

Appendix G.3
Marine Mammal Management Plan

Preliminary Draft Marine Mammal Monitoring and Protection Plan

A Summary of Mitigations, Commitments, and Monitoring Programs to Reduce Potential Effects of the Project on Marine Mammals



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1.0 INTRODUCTION

1.1 BACKGROUND

Pacific NorthWest LNG Limited Partnership (PNW LNG) has developed a preliminary draft Marine Mammal Monitoring and Protection Plan (MMMPP) to address environmental concerns during the construction and operation phase of the Pacific NorthWest LNG Project (the Project). The purpose of the preliminary draft MMMPP is to address potential adverse environmental effects resulting from underwater noise caused by marine pile installation, dredging, blasting, other marine construction activities, and project related vessels. This MMMPP also addresses the potential for marine mammal collisions from project vessels. Management of effects on prey species are addressed in the Habitat Offsetting Plan (Appendix G.10 of the EIS Addendum).

This preliminary draft plan presents a framework for managing potential adverse environmental effects based on the Environmental Impact Statement (EIS) for the Project and subsequent feedback from government agencies, Aboriginal groups, stakeholders and the public. This plan will be updated and refined based on detailed Engineering Procurement Construction and Commissioning (EPCC) Contractor design and permitting requirements.

The marine waters surrounding Prince Rupert provide diverse habitats supporting many species, including marine mammals that contribute to the ecological, cultural, and economic well-being of the region. The Project has potential to affect marine mammal habitats and species during all project phases through:

- Direct mortality or physical injury
- Change in behaviour (as a consequence of underwater noise produced by project activities)
- Change in sediment or water quality (leading to potential for toxicological concerns or increased total suspended solids [TSS]).

1.2 PURPOSE

The purpose of the MMMPP is to outline the various commitments, mitigation measures and monitoring programs that PNW LNG will implement to reduce potential adverse project related environmental effects on marine mammals [see Appendix A of the EIS Addendum]. The geographic boundaries of the MMMPP will include the project development area (PDA), local assessment area (LAA) and regional assessment area (RAA) as applied in Appendix A of the EIS Addendum for marine mammals (Figure 1). The MMMPP will address all marine mammal species that could be directly or indirectly affected by routine Project activities within PDA and LAA boundaries, with a focus on species of commercial, recreational, cultural, or conservation concern (e.g., species listed on the *Species at Risk Act* [SARA]), and related habitats.

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PNW LNG will integrate data collected through the MMMPP into updates to its management plans and operations. Mitigation measures may be refined over the course of the Project, as the result of information learned through this program and ongoing discussions with regulators and Aboriginal groups.

PNW LNG will continue to consult with Aboriginal groups and key government agencies (e.g., Fisheries and Oceans Canada [DFO]), the Prince Rupert Port Authority (PRPA) and other relevant stakeholders in the development of further iterations of the MMMPP.

2.0 MITIGATION MEASURES

During marine construction activities, underwater noise is predicted to change the behaviour of marine mammals. If unmitigated, auditory injuries may occur due to underwater noise produced during blasting and underwater impact pile driving. Blasting can also result in physical injury or direct mortality to marine mammals. Dredging and disposal of sediment at sea can lead to elevated TSS levels during construction, as can vessel maneuvering at the LNG carrier berth during operations; elevated TSS levels can result in avoidance behavior by marine mammals. During operations, LNG carrier transit and berthing will also introduce underwater noise to the marine environment, potentially resulting in temporary behavioural disturbance. An increase in vessel activity in the region also increases the potential for a marine mammal-vessel strike.

Mitigation measures for potential injury or mortality of marine mammals include a Blasting Management Plan (entailing the use of DFO's Blasting Guidelines and a marine mammal observation program) and a Pile Driving Management Plan (entailing the use of vibratory piles, bubble curtains, bubble containment casings, sound level monitoring and marine mammal observation programs; see Appendices J.12 and J.13 of the EIS Addendum). Additional environmental management plans include the Marine and Freshwater Resource Management Plan (see Appendix J.8 of the EIS Addendum), which will detail TSS/turbidity and water quality monitoring, the Waste Management Plan (see Appendix J.10 of the EIS Addendum), the Dredging Management Plan (see Appendix J.13 of the EIS Addendum), and the Environmental Monitoring Management Plan (see Appendix J.16 of the EIS Addendum), which includes details concerning marine mammal observers [MMOs]). Mitigation measures will be used to mitigate potential behavioural effects on marine mammals.

