & G.10
Marine Resources Information Request #27	Appendix G.11
Marine Resources Information Request #31	Appendix G.12
Marine Resources Information Request #34	Appendix G.13
Marine Resources Information Request #36	Appendix G.14
Marine Resources Information Request #37	Appendix G.14
Marine Resources Information Request #38	Appendix G.15
Marine Resources Information Request Annex 1 (Disposal at Sea)	Appendix G.5

13.4 MITIGATION

13.4.1 Changes to Mitigation Measures Presented in the EIS

Based on design changes to the Project and the feedback received during the environmental assessment process, the set of mitigation measures originally presented in the EIS to address potential effects to Marine Resources has been updated. The mitigation measures that have been refined, added to, or removed from mitigation measures initially included in the EIS are provided below.

13.4.1.1 Change in Sediment or Water Quality

The following mitigation measures have been **changed** from:

- Total suspended solids (TSS) and turbidity will be monitored during in-water construction activities (e.g., shoreline infilling, pile installation, blasting, dredging, and ocean disposal). In the event that TSS levels exceed applicable water quality guidelines outside of the immediate work area (defined in consultation with regulatory agencies), the rate of the activity will be adjusted (e.g., slowed), or additional mitigation measures implemented (e.g., silt curtains) to minimize the spatial extent of elevated TSS
- At the disposal site, sediment will be disposed within the approved disposal area at a point distant from the area used on the previous trip
- Use of tugs with less powerful propulsion systems (e.g., Voith Schneider) will be evaluated.

To:

- Turbidity will be monitored in real time during in-water construction activities (i.e., blasting, dredging, and ocean disposal) and compared to predicted TSS levels (through use of a turbidity-TSS calibration curve) and WQG. In the event that calculated TSS levels exceed modelled predictions outside of the active work area (defined as the immediate area surrounding operating construction equipment) or disposal site, the rate of the activity will be adjusted (e.g., slowed), or additional mitigation measures implemented (e.g., silt curtains) to minimize the spatial extent of elevated TSS
- Dredged sediment will be disposed of at or near the center point of the Brown Passage disposal site, to minimize effects on water quality outside the site
- Tugs with less powerful propulsion systems (Voith Schneider tugs) have been evaluated and will be used.

The following mitigation measures have been **added**:

- In areas of low to moderate currents (≤ 1 knot), silt curtains will be installed around dredging and blasting activities if monitoring indicates that inferred TSS levels are greater than predicted (Appendix G.12). Studies suggest that effectiveness of silt curtains is reduced when currents exceed about 1 knot (Francingues and Palermo 2005). Silt curtains are expected to be most effective in the inner, sheltered areas of the MOF. Currents in Porpoise Channel (outer MOF) are likely to be too strong to permit effective use of silt curtains
- Dredging will occur at low tide, where possible.

The following mitigations have been **removed**:

- Extend disposal timelines beyond one year, resulting in fewer disposal events per day
- Consider alternative disposal sites in addition to Brown Passage
- A portion of the seabed will be armoured in the marine berth area
- Arrivals and departures of LNG carriers will be avoided at low water slack tide and as the tide rises from low water up to mean sea level (MSL)
- Beneficial re-use of sediment for construction or fish habitat enhancement. Habitat enhancement could result in the reduction of up to half of the dredged sediment to be disposed at sea from the marine berth area (see Appendix K) [this mitigation measure has been **changed** and **added** to *Change in (permanent alteration or destruction of) Fish Habitat*].

13.4.1.2 Change in (permanent alteration or destruction of) Fish Habitat

The following mitigation measure has been **changed** from:

- Habitat offsetting will be implemented to achieve no net loss of productivity.

To:

- A Habitat Offsetting Plan will be developed and implemented to maintain productivity within the LAA.

The following mitigation measures have been **added**:

- No offset habitats will be located on Flora Bank and Agnew Bank
- Planned scour protection will be placed around tower platform below mud line through use of slightly larger substrate sized materials around the perimeter of tower platform based on 2D and 3D model outputs
- Beneficial re-use of rock for construction of fish habitat offset is being considered and will be determined in consultation with Fisheries and Oceans Canada

The following mitigations have been **removed**:

- The outer limits of foreshore construction areas (the MOF, marine terminal, bridge and pioneer dock) will be demarcated to avoid habitat damage outside of these areas.

13.4.1.3 Direct Mortality or Physical Injury to Fish or Marine Mammals

The following mitigation measure has been **changed** from:

- A Pile Driving Management plan will be implemented to outline low noise techniques (such as vibratory hammer with bubble curtain) to be used to install piles, where technically feasible. If an impact pile driver is used (with bubble curtain) a marine mammal observation program will be implemented.

