UNITED STATES DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL MARINE FISHERIES SERVICE

Office of Protected Resources

PETITION FOR PROMULGATION OF REGULATIONS AND REQUEST FOR LETTER OF AUTHORIZATION PURSUANT TO SECTION 101 (a) (5) (A) OF THE MARINE MAMMAL PROTECTION ACT FOR

the

Taking of Marine Mammals Incidental to Construction and Installation of the Liberty Drilling and Production Island, Foggy Island Bay, Beaufort Sea, Alaska

50 C.F.R. Part 216, Subpart R

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SLR International Corporation Ref. 105.00874.16017. March 2017.
B: Liberty Project Construction and Production Marine Mammal Acoustic Exposure Estimates
SMRU Consulting North America. 5 May 2017.
C: Draft Marine Mammal Mitigation and Monitoring Plan (4MP)
D: Acoustic Monitoring Plan Hilcorp Alaska Liberty Development Project

ACRONYMS AND ABBREVIATIONS

ADFG.....Alaska Department of Fish and Game
ADNR.....Alaska Department of Natural Resources
AEWC.....Alaska Eskimo Whaling Commission
ASAMM.....Aerial Surveys of Arctic Marine Mammals
BCB.....Bering-Chukchi-Beaufort
BIA.....Biologically Important Areas
BPXA.....BP Exploration Alaska, Inc.
BMP.....Best Management Practices
BOEM.....Bureau of Ocean Energy Management
BOWFEST.....Bowhead Whale Feeding Ecology Study
BWASP.....Bowhead Whale Aerial Survey Project
BWCA.....Barrow Whaling Commission
CAA.....Conflict Avoidance Agreement
CFR.....Code of Federal Regulations
COMIDA.....Chukchi Offshore Monitoring and Drilling Area
cy.....cubic yards
CV.....coefficient of variation
DASAR.....Directional Autonomous Seafloor Acoustic Recorder
dB.....decibel
DPP.....Development and Production Plan
esw.....effective strip width
EIA.....Environmental Impact Analysis
ft.....feet
ha.....hectres
Hilcorp.....Hilcorp Alaska, LLC
HR.....High Resolution
ICAS.....Inupiat Community of the Arctic
IHA.....Incidental Harassment Authorization
IHLC.....Inupiat History Language and Culture Center
ITA.....Incidental Take Authorization
LDPI.....Liberty Drilling and Production Island
km.....kilometers
KSOP.....Kuupik Subsistence Oversight Panel
KWCA.....Kaktovik Whaling Commission
L_{eq}.....energy average sound level
L_{max}.....maximum pass-by sound pressure level
LOA.....Letter of Authorization
m.....meters
mi.....miles
MML.....Marine Mammal Laboratory

MMPA.....Marine Mammal Protection Act
MLLW.....Mean Lower Low Water
MPI.....Main Production Island
N_{best}.....best population estimate
N_{min}.....reliable minimum population estimate
NMFS.....National Marine Fisheries Service
NOAA .....National Oceanic Atmospheric Administration
NEPA .....National Environmental Policy Act
NID.....Negligible Impact Determination
NRC.....National Research Council
NSB.....North Slope Borough
NWCA.....Nuiqsut Whaling Commission
OCS.....Outer Continental Shelf
OSRP.....Oil Spill Response Plan
PBR.....Potential Biological Removal
POC.....Plan of Cooperation
PSO .....Protected Species Observers
PTS.....Permanent Threshold Shift
Q.....Quarter
r_{MAX} .....theoretical net productivity rate
re 1µPa.....decibels referenced to 1 micropascal
ROD .....Record of Decision
SDI .....Endicott Satellite Development Island
SEL.....Sound Exposure Level
SEMS .....Safety and Environmental Management System
SPL.....Sound Pressure Level
TAPS.....TransAlaska Pipeline System
TTS.....Temporary Threshold Shift
UAS.....unmanned aircraft system
USC.....United States Code
VSM .....Vertical Support Member
2D.....two-dimensional
3D.....three-dimensional

1. DESCRIPTION OF THE ACTIVITY

Hilcorp Alaska, LLC (Hilcorp), as the Liberty operator, is proposing to develop the Liberty Oil Field reservoir, located on the Outer Continental Shelf (OCS), in Foggy Island Bay, Beaufort Sea, Alaska (Figure 1-1). The Liberty Oil Field reservoir is approximately 5 to 8 mi (8 to 13 km) to the east of the existing Endicott Satellite Drilling Island (SDI). The proposed Liberty Development also includes the Liberty Drilling and Production Island (LDPI), which will be constructed of reinforced gravel in 19 feet (ft) (5.8 meters [m]) of water about 5 miles (mi) (8 kilometers [km]) offshore in Foggy Island Bay. Liberty is located on three leases, OCS-Y-1650, OCS-Y-1886, and OCS-Y-1585 (see Figure 1-2).

The Liberty reservoir is the largest delineated but undeveloped light oil reservoir on the North Slope. It is projected to deliver a peak production rate of between 60,000 and 70,000 barrels of oil per day within 2 years of initial production. Total recovery over an estimated field life of 15 to 20 years is predicted to be in the range of 80 to 150 million stock tank barrels of oil.

The Liberty Oil Field leases were previously owned by BP Exploration Alaska, Inc. (BPXA). In April 2014, BPXA announced the sale of several North Slope assets to Hilcorp including Northstar, Endicott, Milne Point, and Liberty. On November 18, 2014, Hilcorp assumed the duties and responsibilities of Operatorship of the Northstar, Endicott, Milne Point, and Liberty units. In the case of Liberty, 50 percent ownership and full operatorship of the field was transferred from BPXA to Hilcorp. ASRC Exploration, LLC (AEX) currently owns 10 percent of the Liberty Development. In June of 2014, it was determined that the plan as outlined in the 2000 DPP, and subject of the 2002 FEIS, represented the most sound, practical, and expedient way to develop the Liberty reservoir while minimizing impacts to the environment. Therefore, the design has continued to evolve back to the original concept of a gravel island.

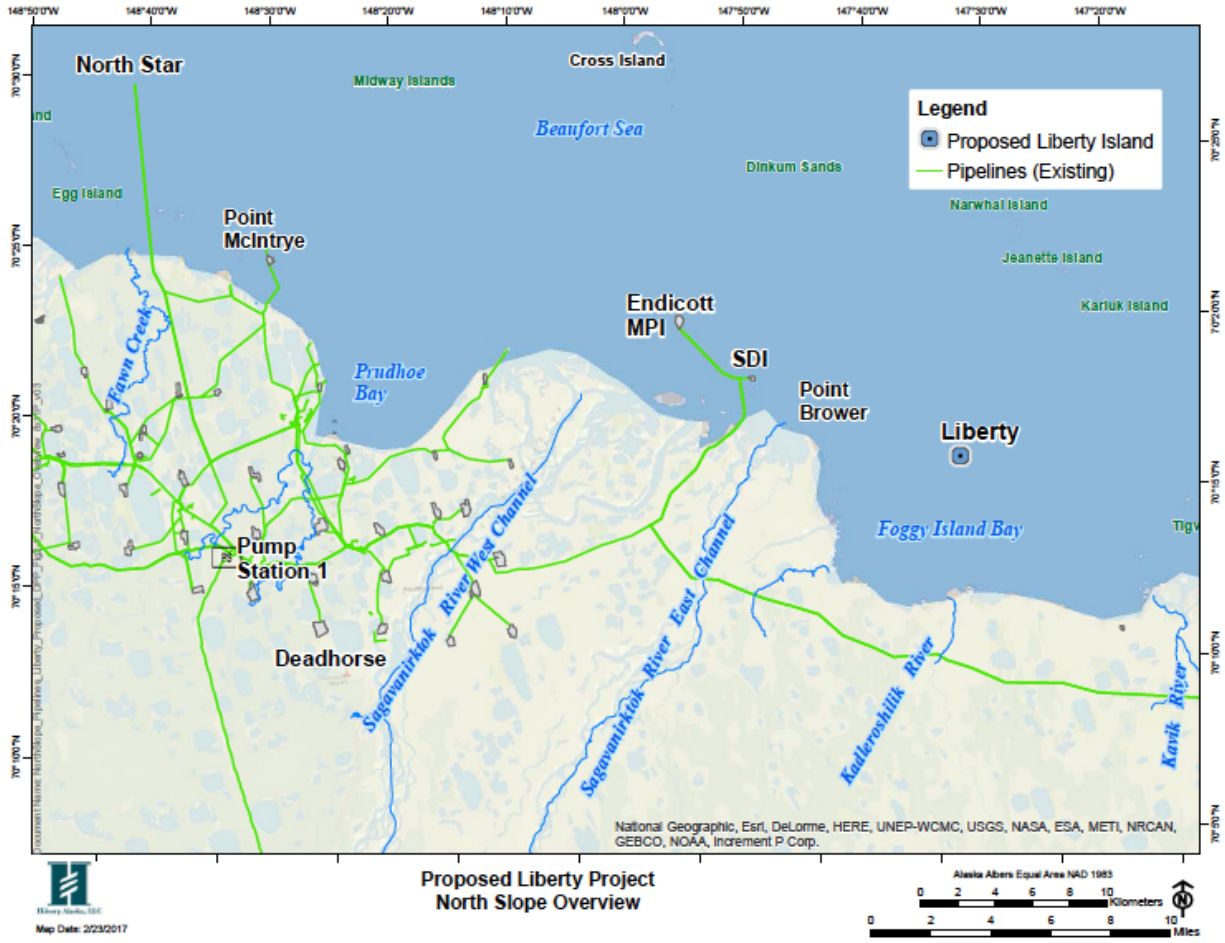
In accordance with the requirements of 30 CFR Part 550, Sections 241-262, the Liberty Development and Production Plan (DPP) was submitted to the Bureau of Ocean Energy Management (BOEM) on December 30, 2014 and deemed submitted on September 18, 2015 (Hilcorp 2015a). Several revisions to the DPP were submitted, with the final Amendment 3 dated May 26, 2017 (Hilcorp 2017). The Liberty DPP describes the subsurface depletion plan, all construction phases of the proposed Project, important safety features and practices, and provides an Environmental Impact Analysis (EIA)[1] of the Project. Submission of the DPP initiated the permitting process and the National Environmental Policy Act (NEPA) review.