2.1 PILE INSTALLATION

Construction of the materials off-loading facility (MOF) and marine terminal (including the suspension bridge and trestle) will use drilled piles, and will occur year round until complete. Use of low noise pile installation techniques (e.g., vibratory hammers, where technically feasible) will reduce the risk of physical injury to marine mammals and fish and reduces potential effects on behaviour (see Sections 13.5.4.2 and 13.5.5.2 of Appendix A of the EIS). Due to the depths of soft sediment in the area, low noise pile installation techniques can (and will) be the primary

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method of pile installation; impact pile driving will likely only be used to seat the piles into bedrock.

2.1.1 Design Measures

Low noise pile installation techniques (i.e., vibratory installation methods) will be used except during seating of some piles into bedrock. To reduce the potential for auditory injury to marine mammals during pile seating and any other instances that an impact pile driver is required, bubble curtains with bubble-containment casing will be used and the impact hammer will be constructed of sound absorbent material. Bubble curtains will also be used during pile installation (i.e., vibratory or impact) at the inner MOF to mitigate for behavioural effects. 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). A Pile Driving Management Plan (see Appendix J.12 of the EIS Addendum) will be implemented to outline the pile installation techniques that will be used when low noise installation methods are not technically feasible (e.g., due to unfavourable substrate).

2.1.2 Monitoring

During all pile installation activities (i.e., impact and vibratory), a marine mammal observation program will be implemented. MMOs will monitor a safety zone (this term is used synonymously with the term 'exclusion zone') around pile installation, including during pile seating, and will halt the activities if cetaceans (of any species or status) or other marine mammal species (if listed under *SARA*) enter this zone. Underwater sound source levels will be measured/monitored in-situ during the first seven days of pile installation to field-validate the effectiveness of each style of curtain/casing implemented, monitor underwater sound levels produced, and confirm the proposed size of the pile installation safety zone (currently set at 1.0 km). Different sized safety radii will apply depending on the activity, as the underwater sound pressure levels (SPLs) will also vary according to activity. The current safety zones are set as 500 m for blasting (as per Fisheries and Oceans Canada's Blasting Guidelines) and 1.0 km for pile installation (based on acoustic modelling). However, follow-up studies will measure the SPLs produced during each activity to field-validate the recommended size of the safety zone(s). The exact size(s) of safety zone ultimately implemented will be determined through consultation with DFO but will not be less than 500 m.

Sound levels from blasting and pile installation will be monitored and if they exceed a root mean square SPL (SPLrms) of 160 dB re 1 μ Pa at the edge of the marine mammal safety zone, the associated construction activities will cease (be halted by the MMO) and additional mitigation measures will be considered in consultation with DFO. Additional measures could include type/configuration of bubble curtain used and size of safety radius monitored for marine mammals.

The Environmental Monitoring Management Plan (see Appendix J.16 of the EIS Addendum) will detail the duties and responsibilities of the MMOs, and will include the following protocols:

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- 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 that may be in the area time to leave the area prior to attainment of underwater noise levels capable of causing injury
- 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 1.0 km safety zone will be monitored by the MMO and impact pile installation will not be commenced until (i) any observed cetacean (regardless of status) or other 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
- During conditions of low visibility (i.e., when the 1.0 km 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 visibility improves. Once visibility improves, the safety zone will be monitored for cetaceans or other SARA-listed marine mammals for 30 minutes before commencing impact pile installation.

The MMO will be stationed in such a manner that they can survey the full extent of the safety radius, and the safety radius itself is centered on the underwater sound source. As such, positioning of the MMO will vary based on the activities in question, their location, and the final size of the safety radii as determined through consultation with DFO and in situ field measurements of sound levels. The primary function of the marine mammal safety zone is to prevent physical injury of marine mammals during underwater construction activities.

PNW LNG has also begun a series of dedicated vessel-based line transect surveys to estimate relative abundance of marine mammal species in the PDA and LAA. These will be conducted prior to the start of construction, during construction, during operations, and during decommissioning. The results of the marine mammal surveys will be analyzed to assess periods of elevated usage/presence, and to ensure appropriate mitigation measures are implemented to reduce the potential for harm and change in behaviour. Additional details concerning these surveys are provided in Section 3.0.

2.2 BLASTING

Blasting will be required to remove bedrock prior to dredging at the MOF. Unmitigated, blasting has the potential to displace, injure, or kill marine mammals within close range of the blast area. Management measures for both terrestrial and underwater blasting will be outlined in a Blasting Management Plan (see Appendix J.11 of the EIS Addendum), which will include methods to reduce the risk of mortality and injury to marine mammals and other marine life. The plan will be based on DFO's Blasting Guidelines (Wright and Hopky 1998) and will be developed in consultation with DFO.

