Appendix G.14
Marine Resources
Information Request #36 and 37

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Dear Ms. Ponsford:

Reference: Marine Resources Information Requests #36 and #37

This letter responds to the request for Outstanding Information received from the Canadian Environmental Assessment (CEA) Agency on August 14, 2014.

Information Request #36

Government of Canada – Outstanding Information:

Context

The proponent has provided information on how project infrastructure will affect scouring (i.e., around piles) and has accounted for scour in the calculation of serious harm to fish. However, the proponent has not presented information (sediment modelling) on how project infrastructure (e.g., Jetty Trestle, Marine Berths (including dredge location), MOF, Access Bridge, and Pioneer Dock) could affect Skeena River sediment deposition in the PDA (either increased deposition or scouring). If sediment movement and deposition in the PDA is altered there could be significant changes to the pre-existing habitat in Skeena River Estuary

Information Request

Provide sediment modelling on how project infrastructure could affect sediment deposition in the PDA, taking into consideration Skeena River sediment deposition. Explain how altering sediment deposition will impact fish and fish habitat and the implications for significance determinations.

If it is determined that the project infrastructure will result in the alteration of existing habitat, this will need to be quantified in table 1 and table 2 in the Fish Habitat Offsetting technical memo.

Information Request #37

Government of Canada – Outstanding Information:

Context

In response to Marine Resources IR #17, the proponent has indicated that "the increase in water depth at the marine terminal berth dredge area will reduce the ocean currents in that area, which will reduce sediment transport and re-suspension events".

Information Request

Please describe how changes in ocean currents will affect the natural sediment deposition on and around Flora Bank and the Skeena Estuary. How will altering sediment deposition affect fish and fish habitat and what are the implications for significance determinations?

Pacific NorthWest LNG Limited Partnership (PNW LNG) - Response:
Four sediment modelling analyses have been undertaken to establish existing sediment transport processes and predict potential sediment scour and deposition associated with the marine infrastructure.

These analyses include:

- ASL Environmental Sciences, 2014b. Sediment transport into the project development area (PDA) from the Skeena River 11p. (submitted with Round 1 IR mem_ir_pnw_marine_asl_skeena_dischrg_sed_transport.pdf)
- Hatch 2014a. Pacific Northwest LNG: Lelu Island Terminal Potential Impacts of the Marine Structures on the Hydrodynamics and sedimentation patterns. 18p
- Hatch 2014b. Pacific Northwest LNG: Lelu Island Terminal Marine Structure Scour. 52p
- Hatch 2014c. Pacific Northwest LNG: LNG Jetty Propeller Scour Analysis. 30p.

Tidal current, sediment patterns and predictive sediment models are based on and calibrated against existing data in the project development area, including:

- Tidal elevation stations (reference port of Prince Rupert, Port Edwards and the secondary ports of Qlawdzeet Anchorage, Refuge Bay and Seabreeze Point)
- Current mooring sites
- Surveyed bathymetry (2012) and existing Canadian Hydrographic Service chart bathymetry
- Skeena and Nass River discharge data (Canadian Hydrological database)
- Prince Rupert airport and Holland Rock wind data
- Oceanographic data records from Fisheries and Oceans Canada (DFO) and reported other sources
- Sediment samples defined through geophysics and geotechnical surveys reported in the original Environmental Impact Statement (EIS)
- Ocean currents collected from a project specific ocean buoy west of Flora Bank and in Porpoise Channel
- Landsat satellite imagery series.

The report results are summarized below and presented in three sections (A) Skeena River sediment transport, (B) effects of marine infrastructure on sediment transport, and (C) potential propeller scour from liquefied natural gas (LNG) vessels.

A) Skeena River Sediment Transport

The movement and water property distribution of the surface waters in Chatham Sound are defined by winds, tides and the Skeena and Nass River discharges (Trites 1956, Birch et al. 1985, ASL 2014, Hatch 2014a, b). The prevailing winds are from the southeast, with northeasterly Arctic outflow winds important in Portland Inlet. Stronger winds and storms often generate wave heights 1 m or less, ranging to 3 m heights. Strong waves can create specific events which re-suspend sediments from the sea floor in subtidal waters less the 10 to 15m (ASL 2014, Hatch 2014a). Currents in Chatham Sound range from 0.06 to 0.10 m/sec with maximum currents to 0.50 m/sec near the sea floor (Trites 1956).