To:

- A Marine Pile Installation Management Plan (see Appendix J.12) which outlines the reduced noise pile installation techniques that will be used when low noise installation methods are not technically feasible (e.g., due to unfavourable substrate) will be implemented
- Low noise pile installation techniques (i.e., vibratory installation methods) will be used except during seating of some piles into bedrock
- In instances when an impact pile driver is required (e.g., during pile seating), bubble curtains with bubble-containment casing will be used and the impact hammer will be constructed of sound absorbent material. To mitigate for behavioural effects, a bubble curtain will also be used during low noise pile installation (see Section 13.5.5.2)
- In instances when the efficacy of bubble curtains is diminished by high currents, isolation casings that contain bubbles will be used in lieu of bubble curtains
- During all pile installation activities, a marine mammal observation program will be implemented. Marine mammal observers will monitor a safety radius (i.e., exclusion zone) around pile installation, including during pile seating, and will halt the activities if cetaceans (of any species) or other marine mammal species that are listed under SARA enter this zone
- The Environmental Monitoring Management Plan will detail the duties and responsibilities of the MMOs, and will include the following protocols:
  - Prior to commencement of impact pile installation activities and any time there is a pause in impact pile installation for more than 30 minutes, the safety zone will be surveyed visually by the MMO, and impact pile installation will not commence until (i) any observed cetacean or SARA-listed marine mammal is seen leaving the safety zone, or (ii) none have been detected in the safety zone for a period of 30 minutes
  - Upon commencement of impact pile installation activities or recommencement after a delay of 30 minutes or more, pile installation will ramp-up by starting with slower, quieter strikes. This is designed to enable any marine mammals in the area time to leave the area prior to attainment of underwater noise levels capable of causing injury
  - During conditions of low visibility (i.e., when the safety zone cannot be monitored, during foggy conditions or darkness), if pile installation activities have ceased for more than 30 minutes, the MMO will delay recommencement of start-up until conditions improve. Once conditions improve, the safety zone will be monitored for cetaceans (of any species) or other SARA-listed marine mammals for 30 minutes before commencing impact pile installation.
  - Underwater sounds levels will be measured/monitored in situ during the first seven days of underwater blasting and impact pile driving to acquire baseline data on sound pressure levels produced during each activity, and to field-validate the effectiveness of bubble curtains and the size of the safety zone (currently

set at 500 m and 1.0 km respectively). Monitoring will be conducted at the sound source and at the edge of the marine mammal safety radius (i.e., exclusion zone). Measurements for source levels are made close to the source, typically at a distance of 10 to 100 m. The exact distance and location will depend on several factors, such as source type and amplitude, and water depth. Measurements may be taken at multiple distances simultaneously to assist with confirming the back-propagation function. Should the construction equipment or technique change notably over the course of construction (e.g., pile installation method or material, blasting charge etc.), such that source levels measured at the onset are unlikely to remain representative, new source levels will be acquiredIn addition:

  - If monitoring indicates pressure levels in excess of 30 kPa or a fish kill is observed during vibratory or impact pile driving, the activity will cease and DFO will be notified. The activity will resume after additional mitigation measures are implemented
  - If monitoring indicates pressure levels in excess of 100 kPa or a fish kill is observed during underwater blasting, the activity will cease and DFO will be notified. The activity will resume after additional mitigation measures are implemented
  - If monitoring indicates sound levels in excess of 160 dB at the edge of the marine mammal safety (exclusion) zone for any activity, the activity will cease and DFO will be notified. The activity will resume after additional mitigation measures are implemented. Additional measures could include type/configuration of bubble curtain and size of safety radius for marine mammals
  - If monitoring indicates sound levels at or below 160 dB are being achieved at a distance of 500 m or less, the marine mammal safety (exclusion) zone for that activity may be reduced to 500 m

- Pile driving planning and operation will adhere to the Best Management Practices Policy for Pile Driving and Related Operations developed by the BC Marine and Pile Driving Contractors Association and DFO (BC Marine and Pile Driving Contractors Association 2003), wherever and whenever feasible.

The following mitigation measures have been **changed** from:

- DFO's Blasting Guidelines (Wright and Hopky 1998) will be implemented, including enforcing a safety radius of 500 m, and ensuring marine mammals are not present in the safety radius prior to blasting
- Blasting will be conducted within DFO least-risk timing windows (November 30 to February 15) to reduce mortality to fish during important lifecycle stages
- Material from the dredge area that is suitable for construction or habitat offsetting will be used rather than disposing of it at sea to reduce potential crushing of marine organisms.

To:

- Fisheries and Oceans Canada's Blasting Guidelines (Wright and Hopky 1998) will be implemented, including enforcing a safety radius of 500 m, and ensuring marine mammals are not present in the safety radius prior to blasting. A marine mammal observation program will be implemented and marine mammal observers (MMOs) will terminate blasting activities if cetaceans or marine mammals listed under the *Species at Risk Act* (SARA) enter the 500 m blasting safety radius (detailed below under 'underwater noise')
- Blasting will be conducted within DFO least-risk timing windows (approximately November 30 to February 15); exact dates to be refined to reflect local conditions, based on pre-construction field surveys and in consultation with DFO to reduce mortality to fish during important lifecycle stages

- Rock from the dredge area that is suitable for construction or habitat offsetting will be used rather than disposing of it at sea to reduce the amount of disposal material and associated potential TSS levels. Turbidity levels in accessible areas of the water column will be monitored during disposal.