Blasting will be conducted within DFO's least-risk timing windows (approximately November 30 to February 15, (DFO 2013); 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. However, as it is known that certain species of marine mammal (such

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as humpback whales) may be present in the LAA during this time period, additional mitigation measures will be implemented, as detailed below.

2.2.1 Design Measures

Project marine blasting activities will comply with DFO's Blasting Guidelines (Wright and Hopky 1998). The blasting design will consider, for example, appropriate measures to reduce overpressure, through the optimum use of explosives for rock blasting. Where possible (i.e., if low tides occur during daylight hours), blasting will be timed with low tides to reduce the number of detonations that occur underwater. Blasting will be conducted within DFO least-risk timing windows (approximately November 30 to February 15, (DFO 2013g); 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 (i.e., potential marine mammal prey species) during important lifecycle stages.

2.2.2 Monitoring

According to DFO's Blasting Guidelines, sounds produced by a 100 kPa blast are unlikely to harm marine mammals that are at least 500 m from the source (Wright and Hopky 1998). As with pile installation, a marine mammal observation program will be implemented, through which trained MMOs will monitor the blasting area for thirty minutes prior to the start of blasting, and throughout blasting operations. The MMOs will be authorized to delay the start or temporarily terminate blasting activities if cetaceans or SARA-listed marine mammals enter the blasting safety radius (i.e., exclusion zone). Blasting will not recommence until the exclusion zone has been clear of such sightings for thirty minutes. Additional information on regulatory permits, exclusion zones, and contacts for blasting will be detailed in the Blasting Management Plan (Appendix J.11 of the EIS Addendum). The exact radius of the exclusion zone (minimum of 500 m) will be determined through consultation with DFO.

Turbidity will be monitored during blasting and, if levels exceed the WQG outside the active work area, further mitigations will be used (rate of blasting reduced, silt curtains installed). Please refer to the Habitat Offsetting Plan (Appendix G.10 of the EIS Addendum) for further information on mitigation measures to reduce project-related effects on fish.

PNW LNG has also begun a series of dedicated vessel-based line transect surveys to identify periods of elevated usage/presence in the PDA and LAA, and to confirm that appropriate mitigation measures are implemented to reduce the potential for harm and change in behaviour of marine mammals. Additional details concerning these surveys are provided in Section 3.0.

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2.3 DREDGING

Construction of the MOF will require dredging of approximately 690,000 m³ of material over an area of less than 60,000 m² and to a depth of 12.5 m. Since submission of the EIS, PNW LNG has advanced the project engineering and determined that of the total volume, less than 200,000 m³ is marine sediment, and the remaining material is rock. The 200,000 m³ will be dredged with a trailing suction hopper dredge (TSHD) to remove surface sediment and a backhoe dredge to remove blasted rock and sediment. Dredging will occur over a period of approximately six months (October through March). Dredging at the MOF will introduce underwater noise and result in resuspension of marine sediment, leading to increases in TSS levels and potential for dispersal of contaminants from sediment.

In a recent study characterizing underwater sound levels of three TSHDs (the louder of the two dredging methods), source levels (SLs) were found to range from 161 to 177 dB_{rms} re: 1µPa @ 1m (Reine et al. 2014). The upper threshold of these values remain below the NOAA interim permanent auditory injury thresholds of 190 and 180 dB_{rms} for pinnipeds and cetaceans, respectively (Appendix A of the EIS Addendum), and will decrease rapidly with distance from the source.

The Canadian Council of Ministers of the Environment (CCME) sediment and water quality guidelines (WQG) for protection of marine life are used to assess potential effects of contaminants and TSS in sediment and water. The sediment release associated with dredging is estimated to be 1% for the TSHD (from bottom disturbance and release of overflow water from the hopper) and 3% for the backhoe dredge (for sediment; however, the material will be a mix of sediment and rock). During dredging at the MOF, TSS levels are predicted to exceed the WQG for continuous activity (5 mg/L above background) only within the active work area (defined as the immediate area surrounding operating construction equipment within the marine infrastructure footprint) and in isolated areas along the Lelu Island shore to the north and south of the dredge area, again mainly near the bottom of the water column.

Disturbance of small amounts of sediment containing proportionally low amounts of contaminants during dredging would result in dispersal along these areas, and the sediment would settle into areas with similar chemistry and contaminant levels. Furthermore, this area already experiences extended periods of elevated TSS during the Skeena River spring freshet and throughout the year. The naturally high and fluctuating levels of turbidity and TSS within these adjacent coastal waters mean that potential effects of suspended sediment plumes will likely be of little concern for marine mammals. Further information about TSS levels and deposition of sediments from dredging activities is provided in Appendix O of the EIS and Appendix J.8 of the EIS Addendum.