The proposed Project lies within marine waters that support several marine mammal species (Figure 1-2) and is therefore subject to review under the Marine Mammal Protection Act (MMPA) (16 United States Code [UCS] 1362). Section 101(a) of the MMPA prohibits the "taking"[2] of marine mammals except under certain situations. Section 101(a)(5) provides for an exception to the take prohibitions of the

[1] Environmental Impact Analysis – Appendix A, Development and Production Plan, Liberty Development Project. Prepared for Liberty Development Project - December 2014.
[2] "Take" is defined under the MMPA (16 USC 1362) and further defined by regulation (at 50 CFR 216.3) as "to harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal." Take is further defined under the ESA as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."

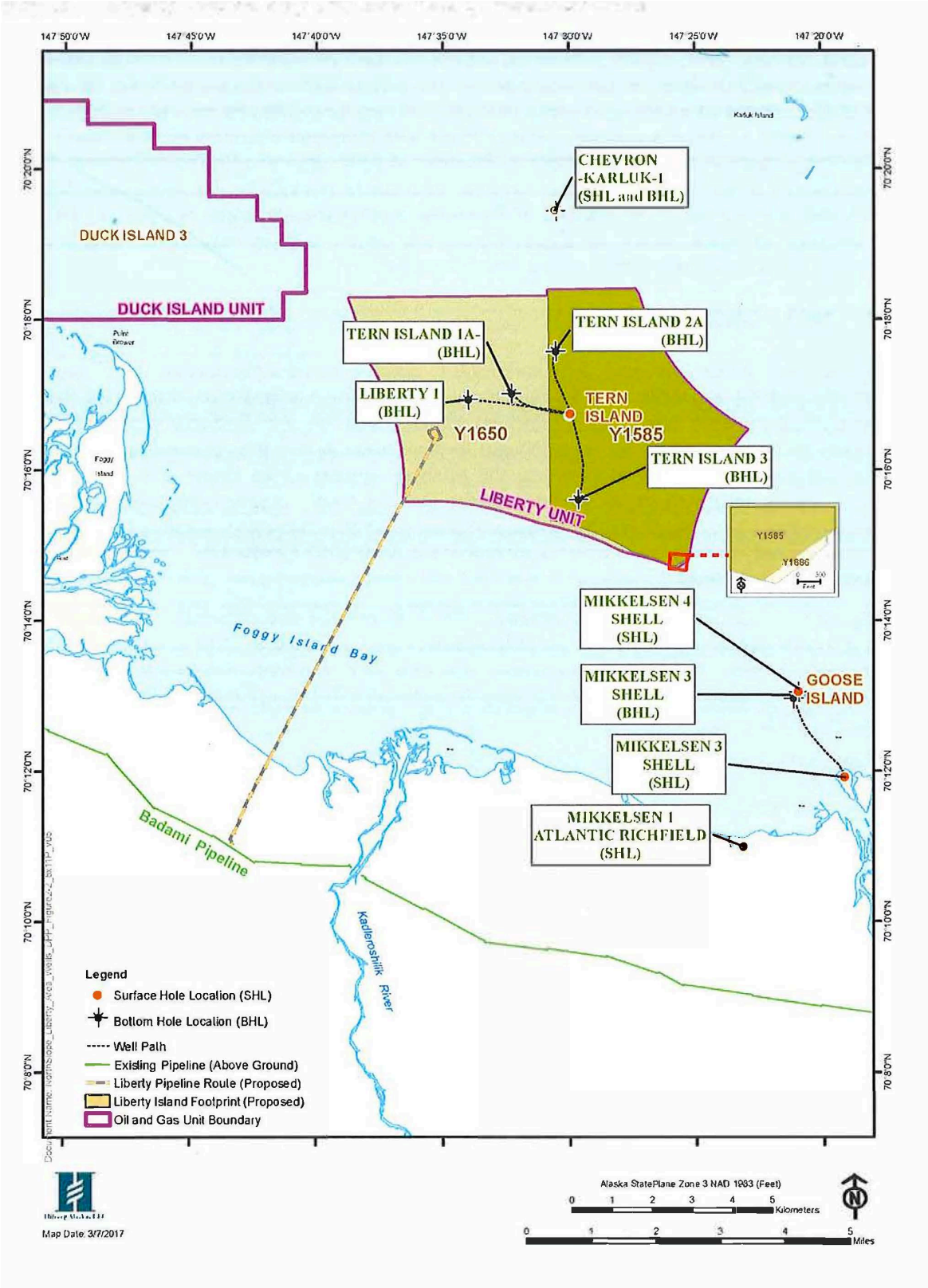
MMPA and allows, upon request, the unintentional incidental take of small numbers of marine mammals by U.S. citizens who engage in a specified activity within a specified geographic region. Incidental take is an unintentional, but not unexpected, take of a marine mammal. Section 101 (a)(5) allows for the issuance of an Incidental Take Authorization (ITA), provided an activity results in negligible impacts on marine mammal species or stocks and would not have an unmitigable adverse effect on subsistence use of these animals.

Figure 1-1. Liberty Location on the Alaska North Slope



Source: Hilcorp 2017

Figure 1-2. Liberty Locater Map with Area Wells and Lease Boundaries



Source: Hilcorp 2017

1.1. Purpose of the Request and Type of Incidental Take Authorization Needed

The purpose of this request by Hilcorp is for NMFS to develop regulations and issue a 5-year Letter of Authorization (LOA), effective approximately November 2019 allowing potential incidental taking of small numbers of whales and seals by harassment during the proposed construction, installation, drilling and initial production phases of the LDPI Project for the period November 2019 through November 2024. Future LOAs would be requested if necessary for any additional construction, drilling, and production operation phases. As described in Section 13, the decision to request a future LOA for drilling or production after 2024 will be determined based on the results of monitoring.

Regulations promulgated under MMPA Section 101(a)(5)(A) allow for the incidental taking of marine mammals. They do not permit, approve, or otherwise allow any individual or class of commercial, industrial, or development activity. Rather, each regulation establishes a regulatory framework, linked to a specified area and a specified time frame not to exceed five years, pursuant to which U.S. citizens may apply to NMFS for an LOA. Each LOA issued by NMFS imposes enforceable mitigation, monitoring, and reporting specific to the activity described in the LOA to ensure that interactions with the identified marine mammal species or stocks occur in small numbers and with no more than a negligible impact.

Hilcorp does not anticipate that the proposed construction and installation of LDPI in Foggy Island Bay, Beaufort Sea, Alaska, will result in the taking of significant numbers of marine mammals. Although some whales and seals are likely to occur near the planned activities, these activities are not anticipated to have any more than negligible consequences for individuals or their populations. Furthermore, there would be no unmitigable adverse impact on the availability of seals or whales for subsistence uses.

Based on a review of literature and monitoring reports from Northstar and other North Slope projects, there is documentation of one seal mortality associated with a vibroseis program outside the barrier islands east of Bullen Point in the eastern Beaufort Sea (MacLean 1998). There has been no history of seal mortalities at Northstar, a development very similar to the proposed Liberty Development. However, while Hilcorp does not believe the construction would result in a serious injury or a mortality of any marine mammal, Hilcorp is requesting takes for two seal mortalities over the 5-year period as part of their ITA request pursuant to Section 101 (a) (5)(A) of the MMPA, 16 USC 1371.101 (a) (5), and 50 CFR 216, Subpart I. This request is a precautionary measure to reduce the likelihood of seal interactions due to increased ice road construction activities and overall increased number of roads during the construction phase of the Project.