The following mitigation measures have been **added**:

- Dredged material will be disposed near the middle of the approved disposal area. Material from the dredge area that is suitable for construction or habitat offsetting (e.g., rock) will be used rather than disposing of it at sea to reduce the amount of disposal material and associated potential TSS levels. Turbidity levels in accessible areas of the water column will be monitored during disposal
- Turbidity will be monitored in real time during in-water construction activities (i.e., blasting, dredging, and ocean disposal) and compared to predicted TSS levels (through use of a turbidity-TSS calibration curve) and WQG. In the event that calculated TSS levels exceed modelled predictions outside of the active work area (defined as the immediate area surrounding operating construction equipment) or disposal site, the rate of the activity will be adjusted (e.g., slowed), or additional mitigation measures implemented (e.g., silt curtains) to minimize the spatial extent of elevated TSS
- A Blasting Management Plan which outlines management measures for both terrestrial and underwater blasting will be implemented (Appendix J.11 of this EIS Addendum)
- The blasting design will consider appropriate measures to reduce overpressure, through the optimum use of explosives for rock blasting. Where possible (i.e., if low tides occur during daytime hours), blasting will be timed with low tides to reduce the number of detonations that occur underwater
- In areas of low to moderate currents (≤ 1 knot), silt curtains will be installed around blasting activities if monitoring results indicate inferred TSS levels will be higher than the WQG outside the active work area. Studies suggest that effectiveness of silt curtains is reduced when currents exceed about 1 knot (Francingues and Palermo 2005). Silt curtains are expected to be most effective in the inner, sheltered areas of the MOF. Currents in Porpoise Channel (outer MOF) are likely to be too strong to permit effective use of silt curtains
- Bubble curtains will be used during pile installation (i.e., vibratory and impact) at the inner MOF. The exact style of bubble curtain and/or casing used will be determined on a case by case basis, taking into consideration the type of activity (and predicted sound levels) and oceanographic conditions (e.g., current speed). In situ field validation of the effectiveness will be measured/monitored during the first seven days of each style of curtain/casing implemented to confirm underwater sound levels produced following implementation of this mitigation
- If it is determined that pile installation and dredging need to occur simultaneously, potential underwater noise levels will be modelled to inform mitigation measures, and a monitoring program will be developed.

13.4.1.4 Change in Behaviour of Fish or Marine Mammals

Mitigations remain unchanged from EIS.

13.4.2 Complete List of Current Mitigation Measures

All of the technically and economically-feasible mitigation measures currently being presented by PNW LNG to address potential effects to Marine Resources are listed below. This includes those originally presented in the EIS that remain relevant, as well as those that have been revised or added as a result of feedback received during the environmental assessment process or as a result of the project changes. By implementing this full set of mitigation measures, PNW LNG is confident that the Project will not result in significant adverse effects to Marine Resources.

13.4.2.1 Change in Sediment or Water Quality

- A 30 m vegetation buffer will be retained around the perimeter of Lelu Island, except at access points (e.g., at the bridge, pioneer dock, MOF, trestle, and pipeline interconnection). Sediment and erosion control measures will be used (e.g., sediment fences) for land-based construction, particularly at the shoreline, to reduce TSS inputs into the water.
- Dredging operations will be conducted using methods and/or equipment that reduces sediment spill
- Turbidity will be monitored in real time during in-water construction activities (i.e., blasting, dredging, and ocean disposal) and compared to predicted TSS levels (through use of a turbidity-TSS calibration curve) and WQG. In the event that calculated TSS levels exceed modelled predictions outside of the active work area (defined as the immediate area surrounding operating construction equipment) or disposal site, the rate of the activity will be adjusted (e.g., slowed), or additional mitigation measures implemented (e.g., silt curtains) to minimize the spatial extent of elevated TSS
- In areas of low to moderate currents (≤ 1 knot), silt curtains will be installed around dredging and blasting activities if monitoring indicates that inferred TSS levels are greater than predicted (Appendix G.12). Studies suggest that effectiveness of silt curtains is reduced when currents exceed about 1 knot (Francingues and Palermo 2005). Silt curtains are expected to be most effective in the inner, sheltered areas of the MOF. Currents in Porpoise Channel (outer MOF) are likely to be too strong to permit effective use of silt curtains
- Dredging will occur at low tide, where possible
- Dredged sediment will be disposed of at or near the center point of the Brown Passage disposal site, to minimize effects on water quality outside the site
- Tugs with less powerful propulsion systems (Voith Schneider tugs) have been evaluated and will be used.