Contaminants associated with dredging are not expected to pose toxicological risks to marine biota. Levels of contaminants measured in sediments within the PDA are consistent with results for other studies in the Prince Rupert area (Fairview Phase II, Canpotex). Sediment meets the criteria provided in the draft Environment Canada (2014) guidance on dioxins and furans in

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sediment for disposal at sea at non-dispersive sites and is not expected to cause effects to aquatic life or to consumers of marine organisms. Other contaminant concentrations were below disposal at sea screening criteria in all samples or were naturally occurring (arsenic and copper). Further information about potential bioaccumulation concerns related to dredging is provided in Appendix L of the EIS.

Any project construction related change in sediment or water quality associated with TSS and contaminants (from dredging, disposal at sea, or vessel maneuvering at the LNG carrier berth) are therefore not expected to result in toxicological risks or cause direct mortality, physical injury, or behavioral changes in marine mammals. However, mitigations (including design measures) that will reduce the extent of TSS and contaminant levels are included below.

2.3.1 Design Measures

Dredging operations will be conducted using methods and/or equipment that reduces sediment spill. The EIS considered plans to dredge a further 7 million m³ of material over an area of approximately 84.6 ha for the marine terminal. As an additional mitigation measure, the marine terminal has been redesigned to avoid the need for this dredging, thus substantially reducing the temporal and spatial extent of potential behavioural effects on marine mammals associated with underwater noise.

2.3.2 Monitoring

Turbidity will be monitored during dredging (as well as during other in-water construction activities such as blasting) and compared to water quality guidelines and to a TSS-turbidity calibration curve to infer TSS levels. In the event that inferred TSS levels exceed modelled TSS levels outside of the active work area, 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 turbidity and TSS.

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.

2.4 DISPOSAL AT SEA

Marine sediment excavated during any project related dredging activities requires disposal. PNW LNG currently anticipates dredging up to 200,000 m³ of sediment for construction of the MOF, along with up to 490,000 m³ of rock. Rock will be reused during construction as fill on Lelu Island, where practical. An application will be made to Environment Canada under the Disposal at Sea Regulations of the *Canadian Environmental Protection Act* for disposal of the sediment at the previously used ocean disposal site at Brown Passage. Disposal of dredged material at Brown Passage will result in an increase in TSS levels and potential for dispersal of contaminants from sediment.

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Disposal of dredge material from the MOF is expected to occur over approximately six months, with one trip every 18 hours to the disposal site at Brown Passage. Barge capacity is expected to be 3,000 m³, and will require approximately 85 one-way trips of barges and assisting tugs to ship up to 200,000 m³ of sediment. Underwater noise produced during vessel transit and disposal at sea activities (including vessel transit) is not likely to cause mortality or physical injury to marine mammals, but may cause behavioural change. Please see Section 3.5 (below) for a discussion of mitigations related to vessel operations.

During disposal of sediment at Brown Passage, TSS levels are expected to meet the WQG in near surface waters (0 to >50 m) but are predicted to be above the WQG in >100 m deep waters for up to six hours after the disposal event. Concentrations at all depths are expected to meet the WQG within 12 hours of the disposal event. After the completion of all disposal operations, TSS levels will decrease to less than 1 mg/L above background within a few days, as the suspended sediment settles out on the seabed and is further dispersed. It is anticipated that the disposal site will rapidly return to near baseline conditions once disposal is complete. Further information about TSS levels and deposition of sediments from disposal activities is provided in Appendix O of the EIS.

Disposal of dredged sediments from the MOF at the disposal at sea site is not expected to pose toxicological risks (i.e., through bioaccumulation) to marine mammals. Dioxins and furans in the dredge material are present at concentrations that are higher than at the disposal site; however, levels are below Environment Canada (2014) draft guidance thresholds for a non-dispersive site (lower action level [LAL] of 9 pg/g TEQ in specific sediment layers and an overall management objective [OMO] of 0.85 pg/g TEQ as a volume-weighted average for the entire dredge volume). Levels are also at least ten times lower than the PEL guideline, and other contaminant concentrations are below disposal at sea screening criteria or, like copper and arsenic, reflect natural background conditions. Further information about potential bioaccumulation concerns related to dioxins and furans at the disposal at sea site is provided in Appendix L of the EIS.

2.4.1 Design Measures

Since submission of the EIS, PNW LNG has advanced the project engineering and determined that of the total volume, less than 200,000 m³ is marine sediment, and the remaining material is rock (as outlined in Section 3.3.1), which reduces the amount of material to be disposed of at sea. At the disposal site, sediment will be disposed within 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. Detailed design engineering has resulted in a decrease in the sediment volume to be disposed of at sea.