Additional detail on the methods used to calculate marine mammal densities in the Action Area as well as the process to calculate takes are presented in Sections 6.1 and 6.5, respectively.

1.2. Description of the Action Area

Hilcorp considers the Action Area for this Project distinct from and larger than just the immediate footprint of the production island because some elements of the Project may affect marine mammal species at some distance. NMFS defines the outer boundary of the action area for a project as the point where no detectable or measurable effect from the project would occur. Therefore, for purposes of this request for rulemaking, the Action Area is defined consistent with Endangered Species Act (ESA)

regulations[3] as the area within which all relevant direct and indirect effects of the Project would occur. The Action Area, therefore, extends to a point where no effects from the LDPI development are expected to occur. This includes the area radiating from LDPI noise sources out to a distance where Level B takes (behavioral disturbance or harassment) of marine mammals as defined in the MMPA, consistent with NMFS acoustic injury guidelines (NMFS 2016)[4], are extremely unlikely.

Foggy Island Bay is located east of Prudhoe Bay and opens north into Stefansson Sound on the central Beaufort Sea coast. The bay and sound are sheltered from the Arctic Ocean by the McClure group of barrier islands which lie northeast, about 9.5 mi (15.5 km) from the coast and 7 mi (11 km) from the proposed LDPI. The coastal and inland physiography is typical of the Arctic Coastal Plain, a low-angle, sloping plain that extends north from the Brooks Range to the Beaufort Sea. Four rivers empty into the Beaufort Sea and form modern deltas south of the proposed Liberty Island location: from west (closest to the LDPI) to east, the Sagavanirktok, Kadleroshilik, Shaviovik, and Canning rivers.

The seafloor in the extreme western part of the Project Area is mantled with coarse-grained sediments—gravel, cobbles, and boulders. Bottom substrate at the LDPI site includes fine sands, soft silts and clay about 6 to 8 ft (1.8 to 2.4 m) thick, with a layer of permafrost varying in depth below the seabed. A summer bathymetric and side-scan sonar survey was conducted in the summers of 2013 and 2014, with the objective of characterizing bottom features (e.g., ice gouges) as well as estimating concentration of hard bottom habitat (including the Boulder Patch)[5] within the Project Area. As shown on Figure 4.2.2-1 of BOEM (2017), the southeast corner of the Boulder Patch lies within 0.3 miles (0.5 km) of the proposed LPDI location.

In April 2014, a winter "through ice" seabed reconnaissance was conducted at the island site (Coastal Frontiers 2014). Holes were cut into the ice at 120 locations, and an underwater video camera was lowered to the seafloor and rotated. The Boulder Patch, an area containing more than 25 percent boulders, forms a critical biological habitat for kelp and associated benthic marine organisms (Dunton *et al.* 1982). No "boulder patch" habitat was found at the proposed island site and is therefore not discussed further in this petition. Potential impacts to the Boulder Patch are not expected to result in effects on marine mammals evaluated in this ITR petition. Sections 4.2.2.1 and 4.3.1 of BOEM's Draft EIS for Liberty Development discuss potential impacts to the Boulder Patch associated with the proposed action. The 2017 Draft EIS Table ES-1 summarizes potential impacts to the Boulder Patch as moderate as a result of the Proposed Action. Impacts would be mostly short-term and localized. While the LDPI is a long-term development, general impacts associated with it would be minor and would have little to no negative impacts on benthic, epontic, and pelagic communities (BOEM 2017).

1.3. Project Description

This section provides a description of Project activities required during construction, including timeframe and likely equipment to be used. Section 1.3.9 provides a summary and corresponding list of these

[3] 50 CFR 402.02
[4] The NMFS acoustic injury guidelines are located at (http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm)
[5] Wilce and Dunton (2014) describe the Boulder Patch as a shallow (4–7 m), unique, and relatively isolated assemblage of cobbles and boulders, in the Alaskan Beaufort Sea, with a high Arctic kelp community. The Boulder Patch contains 78 benthic algal species, all of which represent approximately one-half of the Arctic benthic flora (140 species).

activities as well as the potential sources of noise (i.e., equipment), the location of those potential noise sources and whether there is the potential for Level A or Level B take.

The proposed LDPI Project includes development of a mine-site to supply gravel for the construction of the LDPI, construction of the island and ice roads, and installation of an undersea pipeline that reaches shore from the LDPI and then connects to the existing above-ground Badami pipeline. The LDPI is a self-contained offshore drilling and production facility and will contain infrastructure to support construction and operations including a drill unit and associated equipment, utilities, and living quarters.

The drilling unit or drilling rig is described in Section 8.3 of the DPP. The choice of drilling unit has been narrowed to two options. The first option is the use of an existing platform-style drilling unit that HAK owns and operates in the Cook Inlet. Designated as Rig 428, the rig has been used recently and is well suited in terms of depth and horsepower rating to drill the wells at Liberty. A second option that is being investigated is a new build drilling unit that would be built to not only drill Liberty development wells, but would be more portable and more adaptable to other applications on the North Slope.

Process facilities on the island will separate crude oil from produced water and gas. Gas and water will be injected into the reservoir to provide pressure support and increase recovery from the field. A single-phase subsea pipe-in-pipe pipeline will transport sales-quality crude from the LDPI to shore, where an aboveground pipeline will transport crude to the existing Badami pipeline. From there, crude will be transported to the Endicott Sales Oil Pipeline, which ties into Pump Station 1 of the TransAlaska Pipeline System (TAPS) for eventual delivery to a refinery.

The well row arrangement on the island is designed to accommodate up to 16 wells. Once the 16-well drilling unit is commissioned, drilling operations will continue uninterrupted for approximately 2 years. Drilling through the reservoir section will be limited to the summer open-water season (~July15 through ~October 1) and the winter frozen-ice season, which begins with 18 in. of ice (~November 5) and ends June 1st, as prescribed in the Oil Spill Response Plan (OSRP). Table 1-1 shows the seasons for drilling activities and approximate dates. Drilling though the reservoir section will be limited during periods of soft/broken ice. During the drilling season, Hilcorp will also take measures to avoid impacts from vessel traffic (marine and aircraft) to the Cross Island bowhead whale hunt as described in the Conflict Avoidance Agreement (CAA) (see Section 12).

Table 1-1. Seasons and Approximate Dates for Drilling Activities

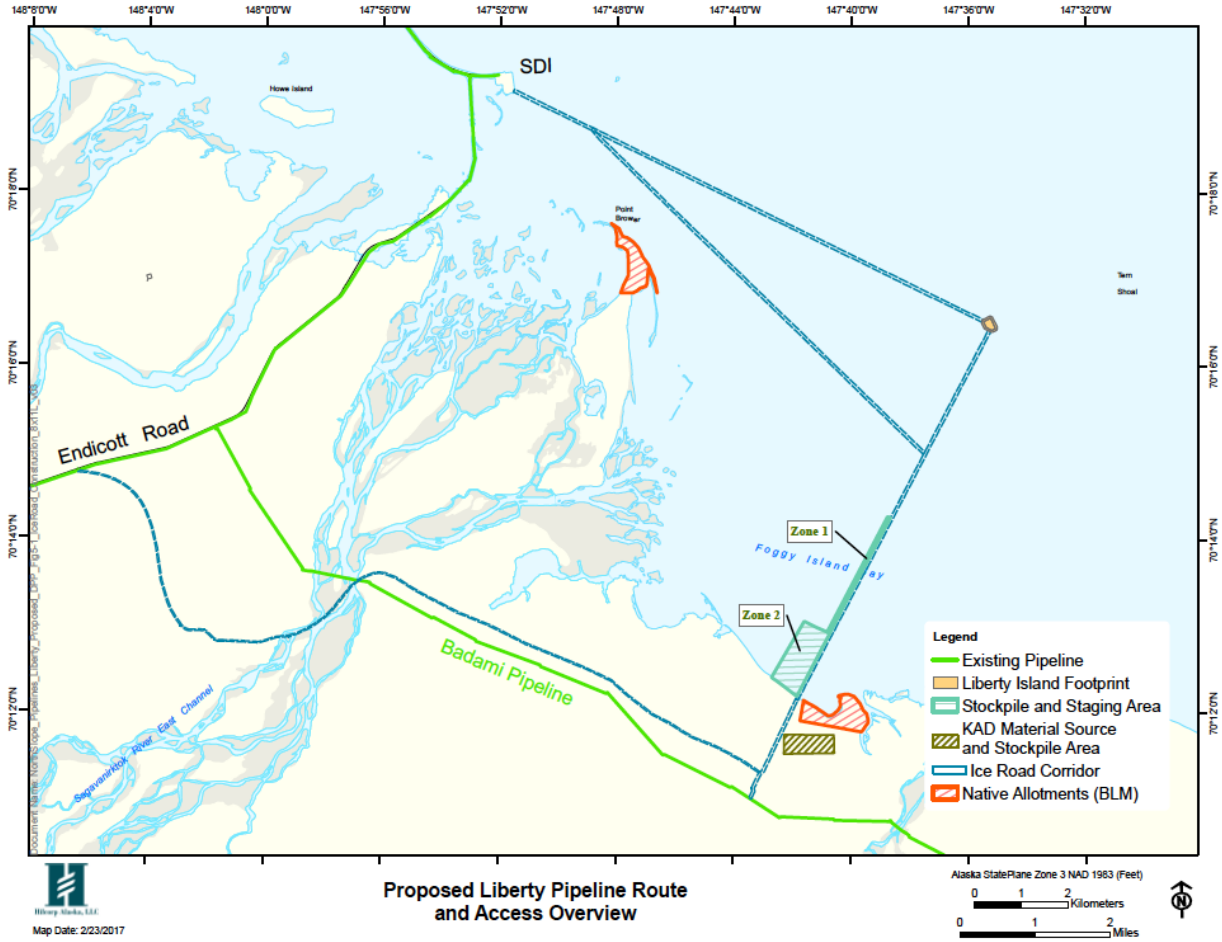
Season (for Drilling Activities)	Approximate Dates
Winter Frozen Ice Season (~ 18 inches of ice)	~November 15 through June 1
Shoulder Season Soft/Broken Ice	~June 2 through July 14
Summer Open Water Season	~July 15 through October 1
Shoulder Season Soft/Broken Ice	~October 2 through November 14