13.4.2.2 Change in (permanent alteration or destruction of) Fish Habitat

- No offset habitats will be located on Flora Bank and Agnew Bank
- Planned scour protection will be placed around tower platform below mud line through use of slightly larger substrate sized materials around the perimeter of tower platform based on 2D and 3D model outputs
- Hard multi-facetted shoreline protection material (e.g., rip-rap boulders) will be used where needed (e.g., trestle abutment) to promote colonization by marine biota
- A Habitat Offsetting Plan will be developed and implemented to maintain productivity within the LAA
- Beneficial re-use of rock for construction of fish habitat offset is being considered and will be determined in consultation with Fisheries and Oceans Canada

13.4.2.3 Direct Mortality or Physical Injury to Fish or Marine Mammals

13.4.2.3.1 Burial, Crushing, or Blasting

- A Blasting Management Plan which outlines management measures for both terrestrial and underwater blasting will be implemented (Appendix J.11 of this EIS Addendum)
- Fisheries and Oceans Canada's Blasting Guidelines (Wright and Hopky 1998) will be implemented, including enforcing a safety radius of 500 m, and ensuring marine mammals are not present in the safety radius prior to blasting. A marine mammal observation program will be implemented and marine mammal observers (MMOs) will terminate blasting activities if cetaceans or marine mammals listed under the *Species at Risk Act* (SARA) enter the 500 m blasting safety radius (detailed below under 'underwater noise')
- Blasting will be conducted within DFO least-risk timing windows (approximately November 30 to February 15); exact dates to be refined to reflect local conditions, based on pre-construction field surveys and in consultation with DFO to reduce mortality to fish during important lifecycle stages
- The blasting design will consider appropriate measures to reduce overpressure, through the optimum use of explosives for rock blasting. Where possible (i.e., if low tides occur during daytime hours), blasting will be timed with low tides to reduce the number of detonations that occur underwater
- Dungeness crabs will be relocated from construction zones using proper handling techniques and strategies that limit stress
- In areas of low to moderate currents (≤ 1 knot), silt curtains will be installed around blasting activities if monitoring results indicate inferred TSS levels will be higher than the WQG outside the active work area. Studies suggest that effectiveness of silt curtains is reduced when currents exceed about 1 knot (Francingues and Palermo 2005). Silt curtains are expected to be most effective in the inner, sheltered areas of the MOF. Currents in Porpoise Channel (outer MOF) are likely to be too strong to permit effective use of silt curtains.

13.4.2.3.2 Turbidity and TSS

- Dredging operations will be conducted using methods and/or equipment that reduces sediment spill
- Dredged sediment will be disposed of at or near the center point of the Brown Passage disposal site, to minimize effects on water quality outside the site
- Turbidity levels in accessible areas of the water column will be monitored during disposal
- Turbidity will be monitored in real time during in-water construction activities (i.e., blasting, dredging, and ocean disposal) and compared to predicted TSS levels (through use of a turbidity-TSS calibration curve) and WQG. In the event that calculated TSS levels exceed modelled predictions outside of the active work area (defined as the immediate area surrounding operating construction equipment) or disposal site, the rate of the activity will be adjusted (e.g., slowed), or additional mitigation measures implemented (e.g., silt curtains) to minimize the spatial extent of elevated TSS.

13.4.2.3.3 Underwater Noise

- A Marine Pile Installation Management Plan (see Appendix J.12) which outlines the reduced noise pile installation techniques that will be used when low noise installation methods are not technically feasible (e.g., due to unfavourable substrate) will be implemented
- Low noise pile installation techniques (i.e., vibratory installation methods) will be used except during seating of some piles into bedrock

- In instances when an impact pile driver is required (e.g., during pile seating), bubble curtains with bubble-containment casing will be used and the impact hammer will be constructed of sound absorbent material. To mitigate for behavioural effects, a bubble curtain will also be used during low noise pile installation (see Section 13.5.5.2)
- In instances when the efficacy of bubble curtains is diminished by high currents, isolation casings that contain bubbles will be used in lieu of bubble curtains
- Bubble curtains will be used during pile installation (i.e., vibratory and impact) at the inner MOF. The exact style of bubble curtain and/or casing used will be determined on a case by case basis, taking into consideration the type of activity (and predicted sound levels) and oceanographic conditions (e.g., current speed). In situ field validation of the effectiveness will be measured/monitored during the first seven days of each style of curtain/casing implemented to confirm underwater sound levels produced following implementation of this mitigation
- If it is determined that pile installation and dredging need to occur simultaneously, potential underwater noise levels will be modelled to inform mitigation measures, and a monitoring program will be developed.
- During all pile installation activities, a marine mammal observation program will be implemented. Marine mammal observers will monitor a safety radius (i.e., exclusion zone) around pile installation, including during pile seating, and will halt the activities if cetaceans (of any species) or other marine mammal species that are listed under SARA enter this zone
- The Environmental Monitoring Management Plan will detail the duties and responsibilities of the MMOs, and will include the following protocols:
  - Prior to commencement of impact pile installation activities and any time there is a pause in impact pile installation for more than 30 minutes, the safety zone will be surveyed visually by the MMO, and impact pile installation will not commence until (i) any observed cetacean or SARA-listed marine mammal is seen leaving the safety zone, or (ii) none have been detected in the safety zone for a period of 30 minutes
  - Upon commencement of impact pile installation activities or recommencement after a delay of 30 minutes or more, pile installation will ramp-up by starting with slower, quieter strikes. This is designed to enable any marine mammals in the area time to leave the area prior to attainment of underwater noise levels capable of causing injury
  - During conditions of low visibility (i.e., when the safety zone cannot be monitored, during foggy conditions or darkness), if pile installation activities have ceased for more than 30 minutes, the MMO will delay recommencement of start-up until conditions improve. Once conditions improve, the safety zone will be monitored for cetaceans (of any species) or other SARA-listed marine mammals for 30 minutes before commencing impact pile installation
  - Underwater sounds levels will be measured/monitored in situ during the first seven days of underwater blasting and impact pile driving to acquire baseline data on sound pressure levels produced during each activity, and to field-validate the effectiveness of bubble curtains and the size of the safety zone (currently set at 500 m and 1.0 km respectively). Monitoring will be conducted at the sound source and at the edge of the marine mammal safety radius (i.e., exclusion zone). Measurements for source levels are made close to the source, typically at a distance of 10 to 100 m. The exact distance and location will depend on several factors, such as source type and amplitude, and water depth. Measurements may be taken at multiple distances simultaneously to assist with confirming the back-propagation function. Should the construction equipment or technique change notably over the course of construction (e.g., pile