2.5 SHIPPING OPERATIONS AND VESSEL MANEUVERING

Approximately 350 LNG carriers will arrive at the marine terminal each year (in Phase 2 of the Project) for at least 30 years. LNG carriers will travel through the LAA between the marine terminal and the Triple Island Pilot Boarding Station (accompanied by one escort tug during both inbound and outbound transits). At full build-out, one LNG carrier per day is expected to call on the marine terminal. Berthing will involve the LNG carrier and up to four tugs. Site decommissioning and clean-up will also require use of vessels.

All vessels associated with construction and operations of the Project have the potential to collide with marine mammals. Depending on the severity of the strike, this may result in recoverable injuries, serious injuries, indirect or direct mortality, or reduced fecundity or fitness. There may also be behavioural effects associated with vessel strike avoidance. While sound levels produced by project related vessels are not predicted to exceed auditory injury levels, underwater noise from movement and berthing of LNG carriers is predicted to result in changes in behaviour to marine mammals (see Appendix A of the EIS Addendum). Underwater noise that exceeds behavioural thresholds could affect localized distributions and communication of marine mammals over the short-term (as potential exposure to the passing vessel will be transient in nature).

2.5.1 Design Measures

LNG carriers for the Project will be piloted between Triple Island and the LNG carrier berth by a qualified marine pilot. Vessels calling on the project terminal will approach Prince Rupert Harbour in designated shipping routes from the open waters north of Haida Gwaii through Dixon Entrance to the pilot station north of Stephens Island. From there they will be guided by pilots and the Coast Guard Marine Communications and Traffic System to avoid collisions with other vessels, hazards of grounding, and where information is available, interaction with marine mammals or concentrations of fishing vessels.

PNW LNG will not own or operate the LNG carriers that will call on the marine terminal and will have no direct control over any vessel other than while at berth; PNW LNG will be able to set requirements on the design and safety requirements of vessels allowed to berth. Estimated speed profiles for LNG carriers described below will reduce the risk of vessel strikes with marine mammals. Additional measures specific to reducing the risk of vessel strikes will include exchange of information on marine mammal activity between pilots, and course alteration if a marine mammal is sighted in the path of a vessel (when and where possible and deemed safe to do so by the vessel master and marine pilot). PNW LNG cannot set speed limits for LNG carrier; this can only be done by the PRPA or Transport Canada and course alterations are at the discretion of the pilot.

Research suggests that the probability and severity of a marine mammal ship strike is positively correlated with vessel speed (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Kite-Powell et al. (2007) used right whale diving behaviour and data from observed encounters to model

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strike probability based on vessel speed. They determined that a large vessel travelling at 25 knots has a 50% chance of striking a whale travelling in its path, but that this probability is reduced to 30% at a speed of 10 knots. Based on historical records of vessel strikes to large whales between 1885 and 2002, Vanderlaan and Taggart (2007) modelled the probability of severe or lethal injury based on a vessel's speed. At speeds of 18 knots and higher, vessels were predicted to have over a 92% probability of lethality. Probabilities decreased with speed: from 78% at 15 knots, 61% at 13 knots, 31% at 10 knots, to below 12% at speeds of 7 knots or less. Laist et al. (2001) similarly concluded that serious injuries to large whales are infrequent at vessel speeds of less than 14 knots, and are rare below 10 knots. The other important factor in predicting likelihood of a strike is the degree of overlap between shipping traffic and whale presence. Ship strikes are more likely in areas (and times of year) when high densities of traffic and marine mammals overlap.

Generally speaking, underwater noise is also reduced at reduced vessel speeds. Vessels will transit to and from the pilot station at reduced speeds to diminish the amount of underwater noise and the likelihood of serious injury to large cetaceans from a vessel strike. LNG carriers, tugs, and barges will not exceed a speed of 16 knots within the LAA, and LNG carrier vessel speed will be reduced to 4 knots when approaching the Triple Island Pilot Boarding Station. Figure 2 provides an overview of the predicted LNG carrier speeds along the 22 nautical mile southern shipping route within the LAA. The Project will also use tugs with less sediment scour-inducing propulsion systems (e.g., Voith Schneider), which is expected to reduce TSS levels, and may reduce underwater noise.

Elevated TSS levels caused by vessel maneuvering during arrival (berthing) and departure were considered for potential adverse effects. However, modelling of maneuvering associated with the marine terminal design mitigation indicate that increased TSS levels from vessel maneuvering are low, occur over a short time, and dissipate quickly.