The following sections provide an overview of the proposed construction activities and the types of equipment to be used (Hilcorp 2017).

1.3.1. Ice Road Construction

All ice road construction will be initiated prior to March 1st following the approach of previous LOAs authorized by NMFS and to minimize potential impacts to ringed seals (see Section 11.2.1). Generally, ice road construction and equipment mobilization will commence in 4Q Execute Year 1 (approximately December 2019) when the environmental conditions allow travel on the tundra and on the sea ice. Ice roads for offshore access are typically constructed beginning in late December or January and are used through mid-May. For onshore access, ice roads are constructed beginning in December and used through mid-April. During winter (November through February), ice roads will be built to support island and pipeline construction activities, and will be used in subsequent years to support drilling activities and production operations. An ice road connecting the Endicott SDI to LDPI is expected to be constructed annually to resupply the island and transport personnel. The approximate proposed ice road routes during island and pipeline construction are shown in Figure 1-3.

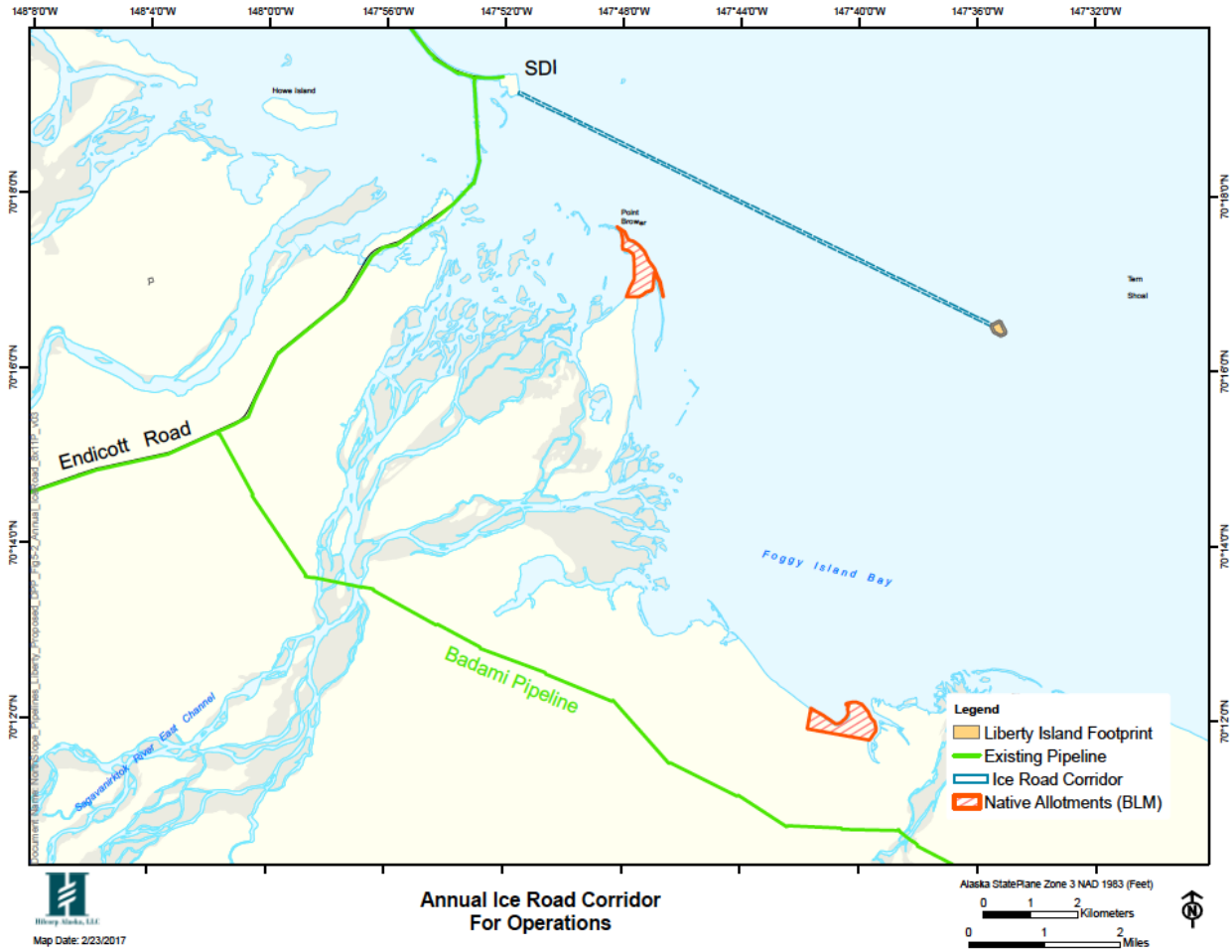
Figure 1-3. Ice Road Locations for Island and Pipeline Construction



Source: Hilcorp 2017

The use of ice roads allows on-ice trench excavation and pipe laying activities, and the bulk hauling of gravel and other materials to the island and pipeline route locations. The ice roads will extend from Endicott Road along the Badami Pipeline, and from LDPI to the Badami Pipeline tie-in to support pipeline construction. An ice road will also extend from LDPI to the proposed mine site to support island construction. Additional ice road spurs will be constructed onshore as necessary to interconnect the ice road system, and to access existing permitted water sources. During all phases of construction and operations, an annual ice road will extend from the SDI to the LDPI as shown in Figure 1-4. As reported in National Research Council (NRC 2003), in most instances, there is little evidence of ice roads or pads built on tundra once snow cover is gone. Ice roads over marine habitats simply melt during breakup, or are carried away in broken ice and then melt.

Figure 1-4. Annual Ice Road Corridor for Operations



Source: Hilcorp 2017

The road built on grounded sea ice and ice roads constructed onshore will have a travel surface approximately 40 ft (12 m) wide. The annual ice road between SDI and LDPI will be approximately 7 mi (11.2 km) long and between 70 and 96 inches (approximately 8 ft [2.4 m]) thick. The road will be approximately 120 ft (36.6 m) wide with a driving lane width of 40 ft, and will cover approximately 103 acres (41.7 hectares [ha]) of sea ice in total. The offshore ice road between the SDI to LDPI ice road and Badami pipeline to LDPI ice road will be approximately 6.18 mi (89.9 acres). During construction, ice roads will cover approximately 251.4 acres of sea ice. The actual width and depth of the ice in a given year will be based upon that year's activities and the required loads.

The ice road connecting the mine site to the island will be about 50 ft (15 m) wide and approximately 6-inches (15 cm) thick onshore. Offshore, this road will consist of two distinct segments: a section constructed on grounded sea ice and a floating section. The floating section of the sea ice will be thickened to approximately 8 ft (96 inches) to support heavy loads required for island construction.

The ice roads will generally be constructed by pumper units equipped with an ice auger to drill holes in the sea ice and then pump water from under the ice to flood the surface of the ice. The ice augers and pumping units will continue to move along the ice road alignment to flood the entire alignment, returning to a previous area as soon as the flooded water has frozen. The ice road will be maintained and kept clean of gravel and other solids. Freshwater can be sprayed onto the road surface to form a cap over the main road structure. Existing permitted water sources will also be used for ice road construction and other water needs. These sources include existing and abandoned gravel mine sites, as well as several tundra lakes and ponds. It is estimated that the total quantity of freshwater required for project construction is approximately 120 million gallons over a period of two construction seasons. During operations, an estimated 20 million gallons would be needed for ice road construction. The use of these water sources will have no effect on marine mammals and are not considered further in the request for rulemaking and the subsequent ITAs.