Skeena River discharges, particularly in May through October, control surface water properties (temperature, oxygen, salinity, transparency, nutrients) in southern and central Chatham Sound around Lelu Island (Trites 1953, 1956, Birch et al. 1985). Low salinity and high freshwater concentrations occur along eastern Chatham Sound in the south, extending to the north above Digby Island (ASL 2014 – Figure 2). Skeena River water is circulated north into Chatham Sound by prevailing south to southeasterly winds throughout the year. Higher freshwater concentrations on eastern coastal areas result in part from the earth’s rotation (Coriolis effect).

Most of the surface water in Chatham Sound, particularly from May to October, transports suspended sediments discharged from the Skeena River. The largest levels of suspended sediments and resulting water turbidity are observed around Kennedy, De Horsey, Smith, Porcher, Kitson and Lelu Islands and often extend offshore to the Kinahan Islands in Chatham Sound (Hoos 1975, ASL 2014, SNC Lavalin Environment 2013a, b, c, 2014a, b, c). The distribution of Skeena River waters and suspended sediments is influenced by the complex bathymetry of the delta and the complex of islands and channels, including Kennedy, Smith, Marrack, DeHoresy and Porcher Islands (Hoos 1975). The Skeena River discharge is carried through three significant passages including: 25% through Inverness Passage, and equal discharge through Telegraph and Marcus passages (Conway et al. 1996, DeGroot 2005, ASL 2014 – Figure 6).

Larger particles of sand are transported as bedload in the Skeena River delta leading to Inverness, Telegraph and Marcus passages. Small to medium sized dunes, and large sand ridges are observed through passages and on the north side of Kennedy Island and between Smith and De Horsey Islands (Conway et al., 1996).

Silt and clay fine grained particle sediments occurs over a buoyant plume north of Kennedy Island beyond Lelu Island and are visible in aerial and satellite imagery (ASL 2014 – Figure 5). The suspended sediments are distributed over the several basins, passages, and tidal flats beyond Kiston Island, and deposited mudflats and shallow, intertidal passages around Smith, Porcher, Kennedy, De Horsey Islands, through Inverness Passage, and between Kitson and Lelu Islands (ASL 2014).

The sediment discharge from the Skeena River is estimated to range from 2 to 5 million m^3/year (Conway et al. 1996). Given an average sediment discharge of 3 million m^3/year, sand composition and deposition of at least 75% of this sediment (Conway et al. 1996), approximately 0.1 m/year of sediment can be deposited over the main Skeena estuary, with smaller levels of deposition ranging from 0.02 to 0.1 m/year in sites north of Smith Island toward Lelu Island. This rough approximation of sediment deposition north of Smith Island and near Lelu Island, is consistent with observations of band of dioxins and furans found in 1.2 m depths of sediment as markers from 50 years (1951 to 2001) of pulp mill operation discharges north of Porpoise Channel (Watson Island) (Section 13 of the EIS Follow-up Technical Data Report on Marine Sediment and Water Quality at the Marine Terminal Berth Dredge Area).

The local sediment deposition patterns around Kitson and Lelu Island are based on suspended sediments discharged and transported from the Skeena River (Conway et al. 1996, DeGroot 2005, ASL 2014). The pattern of deposition, suspension and re-suspension of new and existing sediments in strongly influenced by discharge, density and local tidal currents and tidal cycles around Kitson Island, Flora and Agnew Banks and Porpoise Channel (ASl 2014, Hatch 2014b – Figure 2-1, 2-2). Maximum flood and ebb tidal currents have been recorded greater than 1.0 m /sec (Inverness Passage and Porpoise Channel) (Hatch 2014a, b).