2.5.2 Monitoring

In the event of a vessel strike, all pertinent details will be reported to the BC Marine Mammal Response Network (Observe, Record, Report) at 1-800-465-4336.

3.0 Future Initiatives

In November 2014, PNW LNG began a marine mammal field program that will consist of a series of monthly dedicated vessel-based line transect surveys to estimate relative abundance of marine mammal species in the PDA and LAA. These vessel-based line transect surveys will be conducted once per month for one year prior to construction, will each take approximately four days to complete (plus potential weather delays), and will be designed, conducted, and analyzed using generally accepted and statistically rigorous survey protocols and analytical techniques based on distance sampling methods (Buckland et al. 2001). The data collected during the surveys will be used to estimate densities of marine mammal species sighted, given

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appropriate numbers of sightings. Where possible, density estimates will also be used to produce density surface maps. Results, which will be made publicly available, will be used to further scientific understanding of the densities, seasonal use, and distribution of all marine mammal species present in the study area. An additional finer scale survey of the PDA will be conducted once per month in coordination with fish and fish habitat surveys. The primary purpose of the program is to use survey results to assess and refine mitigation measures, prior to construction activities, to better address the specific needs of local marine mammal populations. For example, further understanding of the time periods for peak densities of marine mammals in the LAA will allow PNW LNG, in consultation with DFO, to identify refined timing windows for marine construction activities, and thus mitigate potential effects. Additional surveys will be conducted during operations (and potentially decommissioning, if deemed necessary at the time).

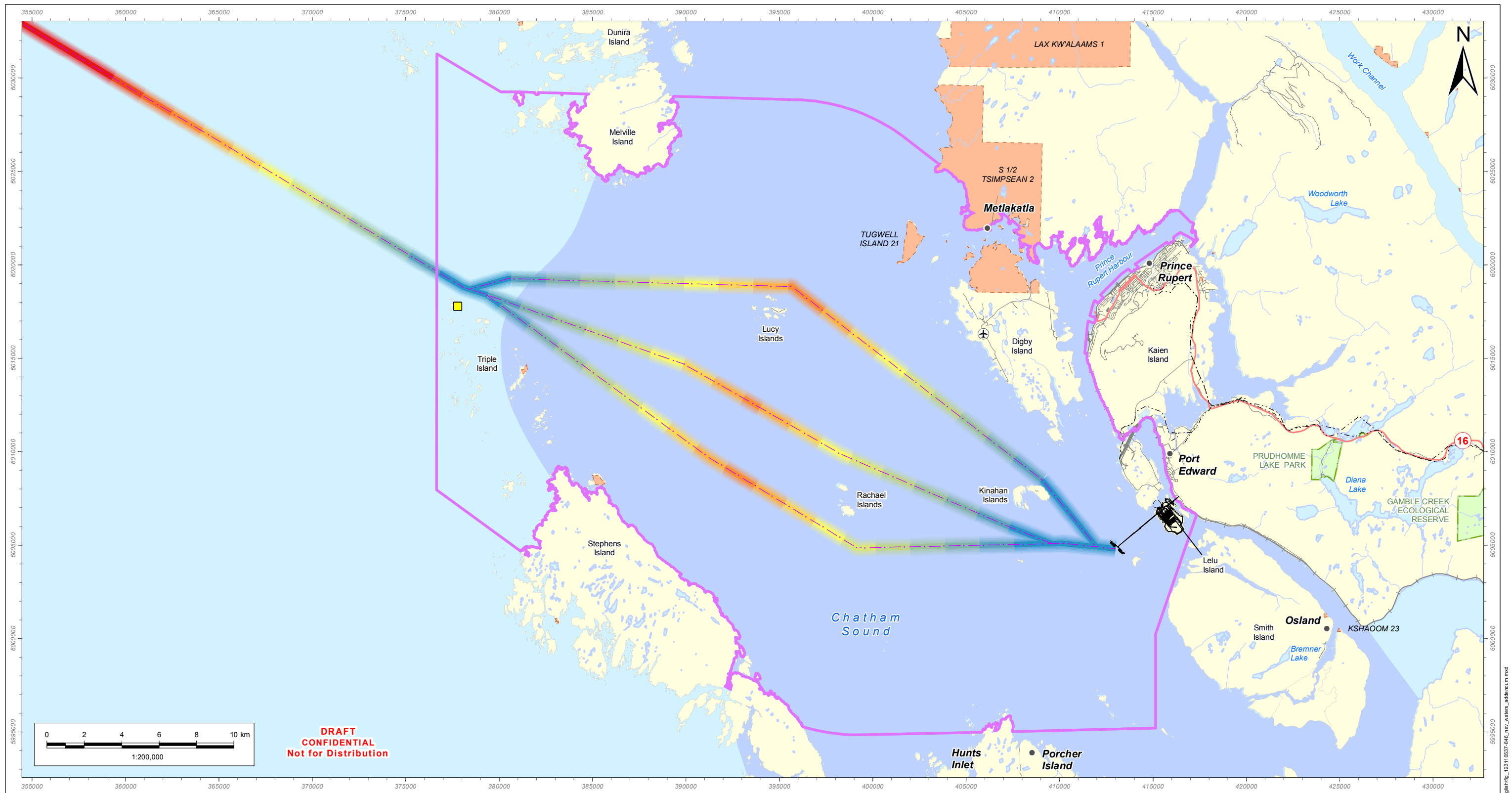
Underwater sound levels will be measured/monitored in situ during the first seven days of underwater blasting and impact pile driving to acquire baseline data on sound pressure levels produced during each activity. Results will be used to field-validate the effectiveness of bubble curtains and the size of the safety radius (currently set at 500 m for blasting and 1.0 km for pile driving). 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. PNW LNG is also investigating options for hydrophone deployment to collect information on vocalizing marine mammal species in the PDA, results of which will be used to supplement the vessel-based visual observation program.