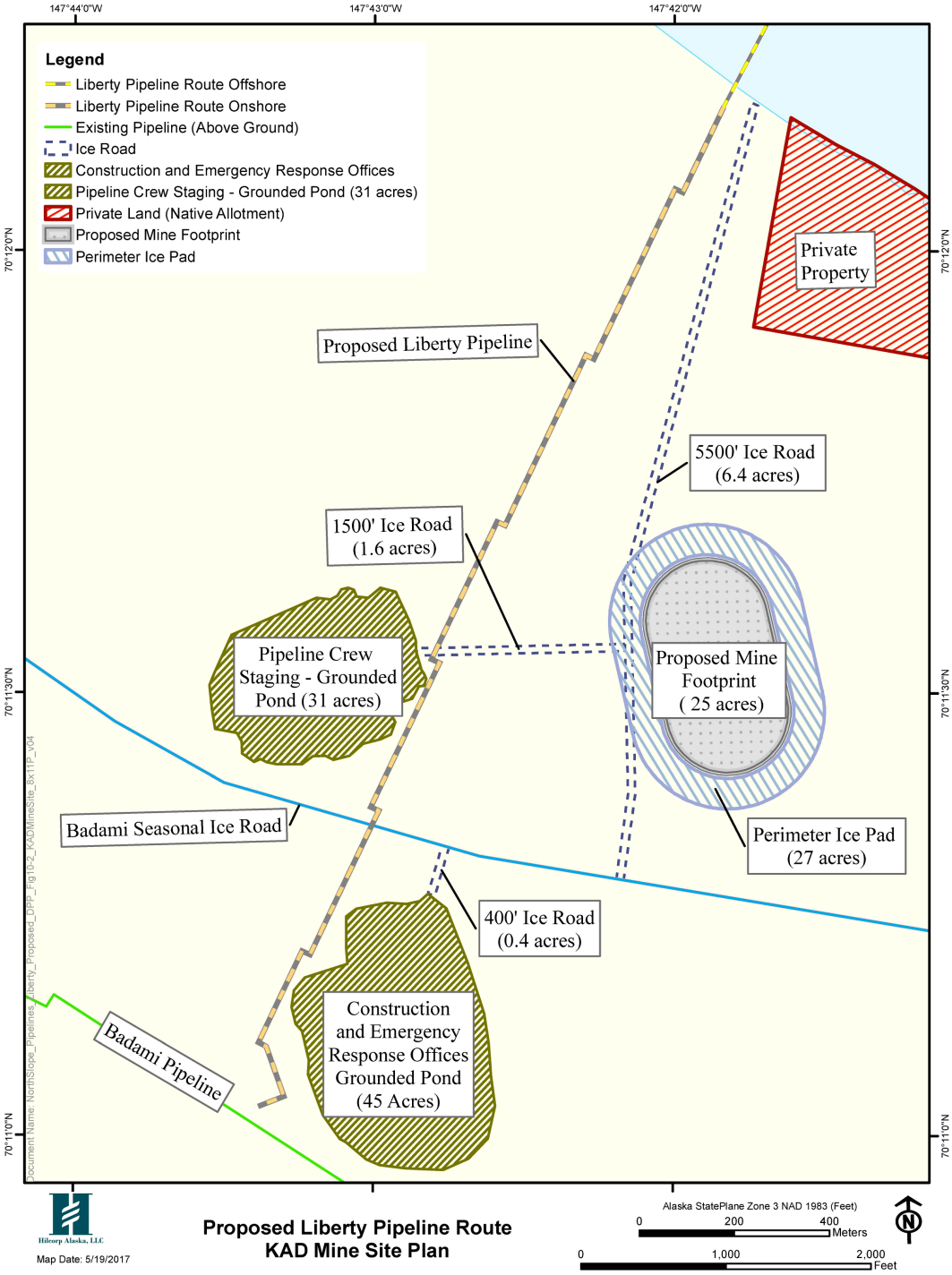
NMFS typically requires that all ice activities are begun no later than 1 March, to reduce the potential for disturbance to ringed seal birth lairs or dens. This is thought to prevent pregnant seals from establishing lairs in the disturbed areas. Once seals have laired, they cannot move away without risk to the pups. There have been no seal mortalities during ice road construction and use at the Northstar Development. One seal mortality reported in the 1990s was associated with a vibroseis program outside the barrier islands east of Bullen Point in the eastern Beaufort Sea (MacLean 1998). For Liberty, Hilcorp will ensure that all ice road construction is initiated prior to March 1. To be precautionary, while construction activities are not anticipated to result in serious injury or mortality of ringed seals, Hilcorp is requesting takes for two seal mortalities over the 5-year period due to the higher level of activity and greater number of ice roads required during the construction phase. These activities include mobilization of materials and equipment to support island, pipeline, and facility construction.

Once construction is complete, the number of ice roads will decrease as will the general level of activity (i.e., travel using ice roads) during operations, thus reducing potential interactions with ringed seals. The ice roads and pads will thaw in the summer season each year. In subsequent years, an ice road system will be constructed to access the island.

Winter ice roads will be constructed according the following general schedule:

- Winter Season (4 Quarter [Q]) Execute Year 1, approximately December 2019 and 1Q Execute Year 3 (January)) – Support for Island Construction. Ice roads will be constructed to support transportation from existing North Slope roads to the proposed mine site, and from the mine site to the proposed LDPI location in the Beaufort Sea as follows:
    - Badami Ice Road
    - Badami Ice Road to Shore Crossing/Material Site Interconnect
    - Sea Ice Material Source/Pipeline Road
    - The onshore Badami Ice Road and the ice road to the shore crossing/material site are shown on Figure 1-5. The ice road from shore to the proposed LDPI location will follow the pipeline route offshore.
- Winter Season (4Q Execute Year 3 and 1Q Execute Year 4) – Support for Offshore Pipeline Construction and Material Delivery to Island. Ice roads will be reconstructed to support the pipeline installation, including the offshore section from the shore crossing to LDPI, and the onshore portion that includes the tie into the Badami pipeline as follows:
    - SDI to LDPI (same as the annual ice road corridor for operations shown on Figure 1-4).
    - Badami Ice Road to Shore Crossing/Material Site (see Figure 1-5)
    - Material Source/Pipeline Road (see Figure 1-5).
    - Additional ice roads along the corridor from the Endicott SDI to LDPI will be constructed in winters of Execute Years 3 through 5 (all construction initiated prior to March 1) to allow additional materials and equipment to be mobilized to support island, pipeline, and facility construction activities. In addition to the ice road system, three offshore ice pads are also planned to support construction. Construction of these ice pads will begin prior to March 1 in conjunction with the adjacent ice roads and will be used for staging of the pipe stringing for stockpiling trench spoils as needed for pipeline construction (see Figure 1-3).

Figure 1-5. Proposed Mine Site



Source: Hilcorp 2017

1.3.2. Mine Site Development

A source of approximately 1,337,000 cubic yards of gravel is required to meet immediate and potential long-term project needs. Approximately 929,000 cubic yards will be needed for the island, approximately 3,500 cubic yards for the Badami tie in pad, and approximately 1,500 cubic yards for the Badami ice road crossing. The remaining yardage would be used for pipeline select backfill, maintenance, and contingency needs. Mining operations are planned for one season, and scheduled to begin in 1Q Execute Year 2.

The proposed source of gravel is a new mine site, developed specifically for this project, west of the Kadleroshilik River (Figure 1-5). The mine site lies approximately 0.5 mi (0.8 km) south of Foggy Island Bay, west of the Kadleroshilik River. The development mine site is approximately 25 acres (10.2 ha) in size, with the primary excavation area developed as one cell. A 27-acre (10.9 ha) ice pad perimeter is planned. The gravel mining and rehabilitation plan will be developed with the objective of minimizing environmental impacts through mitigation features incorporated into the project design.

The general approach of these mining and reclamation plans is to minimize the effects of mining and to create conditions that improve aquatic and bird habitats. The detailed LDPI Mining and Reclamation Plan will be developed in coordination with the state and federal agencies, and will meet Alaska Department of Natural Resources (ADNR) criteria for mine site development and reclamation. The general sequence of activities for mine site development includes removal of snow and ice, removal and stockpiling of unusable overburden material, pit excavation, and gravel hauling. The pit is then reclaimed according to the reclamation plan developed and approved by ADNR. Excavation activities are not expected to impact any marine mammals and will not be considered further in this petition for rulemaking.

1.3.3. Liberty Drilling and Production Island Construction

The LDPI will be an artificial island constructed in 19 ft (5.8 m) of water in Foggy Island Bay approximately 5 mi (8 km) north of the Kadleroshilik River in the Beaufort Sea. The artificial island will include strategic placement of approximately 929,900 cubic yards (cy) of gravel, secured with sheet piling, and armored with linked concrete mats. The surface of the island will be designed to be 15 ft (4.6 m) above sea level with a working surface of approximately 9.3 acres (3.8 ha) and a design seabed footprint of approximately 24 acres (9.7 ha). The elevation of the top of the LDPI will be +15 ft Mean Lower Low Water (MLLW). The island work surface will be overbuilt by a height of 3 ft (0.9 m) on the working surface and by 2 ft (0.6 m) on the bench surface. This overbuild will compensate for settling and thaw subsidence. The island will be constructed of gravel from the proposed mine site west of the Kadleroshilik River.