installation method or material, blasting charge etc.), such that source levels measured at the onset are unlikely to remain representative, new source levels will be acquired. In addition:

- If monitoring indicates pressure levels in excess of 30 kPa or a fish kill is observed during vibratory or impact pile driving, the activity will cease and DFO will be notified. The activity will resume after additional mitigation measures are implemented
- If monitoring indicates pressure levels in excess of 100 kPa or a fish kill is observed during underwater blasting, the activity will cease and DFO will be notified. The activity will resume after additional mitigation measures are implemented
- If monitoring indicates sound levels in excess of 160 dB at the edge of the marine mammal safety (exclusion) zone for any activity, the activity will cease and DFO will be notified. The activity will resume after additional mitigation measures are implemented. Additional measures could include type/configuration of bubble curtain and size of safety radius for marine mammals
- If monitoring indicates sound levels at or below 160 dB are being achieved at a distance of 500 m or less, the marine mammal safety (exclusion) zone for that activity may be reduced to 500 m

– Pile driving planning and operation will adhere to the Best Management Practices Policy for Pile Driving and Related Operations developed by the BC Marine and Pile Driving Contractors Association and DFO (BC Marine and Pile Driving Contractors Association 2003), wherever and whenever feasible.

13.4.2.4 Change in Behaviour of Fish or Marine Mammals

Several of the mitigation measures recommended in Section 13.5.4.2 will also reduce the potential for behavioural change to fish and marine mammals (e.g., use of a vibratory hammer with bubble curtain at the marine terminal). Other mitigations are:

- LNG carriers, tugs, and barges will not exceed a speed of 16 knots within the LAA
- LNG carrier vessel speed will be reduced to 6 knots when approaching the Triple Island Pilot Boarding Station.

13.5 CONCLUSION

Project residual effects on marine resources are predicted to be not significant (Table 13-3). Changes in sediment or water quality will be short-term and are not expected to affect fish health or marine resources as a whole. Changes to fish habitat and sediment and water quality will be localized, and mitigation measures are considered effective and well established. Increases in potential for direct mortality and physical injury to fish and marine mammals are expected to occur during construction. Marine mammals, and to a lesser extent fish, are expected to experience changes in behaviour during project construction, operations, and decommissioning. Harbour porpoise are the marine mammals most likely to change their behaviour (e.g., avoid areas during construction), primarily during the construction period. Because of the short term duration of most effects, the viability of local populations will not be affected. Mitigation measures will reduce the potential for mortality and injury and residual effects are not expected to affect population viability of any species.

Cumulative effects on marine resources are predicted to be not significant (Table 13-4). Cumulative effects to water and sediment quality are not anticipated due to lack of both temporal and spatial overlap of dredging and disposal activities and appropriate scheduling of dredging and disposal at sea associated with other reasonably

foreseeable projects. Through appropriate mitigation and design and implementation of fish habitat offsetting measures, productivity within the LAA will be maintained, resulting in negligible adverse residual effects to fish habitat and no cumulative effects. Cumulative effects of direct mortality or physical injury are expected to be moderate in magnitude, due to potential increases in injury to marine mammals caused by overlap in pile installation schedules with other reasonably foreseeable projects. Pile installation, shipping, and berthing will act cumulatively with other projects, increasing the spatial extent over which marine mammal behaviour could be affected. Marine mammals, namely harbour seals, harbour porpoise, and killer whales, could experience behavioural effects over larger areas and for longer periods of time as a result of concurrent construction and operations activities. Mitigation measures will reduce the potential for mortality and injury and residual effects are not expected to affect population viability of any species.

Changes to the information presented in Table 13-3 and Table 13-4 compared to the EIS are identified with underlined text.

The overall project effect on marine resources is determined to be not significant.

The prediction confidence in this assessment is deemed to be moderate.