Fisheries and habitat studies will also be conducted between November 2014 and June 2015 and will focus on the project area around Lelu Island, Flora, Agnew and Horsey Banks. These studies may be used to further the understanding of distribution and timing of potential marine mammal prey species. The proposed fisheries work uses a range of methods to quantify the relative abundance, distribution and habitat use of CRA species and forage fish that have been identified as important by DFO, including Pacific salmon, crab, shrimp, herring, eulachon, and flatfish (flounder, sole), and forage fish species (surf smelt, sandlance). The proposed survey program will integrate: hydroacoustic surveys paired with trawls; seining, intertidal and subtidal trapping; collection of oceanographic water property data and physical habitat information; and habitat surveys at a reconnaissance level by site. Based on the results, the fisheries assessment program will be amalgamated into the construction monitoring and compliance follow-up program for the Project and continued for a multi-year program as required. Please refer to the Habitat Offsetting Plan (Appendix G.10 of the EIS Addendum) for further information on future field programs associated with potential marine mammal prey species.

Figures
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4.0 FIGURES

Please see the following pages.

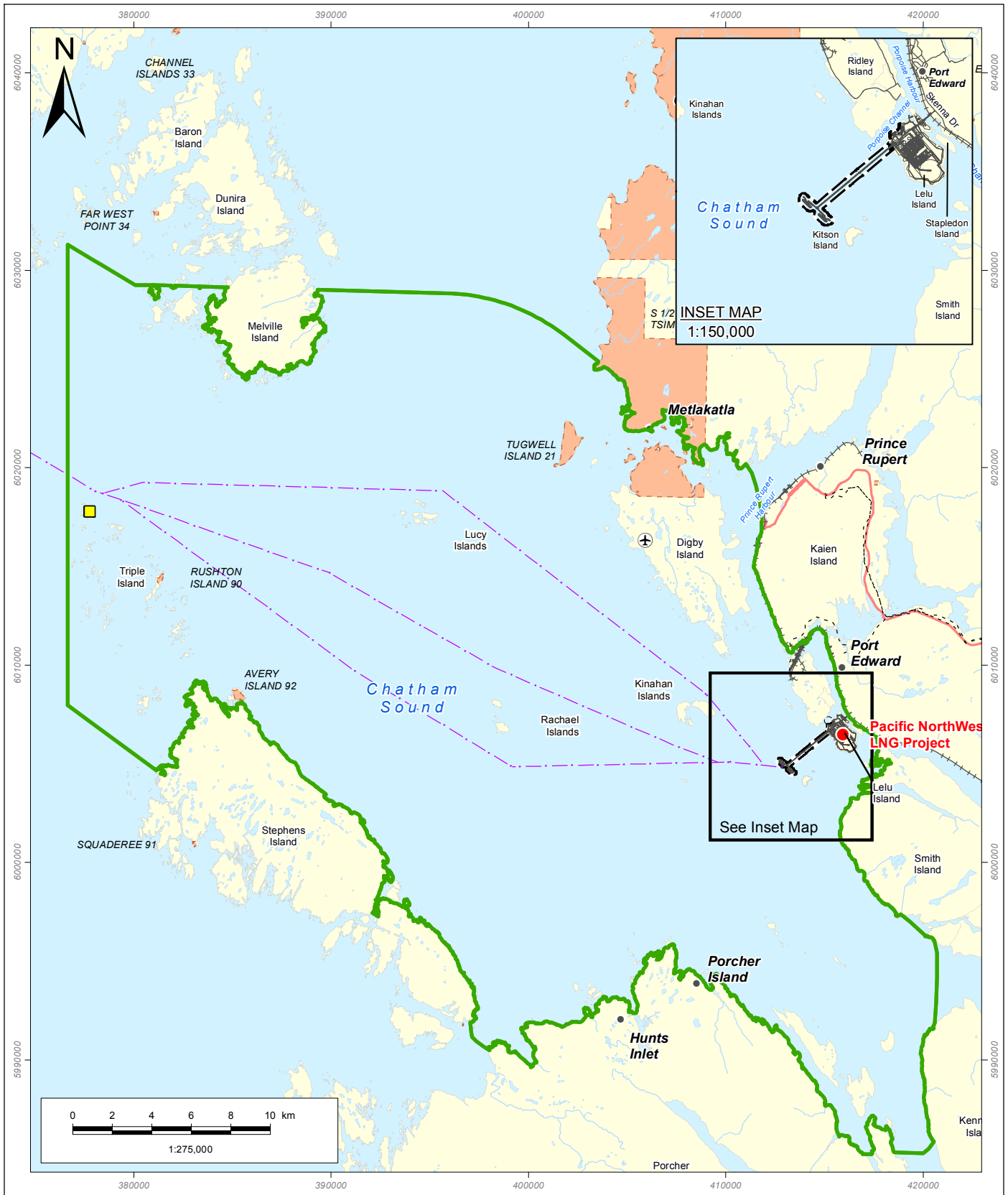


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Marine Resources Local Assessment Area and Regional Assessment Area	Airport	Watercourse	Speed (kt)	
Project Component	City or Town	Water Body		4
Project Shipping Route	Highway	Skeena Estuary		5
Pilotage Station	Secondary Road	Indian Reserve		6
	Railway	Protected Area		7
	Electrical Power Transmission Line			8
				9
				10
				11
				12
				13
				14
				15
				16

Pacific NorthWest LNG		
Estimated LNG Carrier Speeds		
<small>Sources: Government of British Columbia; Government of Canada, Natural Resources Canada, Centre for Topographic Information; Progress Energy Canada Ltd.</small>		