During the process of construction, sections of sea ice will be cut and removed from the location of the island and placed in shallow waters less than 10 ft (~3 m) where seals do not lair. A ditchwitch will be used to cut through the ice while a backhoe and support trucks will move the ice away. All construction activities involving cutting of sea ice or construction of ice roads will commence prior to March 1 in order to avoid disturbing seals as described in Section 1.3.1. Initiating construction activities prior to March 1 should prevent ringed seals from lairing along the path of the ice roads and in the region of island construction, and should also be a deterrent for seals entering the area as construction activities are ongoing. Once the ice is removed, gravel will be poured through the water column to the sea floor, building the island structure from the bottom up. A conical pile of gravel will form on the sea floor until

it reaches the surface of the ice. The construction will continue with a sequence of removing additional ice and pouring gravel until the surface size is achieved. Slope protection installation, including slope shaping, will follow placement of the gravel, followed by installation of the driven sheet pile wall around much of the island perimeter before the end of the second year. Well conductors and some foundation piles will be driven during this same time frame. Conductor pipes are for the wells and will be set in the well row located in the middle of the island. Depending on the substrate the conductor pipes would be driven into the middle of the island by impact or vibratory methods or both.

The foundation for new facilities at LDPI will be a combination of pad footings and piles, and will not depend on a permafrost substrate for direct support. A pad footing is a concrete block that is placed on the gravel. The facility is then placed or constructed on top of these footings, or footers. There is no acoustic impact associated with placement of the footings.

The proposed plan view layout has a surface area of approximately 9.3 acres (3.7 ha) with open space around the work surface perimeter that is capable of supporting future construction efforts to modify the elevation of the bench and sheet pile wall if warranted due to long-term evaluations of changes in sea level and wave conditions. Table 1-2 provides a summary of the design dimensions and features of the LDPI.

Table 1-2. Design Summary for LPDI

FEATURE	DESCRIPTION[1]
Height of Working Surface	15 ft above MLLW
Total Surface Area / Total Seafloor Area	9.3 acres / 24 acres
Gravel Volume (approximate)	929,000 cy
Sheetpile Wall	2,700 LF of Z-Pile[2] Top of sheetpile is +20 ft on east side and +25 ft on west side where storm surge and high waves will be produced by westerly storms.
Sheetpile Around Well Row	1,100 LF of Pipe-Z[2], top at grade level
Slope Protection – Concrete Mat	430,000 sq. ft.

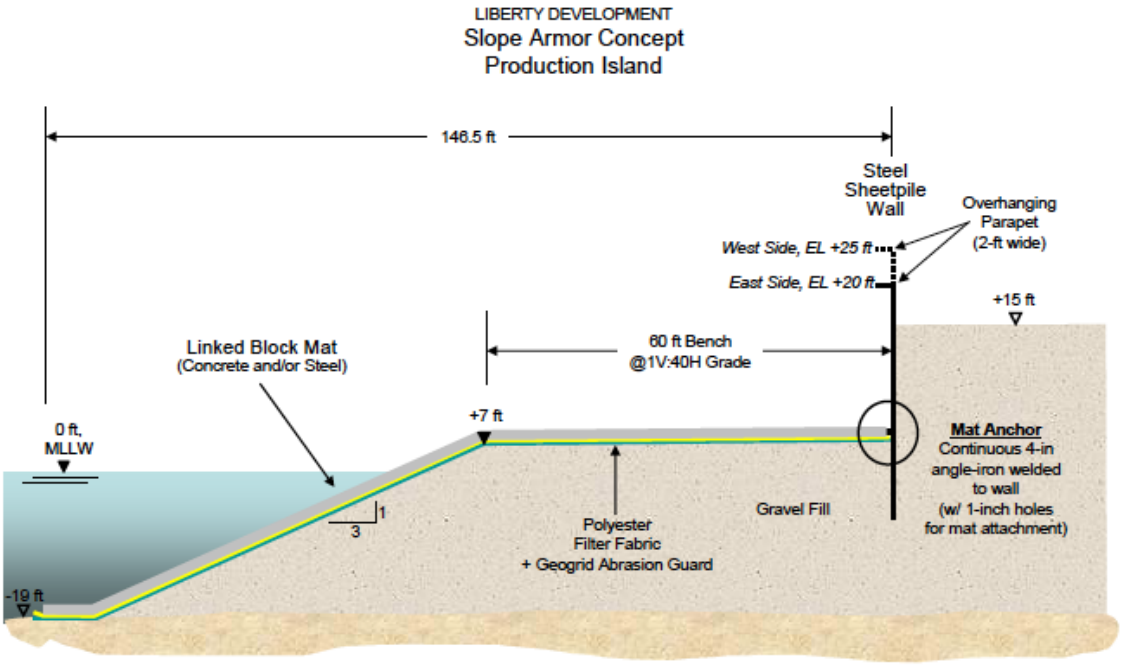
[1]All values (e.g., dimensions, volumes, and areas) are approximate, based on current project design.
[2]Z-Pile and Pipe-Z are interlocking sheet piles.
Key: cy = cubic yard; ft = feet; LF = linear feet; MLLW = mean lower low water.

Island slope protection is required to assure the integrity of the gravel island by protecting it from the erosive forces of waves, ice ride-up, and currents. As shown in Figure 1-6, the island will have a working surface elevation of 15 ft (4.6 m) above MLLW, with a sheet pile wall rising to 20 to 25 ft (6.1-7.6 m) above MLLW depending on the side of the island. The slope protection profile includes a 60-ft (18.3 m) wide bench covered with a linked concrete mat that extends from the sheetpile wall to slightly above MLLW, concrete mat continues to -19 ft (-5.8 m). The elevation of the outer edge of the bench subgrade is +7 ft (2.1 m) (MLLW). The bench dissipates wave and ice forces and will provide operational support for equipment and personnel around the island for construction, maintenance, spill response, and major incident evacuation. The horizontal distance from the sheetpile wall to the toe of the slope armor measures approximately 150 ft (46 m). These dimensions were used to calculate the seabed footprint of the island. Figure 1-6 shows the island profile, and Figure 1-7 provides an example of armoring used on Endicott Island.

At the back of the 60-ft (18.3-m) wide bench, a vertical sheetpile wall is installed. The wall protects the work surface of the island from ice and wave impacts. It also prevents most marine mammals from

entering the work area. This design is similar to Northstar Production Island constructed by BPXA in 2000. Given the high storm surge and larger waves that are expected to arrive at the LDPI site from the west and northwest, the wall will be higher on the west side than on the east side. This differing wall height was also successfully implemented at Northstar. Engineering work will be conducted in the Final Engineering phase to confirm the exact height and construction techniques for the sheet pile wall. At this time, the wall elevation on the east side is assumed to be +20 ft (+6.1 m) (MLLW), and the elevation on the west side is assumed to be +25 ft (+7.6 m) (MLLW). A 3-D rendering of the island is shown in Figure 1-8.

Figure 1-6. Island Profile



Note: concrete block pad footings are placed on top of the gravel. They are not part of the mat anchoring system.
Source: Hilcorp 2017

Figure 1-7. Linked Armor on Endicott Island

Source: Hilcorp 2017

Figure 1-8. 3-D Rendering of the Completed LDPI

Source: Hilcorp 2017

The LDPI site is more comparable to the Endicott site and is not as challenging as the deeper, more exposed Northstar location (39-foot water depth), where concrete mat repair has been required due to damage caused by large waves and thick multi-year ice. The linked concrete mat requires a high strength, yet highly permeable woven polyester fabric under layer to contain the gravel island fill. The filter fabric panels will be overlapped and tied together side-by-side (requiring diving operations) to prevent the panels from separating and exposing the underlying gravel fill. No additional equipment is needed to deploy the fabric. Above the fabric under layer, a robust geo-grid will be placed as an abrasion guard to prevent damage to the fabric by the linked mat armor. At the top of the sheet-pile wall, overhanging steel "parapet" will be installed to prevent wave passage over the wall.

Maintenance procedures designed to inspect for and repair damage will be implemented. An annual inspection will be conducted including a slope protection inspection, a topographic survey, and a bathymetric survey as described below.

- Slope Protection Annual Inspection: A detailed inspection of the island slope protection system will be conducted during the open-water season to document changes in the condition of the island slope protection system that have occurred since the previous year's inspection. Above-water activities will consist of a visual inspection of the dock and sheet pile enclosure, and documenting the condition of the island bench and ramps. The below-water slopes will be inspected by divers or if water clarity allows, remotely by underwater cameras contracted separately by Hilcorp. The results of the below-water inspection will be recorded for repair if needed. No vessels will be required. No takes are requested for these activities.