Table 13-3 Characterization of Residual Effects for Marine Resources

Project Phase	Mitigation/Compensation Measures	Residual Effects Characterization						Likelihood	Significance	Confidence	Follow-up and Monitoring
		Context	Magnitude	Extent	Duration	Reversibility	Frequency				
Change in Sediment or Water Quality											
Construction	• A 30 m vegetation buffer will be retained around the perimeter of Lelu Island, except at access points • Sediment and erosion control measures will be used (e.g., sediment fences) for land-based construction, particularly at the shoreline, to reduce TSS inputs into water • Dredging will be conducted using methods and/or equipment that reduces sediment spill • TSS and turbidity will be monitored, the rate of the activity will be adjusted, or additional mitigation measures implemented as required • In areas of low to moderate currents (≤ 1 knot), silt curtains will be installed around dredging and blasting activities if monitoring indicates that inferred TSS levels are greater than predicted. Studies suggest that effectiveness of silt curtains is reduced when currents exceed about 1 knot • Dredging will occur at low tide, where possible • Dredged sediment will be disposed of at or near the center point of the Brown Passage disposal site, to minimize effects on water quality outside the site • Tugs with less powerful propulsion systems (Voith Schneider tugs) have been evaluated and will be used.	H	L–M	L	S	R	M	H	N	H	**Follow-up Program:** • Sediment Transport • Marine Country Foods **Monitoring:** • Compliance monitoring required for permits
Operations		H	L–M	L	L	R	C				
Decommissioning and Abandonment		N/A	N/A	N/A	N/A	N/A	N/A				
Residual Effects for All Phases		H	L–M	L	S-L	R	M/C				
Change in Fish Habitat											
Construction	• No offset habitats will be located on Flora Bank and Agnew Bank • Planned scour protection will be placed around tower platform below mud line through use of slightly larger substrate sized materials around the perimeter of tower platform based on 2D and 3D model outputs • Hard multi-facetted shoreline protection material (e.g., rip-rap boulders) will be used where needed (e.g., trestle abutment) to promote colonization by marine biota. • A Habitat Offsetting Plan will be developed and implemented to maintain productivity within the LAA. • Beneficial re-use of rock for fish offsets is being considered and will be determined in consultation with DFO	M	N	L	P	R	S	L	N	M	**Follow-up Program:** • Marine Fish and Fish Habitat • Habitat Offsetting Plan **Monitoring:** • Compliance monitoring required for permits
Operations		M	N	L	P	R	S				
Decommissioning and Abandonment		N/A	N/A	N/A	N/A	N/A	N/A				
Residual Effects for All Phases		M	M	L	P	R	S				

Project Phase	Mitigation/Compensation Measures	Residual Effects Characterization						Likelihood	Significance	Confidence	Follow-up and Monitoring
		Context	Magnitude	Extent	Duration	Reversibility	Frequency				
Direct Mortality or Physical Injury to Fish or Marine Mammals											
Construction	• A Blasting Management Plan will be implemented • Fisheries and Oceans Canada's Blasting Guidelines will be implemented, including enforcing a safety radius of 500 m, and ensuring marine mammals are not present in the safety radius prior to blasting • Blasting will be conducted within DFO least-risk timing windows (approximately November 30 to February 15); exact dates to be refined based on additional studies and in consultation with DFO • Blasting design will consider measures to reduce overpressure • Dungeness crabs will be relocated from construction zones • In areas of low to moderate currents (≤ 1 knot), silt curtains will be installed around blasting activities if monitoring results indicate • inferred TSS levels will be higher than the WQG outside the active work area • Dredging operations will be conducted using methods and/or equipment that reduces sediment spill • At the disposal site, sediment will be disposed within the previously used disposal area at or near the center point of the disposal site • TSS and turbidity will be monitored, the rate of the activity will be adjusted, or additional mitigation measures implemented as required • A Marine Pile Installation Management Plan will be implemented • Low noise pile installation techniques (i.e., vibratory installation methods) will be used except during seating of some piles into bedrock • In instances when an impact pile driver is required (e.g., during pile seating), bubble curtains with bubble-containment casing will be used and the impact hammer will be constructed of sound absorbent material. To mitigate for behavioural effects, a bubble curtain will also be used during low noise pile installation • In instances when the efficacy of bubble curtains is diminished by high currents, isolation casings that contain bubbles will be used in lieu of bubble curtains • Bubble curtains will be used during pile installation (i.e., vibratory and impact) at the inner MOF. The exact style of bubble curtain and/or casing used will be determined on a case by case basis • If it is determined that pile installation and dredging need to occur simultaneously, potential underwater noise levels will be modelled to inform mitigation measures, and a monitoring program will be developed • A marine mammal observation program will be implemented during pile installation activities.	M	M	P–L	S	R	M	H	N	M	**Monitoring:** • Measure sound levels during pile installation
Operations		M	L	P	L	R	M				
Decommissioning and Abandonment		N/A	N/A	N/A	N/A	N/A	N/A				
Residual Effects for All Phases		M	M	L	L	R	C				
Change in Behaviour of Fish or Marine Mammals											
Construction	• Vessels will not exceed a speed of 16 knots within the LAA • LNG carrier vessel speed will be reduced to 6 knots when approaching the Triple Island Pilot Boarding Station.	L–M	M	L	M	R	M	H	N	M	None
Operations		M–H	M	L	L	R	M				
Decommissioning		M	L	L	S	R	M				
Residual Effects for All Phases		L-M	M	L	L	R	M/C				