<small>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.</small>		
DATE: 07-OCT-14	PROJECTION: UTM - ZONE 9	DRAWN BY: R. COATTA
FIGURE ID: 123110537-846	DATUM: NAD 83	CHECKED BY: B. BYRD
PREPARED BY:		PREPARED FOR:
FIGURE NO: 2		

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<ul style="list-style-type: none"> Airport City or Town Pilotage Station Project Location Electrical Power Transmission Line Highway or Road Project Component Project Shipping Route Railway Watercourse Indian Reserve Marine Resources Local and Regional Assessment Area Protected Area Waterbody 	<p>Pacific NorthWest LNG</p> <p>Marine Resources Local Assessment Area and Regional Assessment Area</p> <p><small>Sources: Government of British Columbia; Government of Canada, Natural Resources Canada, Centre for Topographic Information; Fisheries and Oceans Canada, 2011, Commercial Fisheries Data; 2000-2009. Data derived from Pacific Biological Station Stock Assessment Harvest Log Database.</small></p> <p><small>Metadata available through Mapster: http://www.pac.dfo-mpo.gc.ca/gis-sig/maps-cartes-eng.htm</small></p> <p><small>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.</small></p> <table border="1" style="width: 100%;"> <tr> <td>DATE: 07-OCT-14</td> <td>PROJECTION: UTM - ZONE 9</td> </tr> <tr> <td>FIGURE ID: 123110537-841</td> <td>DATUM: NAD 83</td> </tr> <tr> <td>DRAWN BY: T. CARDINAL</td> <td>CHECKED BY: C. LION</td> </tr> </table>	DATE: 07-OCT-14	PROJECTION: UTM - ZONE 9	FIGURE ID: 123110537-841	DATUM: NAD 83	DRAWN BY: T. CARDINAL	CHECKED BY: C. LION	<p>PREPARED BY:</p> <p> Stantec</p> <p>PREPARED FOR:</p> <p> Pacific NorthWest LNG</p> <p>FIGURE NO:</p> <p style="font-size: 2em; text-align: center;">1</p>
DATE: 07-OCT-14	PROJECTION: UTM - ZONE 9							
FIGURE ID: 123110537-841	DATUM: NAD 83							
DRAWN BY: T. CARDINAL	CHECKED BY: C. LION							

PRELIMINARY DRAFT MARINE MAMMAL MONITORING AND PROTECTION PLAN

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December 12, 2014

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