The fine sand and silt sediments suspended and deposited in shallower areas around the marine terminal, will be the main source of sediments that can be affected by construction of marine structures adjacent to Lelu and Kitson Islands. Particle tracking Model (PTM) results predict shallow bedload and suspended sediments around the project area will be transported offshore out of Porpoise Channel and north of Agnew Bank during maximum spring ebb tidal currents (Hatch 2014a – Figure 2-1). During flood tidal currents, sediment is transported from shallow areas from Horsey, Agnew to Flora Bank along and into Porpoise Channel (Hatch 2014a – Figure 2-2). The tidal currents into and out of Porpoise Channel help maintain the northern edge of Flora Bank and the depths and distribution of substrates in Agnew and Horsey Banks. The tidal current between Smith and Porcher Islands (Marcus Passage) and Smith Island the mainland (Inverness Passage) help maintain the southern edge of Flora Bank.

Fine sands were found distributed at deeper depths and in more stable layers of settlement further away from the Kitson Island and Porpoise Channel. Dioxins and furans were observed in these samples distributed deeper in the sand layers indicating a process of continuous transport and settlement of sediments at depth in Agnew and in Horesy Banks. Silts and less consolidated sediments were found closer to the edge of Agnew and Flora Banks along a west to east line from Kitson Island to Lelu Island. The silty – clay sediments indicated little presence of 50 years of dioxins and furans, originating from inside Porpoise Channel, at any depths and indicated a more continuous or changing pattern of sediment transport, re-suspension and distribution.

The transport, distribution and settlement of sediment particle sizes, concentration of silt and general sediment consolidation (compactness and silt embeddedness) support observations of substrates, habitats characteristics and species habitat use. Less consolidated silty substrates near the west to east edge of northern Flora bank, were observed as habitats for coonstripe shrimp and eelpouts and tubesnouts (Appendix M EIS) which use more turbulent open soft – sediment habitats (EIS, Section 13: Species Use of Marine Habitats in the Local Assessment Area 2014). Deeper areas of sandy substrates along Agnew Bank were observed as habitats used by Dungeness crab, flounder and sole (Appendix M EIS) which use stable, compact, soft - sediment open habitats (EIS, Section 13: Species Use of Marine Habitats in the Local Assessment Area 2014).

B) Marine Structure Effects on Sediment Transport

Hydrodynamic modelling using Coastal Modelling System (CMS) Flow (U.S. Army Corps of Engineers) was conducted for the waters around the marine terminal structures during four different periods of meteorological and oceanographic conditions: Storm, Freshet, Post Freshet, and Fall. Average current velocity was obtained at six locations around the marine infrastructure to estimate the effects of these structures on current velocities and resulting sediment deposition rates and distribution.

Results from all hydrodynamic simulations with and without marine terminal structures indicated that the areas around the large marine terminal structures, including the southwest Anchor Block and southwest Tower, are predicted to reduce both ebb and flood tide currents immediately around marine terminal structures by 0.01 m/sec around individual jetty piles and up to 0.17 m/sec adjacent to the southwest anchor platform of the suspension bridge during Storm (February 10th) conditions (Hatch 2014a – Tables 4-1, 4-2). Spring ebb and flood tidal currents are normally observed in the area of planned marine structures range from 0.1 m/sec to 0.5 m/sec (Hatch 2014b – Table 2-1, 2-2, Hatch 2014c – Figure 6.1).

Model predictions indicated a smaller reduction in tidal currents during the Post Freshet period relative to Fall or Storm conditions (Hatch 2014a – Table 4-1). The reduced current velocities would deposit additional sediment around the marine structures (Hatch 2014a – Figure 5-3). Changes to current velocities from the marine structures are predicted to be smaller where the currents are already weak (e.g., the Trestle).

Particle Tracking Model (U.S. Army Corps of Engineers) results predicted additional sediment deposition rates of 0.05 m/year to 0.1 m/year at distances from 100 m to areas adjacent to the southwest Anchor Block and southwest Tower. As discussed above in A), normal sediment deposition from the Skeena River ranges from 0.02 to 0.1 m /year. The predicted sediment deposition was higher associated with flood tides south to north across Flora Bank, with sediment deposition into Agnew Bank predominately on the north side of marine structure (Hatch 2014a – Figure 5-1). Ebb tide currents tended to deposit sediment against the northern side of marine structures on Agnew Bank, with some overlap during storm events onto the southern side of marine structure into Flora Bank (Hatch 2014a – Figure 5-2). The predicted effects of the pilings (for the marine terminal trestle) on sediment deposition ranged from 0 to 0.05 m/year and are smaller when compared with the southwest anchor block and southwest tower platforms. The largest change in predicted average current velocities and subsequent sediment deposition patterns with marine structures (jetty, berth, anchor and tower blocks) are during turbulent storm events in the fall and winter outside the growing season and Skeena River freshest.