Project Phase	Mitigation/Compensation Measures	Residual Effects Characterization									Follow-up and Monitoring
		Context	Magnitude	Extent	Duration	Reversibility	Frequency	Likelihood	Significance	Confidence	
KEY **CONTEXT:** **Low resilience (L)**—under baseline conditions, marine resources are rarely exposed to anthropogenic effects and are highly sensitive to them; such changes could trigger large and lasting ecological effects. **Moderate resilience (M)**—under baseline conditions, marine resources are occasionally exposed to anthropogenic effects and are sensitive to them; such changes trigger small and short-term ecological effects. **High resilience (H)**—under baseline conditions, marine resources often experience anthropogenic effects and are unaffected by them; such changes trigger no detectable ecological effects.	**MAGNITUDE:** **Negligible (N)**—no measurable change in fish and marine mammal populations, habitat quality or quantity, or contaminant levels. **Low (L)**—a measurable change but within the range of natural variability (change in population levels or contaminant concentrations consistent with baseline levels). Will not affect population viability. **Moderate (M)**—measurable change outside the range of natural variability but not posing a risk to population viability. **High (H)**—measurable change that exceeds the limits of natural variability and may affect long-term population viability (includes exceedances of toxicological thresholds for sediment and water quality and thresholds for underwater sound levels, considering natural background levels). **EXTENT:** **P**—effect is restricted to the PDA. **L**—effect is prevalent in the LAA.				**DURATION:** **Short-term (S)**—change limited to project construction and decommissioning phases. **Medium-term (M)**—change continues for up to two years following construction or decommissioning before returning to baseline condition. **Long-term (L)**—change continues for more than two years after construction project phase, or continues during operations project phase. **Permanent (P)**—measurable parameter unlikely to return to baseline level. **REVERSIBILITY:** **Reversible (R)**—will recover to baseline conditions after project closure and reclamation. **Irreversible (I)**—permanent. **FREQUENCY:** **Single event (S)**—occurs once. **Multiple regular event (M)**—occurs often throughout the construction, operations, or decommissioning phase. **Continuous (C)**—effect occurs continuously throughout the life of the Project.				**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** 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.	

Table 13-4 Summary of Cumulative Residual Environmental Effects on Marine Resources

Cumulative Environmental Effect and Project Contribution		Other Projects, Activities and Actions	Mitigation and Compensation Measures	Residual Cumulative Effects Characterization						Likelihood	Significance	Prediction Confidence	Follow-up and Monitoring Programs
				Context	Magnitude	Extent	Duration	Reversibility	Frequency				
Change in sediment or water quality • Disposal at sea screening criteria and CCME and BC guidelines for protection of marine life are used to assess potential for effects • Draft guidance from Environment Canada outlines criteria specific to dioxins and furans for sediment proposed for open water disposal.	**Cumulative Effect with Project** • Some legacy sediment contaminants (dioxins and furans) • Sediment disturbance from construction activities • Disposal in Brown Passage.	• Canpotex Potash Export Terminal • Fairview Container Terminal Phase I • Fairview Container Terminal Phase II • Prince Rupert Gas Transmission Project • Prince Rupert Grain Limited • Ridley Terminals Inc. • WatCo (formerly Skeena Cellulose) Pulp Mill • Westcoast Connector Gas Transmission Project.	None	H	L-M	L	S-L	R	M/C	H	N	H	None
	Project Contribution to Cumulative Effect (in RAA) • Dredging of 790,000 m^3 of material at MOF • Disposal of <200,000 m^3 of material at sea from MOF dredging (85 return trips to Brown Passage) • TSS levels are expected to be temporarily elevated during dredging and disposal • LNG carrier arrivals and departures during operations (two movements per day).	**Construction:** • Site preparation (land-based) • Onshore construction • Dredging • Marine construction • Waste management and disposal • Disposal at sea • Operational testing and commissioning • Site clean-up and reclamation. **Operations:** • Marine terminal use • Shipping • Waste management and disposal. **Decommissioning:** • Dismantling facility and supporting Infrastructure • Dismantling of marine terminal • Waste disposal Site clean-up and reclamation.	See Table 13-3 Summary of Residual Effects on Marine Resources	H	L-M	L	S-L	R	M/C	H	N	H	**Follow-up Program:** • Sediment Transport