- Topographic Survey: Topographic data on shore-perpendicular profiles on the above-water portion of the island will be obtained using traditional surveying techniques. No vessels will be required. No takes are requested for these activities.
- Bathymetric Survey: Multi-beam bathymetry and side-scan sonar imagery of the below-water slopes and adjacent sea bottom will be acquired using a bathymetry vessel. A single-beam echosounder and side scan sonar will be used to obtain highly accurate seafloor bathymetry. In water too shallow to be accessible by the larger vessel, the condition of the slopes shall be documented by obtaining soundings on a minimum of 28 shore-perpendicular profiles using a single-beam echo sounder operated from a shallow-draft inflatable survey vessel. These transects shall be coincident to those identified in the topographic survey. NOAA has not regulated or required take assessments for activities using sonar with source frequencies at or above 180 kHz. The sidescan sonar would operate at a frequency between 200-400kHz. The single-beam echosounder would operate at a frequency of about 210 kHz. Therefore, because source frequencies occur outside of range of marine mammal functional hearing groups, no takes are requested for these activities.

Key preliminary findings of the inspection tasks identified above will be developed, particularly those concerning the extent of observed damage and the possible need for maintenance. A report will be prepared that conveys the methods employed and results obtained as part of the inspection. Mats are designed for the 25-year lifespan of the project. However, any mats or sheet piles damaged from unforeseen events (i.e., extreme weather) would be repaired or removed and replaced. No additional pile driving is anticipated. All damaged mats would be retrieved and removed from the ocean.

1.3.4. Pipeline Installation

Pipeline construction is planned for the winter after the island is constructed currently anticipated to be from 1Q to 2Q Execute Year 3 (January through May). The pipeline will extend from the island to a tie-in with the Badami Pipeline system. Ice seals may be present during the period when pipeline construction would occur. Section 6.5.3 describes the number of seal takes requested per year.

The offshore and onshore pipeline segments are planned to be installed within the same time frame with two separate construction spreads of equipment and manpower. The onshore sequence of activities includes the installation of Vertical Support Members (VSMs), placement of the pipeline on the VSMs, and installation of the pigging facilities at the Badami tie-in pad. The onshore section is approximately 1.5 mi (2.4 km) long.

For the offshore segment, construction will progress from shallower water to deeper water with multiple construction spreads. The pipeline trench will be excavated using long reach excavators with pontoon tracks, the pipeline bundle will be lowered into the trench suing side booms to control its vertical and horizontal position, and the trench will be backfilled by excavators using excavated trench spoils and select backfill. Hilcorp intends to place all material back in the trench slot. Work will be done from thickened ice using conventional excavation and dirt-moving construction equipment. The offshore pipeline target trench depth is 9 to 11 ft (2.7 to 3.4 m) with a proposed maximum depth of cover of approximately 7 ft (2.1 m). The pipeline will be about 5.6 mi (9 km) long. Hydro-testing (pressure testing using sea water) of the entire pipeline will be completed prior to commissioning in 3Q Execute Year 3.

1.3.5. Facilities Construction

All modules, buildings, and material for on-site construction will be trucked to the North Slope via the Dalton highway and staged at West Dock, Endicott SDI, or in Deadhorse. Another option is to use ocean-going barges from Dutch Harbor to transport materials or modules to the island during the open water season.

Depending on the season, equipment and material will be transported via coastal barges in open water, or ice roads from SDI in the winter. The first modules will be delivered in 3Q Execute Year 2 to support the installation of living, drilling, and production facilities. Remaining process modules will be delivered to correspond with first oil and the ramp up in drilling capacity.

Onsite facility installation will commence in August of Execute Year 2 and be completed by the end of Execute Year 4 (May) to accommodate the overall construction and production ramp-up schedule. Some facilities that are required early will be barged in 3Q Execute Year 2 and will be installed and operational by the end of 4Q Execute Year 2. Other modules will be delivered as soon as the ice road from SDI is in place.

None of the construction activities associated with building the facilities are anticipated to result in a take by harassment of a marine mammal. They are discussed herein to complete the description of the action but are not discussed further in this request for rulemaking or LOA.

1.3.6. Vehicular and Marine Vessel and Aircraft Movements

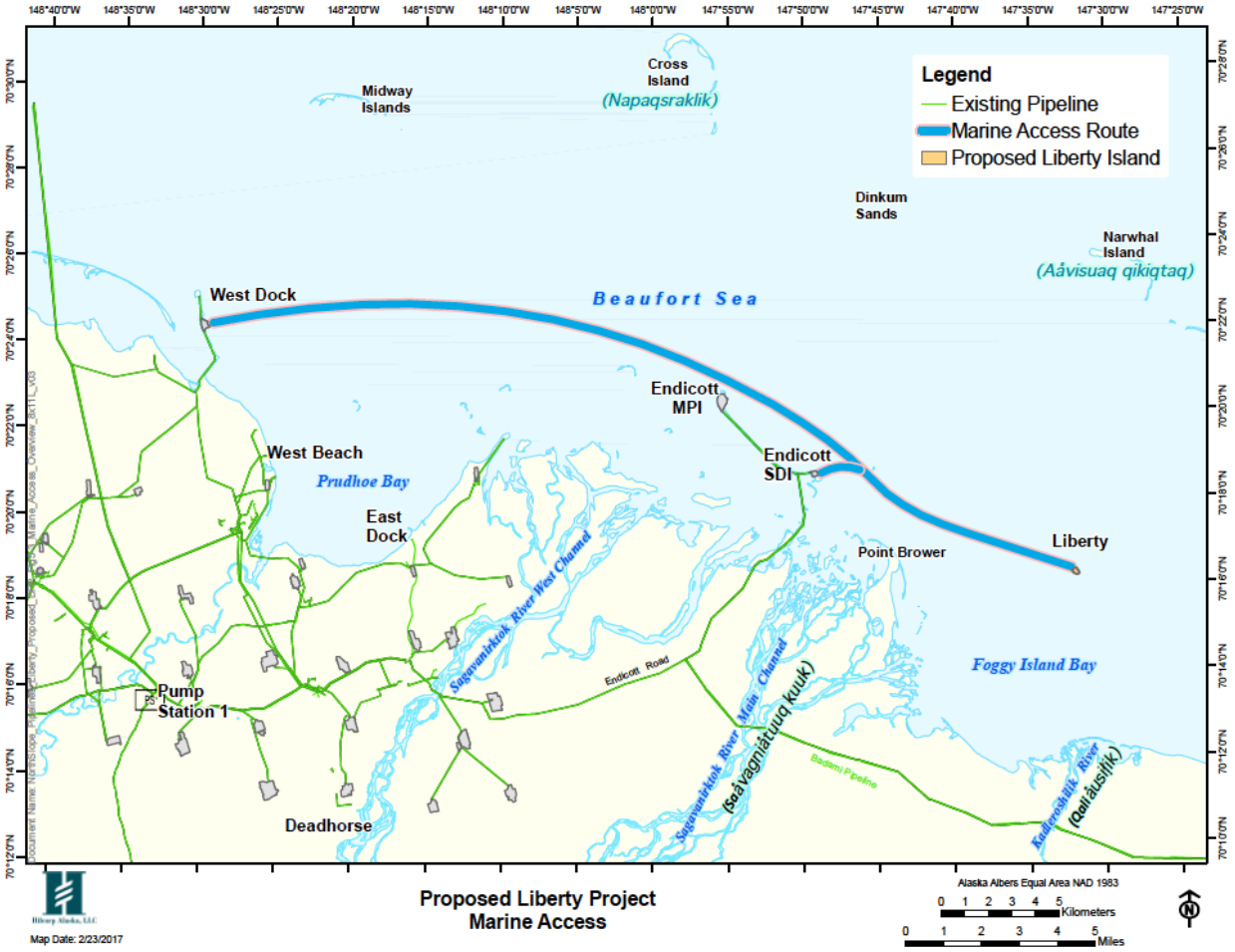
During construction, large quantities of gravel, pipe, and heavy modules will be moved to the island. Road vehicle traffic will use the Alaska Highway System to transport material and equipment from supply points in Fairbanks, Anchorage, or outside of Alaska to the supply hub of Deadhorse. North Slope gravel roads will be used for transport from Deadhorse to the SDI. Existing gravel roads within the Endicott field between the Main Production Island (MPI) and the SDI will also be used to support the project. No new gravel roads will be constructed.

During winter construction, workers will access the Project Area from existing facilities via existing gravel roads and the ice road system (Figure 1-9). Construction vehicles will be staged at the construction sites, including the gravel mine. Access to the LDPI by surface transportation is limited by periods when ice roads can be constructed and used. Surface transportation to the onshore pipeline can occur in winter on ice roads and can occur in summer by approved tundra travel vehicles. The highest volume of traffic will occur during gravel hauls to create the LDPI. Section 2.1.2 of the Liberty DEIS estimates gravel hauling to the island will require approximately 14 trucks working for 76 days (BOEM 2017). Section 5.1.5 of the Liberty DPP estimates 21,400 surface vehicle trips per season during island construction.