Sediment deposition around marine structures is expected to be localized, and within 50 m to 100 m of the southwest Anchor Block and Tower platforms, predominately during storm periods in the fall and winter outside the marine summer growing season. Changes in tidal current velocities and sediment re-suspension and deposition patterns are not expected to alter or destroy fish habitats or cause death of fish in proximity to the project marine terminal structures. The rate of sediment deposition and changes within the area are predicted within the range of existing sediment deposition originating from the Skeena River sediment transport (ASL Environmental Sciences, 2014). The predicted changes in sediment deposition onto vegetated or growing areas of Flora Bank are expected to be reduced to negligible levels during the growing season based on limited changes in tidal current velocities (Hatch 2014a – Table 4-1). Eelgrass dies back each fall and grows up through the substrate each May and June. Eelgrass seed survival and growth is enhanced with additional sediment deposition (Marion and Orth 2012).

Eelgrass on Flora bank is predominantly the native Zostera marina species and grows extensive rhizomes, stems and leaves in lengths greater than 0.5 m. Flora Bank eelgrass has been observed distributed in conditions on the bank exposed to normal tidal currents > 1 m /sec, low light levels (transparencies < 0.25 m), water turbidity > 25 mg/L TSS, and tidal cycles which vary by greater than 7 m within a 24 hour period.

Dense eelgrass patches (eelgrass cover > 70%) are distributed on Flora Bank in areas of higher elevation (shallow bathymetry, > -0.5 m) and lower tidal currents relative to other portions of the bank. The dense eelgrass patches grow in local conditions of lower tidal current velocities immediately adjacent to Lelu Island and Kitson Islet (Hatch 2014c, Figures 6-1, 6-2), and in shallower areas of the bank with greater exposure to direct sunlight. Eelgrass on Flora Bank is not distributed in lower intertidal areas (> -1.0 m depths) or in subtidal areas (Faggetter 2009, Appendix M EIS). Eelgrass growth and survival is dependent on fast growth during low tide cycles in daylight hours over the summer growing season. Eelgrass density, distribution, and potentially seed survival and nutrients for growth, appear positively influenced by annual and seasonal sediment deposition onto Flora Bank. These results are consistent with other areas of the Skeena estuary (Faggetter 2013) and other studies around North America (Vandermeulen et al. 2012).

C) LNG Vessel Potential Propeller Scour

A sediment model was used to predict potential propeller scour and sediment generation and suspension from vessel maneuvering at the LNG carrier berth (Hatch 2014c). The model was developed using CMS Flow to predict local hydrodynamic conditions and PTM to investigate the sediment fate, including deposition areas and levels of total suspended solids (TSS) above background. This study was conducted assuming 29 LNG carrier arrivals and 29 departures during one month that represents the most conservative conditions for generation of scoured sediment volumes. The PTM simulation provided results about the sediment fate during one month of simulation, assuming two different paths used by the LNG vessels (bows north or south) (e.g., Hatch 2014c – Figure 4-4, 4-5).

LNG carrier vessels are expected to arrive and berth at dead slow speed (less than 0.1 m/sec), with maneuvering conducted entirely by tugs. Vessels will be in neutral and will propulsion and propeller RPMs at distances more than two boat lengths from the berth at ocean depths greater than 50m. Four Voith Schneider (VS) Tractor tugs (Hatch 2014c) will be secured to the LNG carrier to maneuver, berth and secure the vessel to mooring and berthing dolphins to facilitate LNG loading. Vessels will depart through assistance of tugs to pull the loaded LNG carrier away from the berth at distances one to two boat lengths from the berth. Loaded LNG carriers will engage their propulsion with all clear to their bows with the assistance of tugs and escort tugs. Loaded LNG carriers will engage engines and their propulsion in water depths greater than 30 m.