Cumulative Environmental Effect and Project Contribution		Other Projects, Activities and Actions	Mitigation and Compensation Measures	Residual Cumulative Effects Characterization						Likelihood	Significance	Prediction Confidence	Follow-up and Monitoring Programs
				Context	Magnitude	Extent	Duration	Reversibility	Frequency				
Direct mortality or physical injury to fish or marine mammals • Direct mortality, or injury that leads to mortality or reduced fitness, can negatively affect population viability • Compliance with Section 35 of the Fisheries Act and Section 32(1) of SARA • Predicted noise levels can be compared to published thresholds predicted to cause injury to marine mammals and mortality to fish.	**Cumulative Effect with Project** • Construction activities involving blasting, dredging, excavation, pile driving • Disposal at sea.	• Canpotex Potash Export Terminal • Fairview Container Terminal Phase II • Prince Rupert Gas Transmission Project • Westcoast Connector Gas Transmission Project.	None	M	M	L	L	R	C	H	N	M	None
	Project Contribution to Cumulative Effect (in RAA) • Construction activities involving blasting, dredging, excavation, pile driving • Disposal at sea.	**Construction:** • Dredging • Marine construction • Disposal at sea. **Operations:** • Marine terminal use. **Decommissioning:** • Dismantling facility and supporting Infrastructure • Dismantling of marine terminal • Site clean-up and reclamation.	See Table 13-3 Summary of Residual Effects on Marine Resources	M	M	L	L	R	C	H	N	M	Monitor underwater noise during pile installation
Change in behaviour of fish or marine mammals • Change in behaviour can reduce access to habitats important for completing life-cycle stages (e.g., feeding), potentially affecting population viability • Predicted noise levels can be compared to published thresholds predicted to affect marine mammal behaviour • Published thresholds do not exist for fish; therefore, time and duration are used to qualitatively assess changes in behaviour caused by underwater noise.	**Cumulative Effect with Project** • Marine construction noise from pile driving • Shipping and berthing noise: increase annual shipping from 1,000 to 2,000 ships (4,000 movements) by 2025.	• Atlin Terminal • Canpotex Potash Export Terminal • Douglas Channel LNG • Enbridge Northern Gateway Project • Fairview Container Terminal Phase I • Fairview Container Terminal Phase II • Kitimat LNG Terminal Project • LNG Canada Project • Northland Cruise Terminal • Odin Seafood • Pinnacle Pellet Inc. • Prince Rupert LNG Facility • Prince Rupert Gas Transmission Project • Prince Rupert Ferry Terminal • Prince Rupert Grain Limited • Ridley Terminals Inc. • Rio Tinto Alcan Aluminum Smelter and Modernization Project • Westcoast Connector Gas Transmission Project.	None	L-M	M	L	L	R	C	H	N	L-M	None
	Project Contribution to Cumulative Effect (in RAA) • Dredging, disposal at sea, and construction-related vessel movement, shipping and berthing.	**Construction:** • Dredging • Marine construction • Disposal at sea.	See Table 13-3 Summary of Residual Effects on Marine Resources	L-M	M	L	L	R	M/C	H	N	M	None

Cumulative Environmental Effect and Project Contribution	Other Projects, Activities and Actions	Mitigation and Compensation Measures	Residual Cumulative Effects Characterization						Likelihood	Significance	Prediction Confidence	Follow-up and Monitoring Programs
			Context	Magnitude	Extent	Duration	Reversibility	Frequency				
	Operations: • Marine terminal use • Shipping. **Decommissioning:** • Dismantling facility and supporting Infrastructure • Dismantling of marine terminal.											

KEY

CONTEXT:

Low resilience (L)—under baseline conditions, marine resources are rarely exposed to anthropogenic effects and are highly sensitive to them; such changes could trigger large and lasting ecological effects.

Moderate resilience (M)—under baseline conditions, marine resources are occasionally exposed to anthropogenic effects and are sensitive to them; such changes trigger small and short-term ecological effects.

High resilience (H)—under baseline conditions, marine resources often experience anthropogenic effects and are unaffected by them; such changes trigger no detectable ecological effects.

MAGNITUDE:

Negligible (N)—no measurable change in fish and marine mammal populations, habitat quality or quantity, or contaminant levels.

Low (L)—a measurable change but within the range of natural variability (change in population levels or contaminant concentrations consistent with baseline levels). Will not affect population viability.

Moderate (M)—measurable change outside the range of natural variability but not posing a risk to population viability.

High (H)—measurable change that exceeds the limits of natural variability and may affect long-term population viability (includes exceedances of toxicological thresholds for sediment and water quality and underwater sound levels, considering natural background levels).

EXTENT:

P—effect is restricted to the PDA.

L—effect is prevalent in the LAA.

DURATION:

Short-term (S)—change limited to project construction and decommissioning phases.

Medium-term (M)—change continues for up to two years following construction or decommissioning before returning to baseline condition.

Long-term (L)—change continues for more than two years after construction project phase, or continues during operations project phase.

Permanent (P)—measurable parameter unlikely to return to baseline level.

REVERSIBILITY:

Reversible (R)—will recover to baseline conditions after project closure and reclamation.

Irreversible (I)—permanent.

FREQUENCY:

Single event (S)—occurs once (e.g., blasting).

Multiple regular event (M)—occurs often throughout the construction, operations, or decommissioning phase (e.g., dredging, pile driving).

Continuous (C)—effect occurs continuously throughout the life of the Project (e.g., shipping).

LIKELIHOOD:

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

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.