Vessel berthing and maneuvering at the marine terminal are not predicted to generate or suspend concentrations of sediment, above total suspended solids concentrations of 25 mg/L, which could alter or destroy fish habitats, or cause death of fish in proximity to the project marine terminal. When the LNG vessels are berthing with bow towards north, the TSS threshold value of 25 mg/L is exceeded for a duration of less than one hour along Kitson Island, and less than 1 hour on the southern edge of Flora Bank. If carriers are berthed with bows south (not expected), the TSS concentrations were below the threshold value (25 mg/L). All model estimates of TSS over Flora Bank were considered as negligible TSS concentrations during the simulation period of one month. If sediment is generated or suspended from tug, or LNG carrier propulsion, the existing currents and waves will deposit sediments in patterns seaward of the LNG carrier berth in water depths greater than 50 m (Hatch 2014c, Figure 8-6).

Vessel berthing and maneuvering at the marine terminal are not predicted to generate or suspend concentrations of sediment, above total suspended solids concentrations of 25 mg/L, which could alter or destroy fish habitats, or cause death of fish in proximity to the project marine terminal. When the LNG vessels are berthing with bow towards north, the TSS threshold value of 25 mg/L is exceeded for a duration of less than one hour along Kitson Island, and less than 1 hour on the southern edge of Flora Bank. If carriers are berthed with bows south (not expected), the TSS concentrations were below the threshold value (25 mg/L). All model estimates of TSS over Flora Bank were considered as negligible TSS concentrations during the simulation period of one month. If sediment is generated or suspended from tug, or LNG carrier propulsion, the existing currents and waves will deposit sediments in patterns seaward of the LNG carrier berth in water depths greater than 50 m (Hatch 2014c, Figure 8-6).

Potential propeller derived sediment movement is not predicted to deposit on eelgrass areas of Flora Bank. Potential propeller scour will create a scour pocket immediately adjacent to the berths and maintain this pocket at equilibrium within approximately two to five years. Sediment movement associated with propeller scour will be mitigated by use of VSP tugs, low RPM propeller rotation for LNG carriers adjacent to the berths, maneuvering with use of four tugs, and deep berths sited outside the scour potential (greater than 30 m deep) of LNG carrier propeller wash. Sediment moved from propeller wash is predicted to move at distances up to 300 m from the berth at a rate of 0 to 2 mm per month (29 vessel movements). Sediments will be moved and deposited immediately adjacent to the berths (Hatch 2014c, Figure 8-2 and 8-5). Fish habitat around the proposed berths is considered widely distribution, soft silt-clay – mud like sediment with no cover and uniform substrates. No life process dependent fish habitats have been observed in these areas.

TSS potentially generated by potential propeller wash is not expected to be distributed to sensitive eelgrass areas and is not expected to impact fish and fish habitats. Models have presently used very conservative vessel maneuvering scenarios. Maneuvering for LNG carriers is expected to not engage full trust from the carriers, maintain low RPM (less 60) and rely on VSP low propeller wash tugs for maneuvering and berthing. Based on natural tidal currents and diel tidal cycles, TSS is not predicted to be deposited onto sediments. TSS generated from propeller wash may circulate associated with tidal currents, but is considered within normal variation presently exhibited in the area around Kitson Island and Flora Bank (Summary in Appendix G14, G16, and ASL 2014).

LNG carrier maneuvering and berthing will examined, within the limits of routine safe vessel operations, to characterize propeller wash derived scour and generated TSS and sediment movement. TSS and changes in bathymetry (sediment elevation) will be monitoring around the berth areas and during vessel berthing to avoid and limit generated TSS and sediment scour.

Conclusions

Sediment deposition rates and patterns of distribution resulting from placement of marine terminal structures fall within normal variation and ranges of annual sediment deposition onto Agnew and Flora Bank areas. Sediment deposition around marine structures is expected to be localized, and within 50 m to 100 m of the SW Anchor Block and Tower platforms, predominately during storm periods in the fall and winter outside the marine summer growing season. Changes in tidal current velocities and sediment re-suspension and deposition patterns are not expected to alter or destroy fish habitats or cause death of fish in proximity to the project marine terminal structures.

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