In general, ice roads will be used in the winter months, marine vessels will be used in the summer months, helicopters will be used during all seasons, and hovercraft (if necessary) will be used in the shoulder season when ice roads and open water are not available. By spring breakup, all materials needed to support ongoing construction will have been transported to the island over the ice road system. Personnel will access the island during breakup via helicopter or if necessary, using a hovercraft.

During the open-water season, personnel will continue to access the island via helicopter, hovercraft (if necessary), or crew boat. Any needed construction materials and supplies will be mobilized to the site by barge from West Dock or Endicott. Larger barges and tugs can over winter in the Prudhoe Bay area and travel to the LDPI in the open-water season (Figure 1-9), and will be generally chartered on a seasonal basis or long-term contract. Vessels will include coastal and ocean going barges and tugs to move large modules and equipment. Smaller vessels will be used to move personnel, supplies, tools, and smaller equipment. Barge traffic consisting of large ocean going barges originating from Dutch Harbor is likely to consist of one to two vessels approximately two to five times per year during construction and only one trip every five years during operations. Although hovercraft may be used year-round depending on ice conditions, they would primarily be used to transport personnel and small loads during shoulder seasons when ice roads and open-water vessel support are not available. During the first two years following LDPI construction, hovercraft may make up to 3 trips per day from Endicott SDI to LDPI. After those two years, hovercraft may make up to 2 trips per day from Endicott SDI to LDPI (approximately 7 miles).

Figure 1-9. Offshore Marine Transportation Routes



Source: Hilcorp 2017

Air operations are often limited by weather conditions and visibility. In general, air access will be used for movement of personnel and foodstuffs, and for movement of supplies or equipment when necessary. Helicopter use is also planned for personnel transport, re-supply during the broken ice seasons, and access for maintenance and inspection of the onshore pipeline system. Typically, air traffic routing is as direct as possible from departure locations such as the SDI, West Dock or Deadhorse to the LDPI, with routes and altitude adjusted to accommodate weather, other air traffic, and subsistence activities. As described in Section 11, aircraft will use an established corridor to the extent practicable and if safe to do so, to minimize potential impacts to marine mammals or subsistence activities. Fixed wing aircraft[6] are not planned for use under normal operations; fixed wing aircraft would only be used at Liberty on an occasional, as-needed basis for purposes of spill response (spill delineation) and aerial reconnaissance of anomalous conditions, or unless otherwise required by regulatory authority.

In the period between completion of hydro-testing and facilities start-up, an estimated one to two helicopter flights per week for several weeks will be required for personnel access and to transport

[6] Does not include Unmanned Aerial Systems (UAS).

equipment to the tie-in area. Equipment located at the pipeline tie-in location and the pipeline shore landing will be accessed by helicopter or approved tundra travel vehicles to minimize impacts to the tundra.

1.3.7. Emergency Oil Spill Response Training

Similar to the oil spill response training conducted each year at Northstar, emergency and oil spill response training activities will occur at various times throughout the year. Oil spill equipment deployment exercises will be conducted by ACS during both the ice-covered and open-water periods. During the ice-covered periods, exercises will be conducted to practice tactics involving detection, containment and recovery of oil on and under ice. These exercises will mostly be on bottom-fast ice and will require snow machines and all-terrain vehicles. The spill equipment deployment exercise includes using various types of equipment to cut ice slots or drill holes through the floating sea ice. Typically, the snow is cleared from the ice surface with a skidsteer loader and snow blower that allows access to the ice. Two portable generators are used to power light plants at the exercise site. The locations and frequency for future spill drills or exercises will vary depending on the sea ice condition and training needs. ACS conducts spill response training activities during the open-water season during late July through early October. Vessels used as part of this training typically include Zodiacs, Kiwi Noreens, and Bay-class boats that range in length from 3.7-13.7 m (12-45 ft.). Future exercises could include other vessels and equipment. ARKTOS amphibious emergency escape vehicles may be stationed at Liberty as they are at Northstar Island. Each ARKTOS is capable of carrying 52 people. Training exercises with the ARKTOS are conducted monthly during the ice-covered period. ARKTOS training exercises are not conducted during the summer. Equipment and techniques used during oil spill response exercises are continually updated, and some variations relative to the activities described here are to be expected." (pers. comm. C. Hall [Alaska Clean Seas]; also based on NMFS BiOp for Northstar Operations 2014-2019).

1.3.8. LDPI Abandonment

Detailed plans for the decommissioning of LDPI will be prepared near the end of field life which will not occur during the period addressed in this request. Decommissioning will be conducted in accordance with the provisions of federal, state, and local laws, regulations, and permit conditions. In general, the applicable laws and regulations provide for discretion with respect to rehabilitation requirements. This flexibility allows for consideration of the environmental effects of decommissioning taking into consideration site-specific factors.

1.3.9. Summary of Project Activities and Noise Sources and Locations

Project activities that produce noise and have the potential to result in takes of marine mammals in the Action Area are summarized in Table 1-3. Section 6.3 provides distances to distances to predicted noise thresholds for these activities and Section 6.5 provides exposure estimates for marine mammals.

Table 1-3. Potential for Marine Mammal Takes Associated with Project Activities

Project Activity	Year[1]	Noise Source	Source Location(s)	Potential for Level A Takes	Potential for Level B Takes
ICE-COVERED SEASON					
Ice road construction and maintenance (Section 1.3.1)	1-5	Grader Ice auger Water pump trucks	Ice roads	No[2]	Yes
Pipeline installation (Section 1.3.4)	3	Trucks on ice road Backhoe digging Ditchwitch sawing ice	Ice roads along pipeline route	No	Yes
Gravel Mine Site Development	2 - 3	Excavation equipment and trucks	0.5 mi south of Foggy Isl. Bay	No	No
Island construction[3] (Section 1.3.3)	2[3]	Trucks on ice road Backhoe digging Ditchwitch sawing ice	Ice roads Island Island	No	Yes
Vibratory sheet pile driving (Section 1.3.3)	2	Vibratory pile driver	Island edge	No	Yes
Impact sheet pile driving (Section 1.3.3)	2	Impact pile driver	Island edge	No	Yes
Conductor pipe impact driving (Section 1.3.3)	2	Impact pile driver	Island interior	No	No
Emergency and oil spill response training (Section 1.3.7)	1-5	Grader Bobcat loader Ice auger Generators / Light plants Snowmachine All-terrain vehicle ARKTOS	Island and vicinity	No	No
Helicopter transportation (Section 1.3.6)	1-5	Helicopter	Island and vessel route	No	No
Drilling & Production	3-5	Drilling & Production	Island interior	No	Yes
Production only	5	Production	Island interior	No	Yes
OPEN WATER SEASON					
Slope shaping, armament installation	2	Excavator	Island edge	No	Yes
Vibratory sheet pile driving	2	Vibratory pile driver	Island edge	Yes	Yes
Impact sheet pile driving	2	Impact pile driver	Island edge	Yes	Yes
Conductor pipe impact driving[4]	2	Impact pile driver	Island interior	Yes	Yes
Emergency and oil spill response training	1-5	12-45 ft. vessels (i.e., Zodiak)	Island vicinity	No	No
Vessel transportation	1-5	Barge Tugs Small/crew boat	Island & vessel route	No	No
Helicopter transportation[5]	1-5	Helicopter	Island & vessel route	No	No
Drilling & Production	3-5	Drilling & Production	Island interior	No	Yes
Production (Year 5 only)	5	Production	Island interior	No	Yes

[1] Additional schedule details are provided in Section 2 and Table 2-1. Note: this ITR is requesting takes only for the first 5 years.
[2] There would be no Level A takes associated with PTS from underwater noise exposure associated with this activity. Hilcorp is requesting two takes for potential serious injury or mortality for the first 5 years of construction.
[3]"Island construction" in this instance, includes cutting through ice and placement of gravel. Island construction may take two seasons depending on ice conditions.
[4] The location of conductor pipes in the interior of the island means underwater noise levels are inherently low, especially under ice conditions (see Table 20 of Noise Report). The need for impact driving would depend on local conditions.
[4] Underwater noise generated by helicopters flying at 500 ft is expected to be around 109 db re 1uPa (Richardson *et al*. 1995)

2. DATES, DURATION AND SPECIFIC GEOGRAPHIC REGION OF ACTIVITY

The Project can be broken into several distinct but overlapping phases. For the purposes of this request, the project is presented as two major phases: Project Review Phase (including approvals) and Project Execution Phase. The specific location of the proposed LDPI is provided in Figures 1-1 and 1-2.

2.1. Project Review Phase

The Agency Review and Approval phase began in 2015 and will continue until the ROD is posted and financial sanction is secured. Following the ROD and review of all permit stipulations, the owners will review the project in light of new information and determine whether the project is a prudent investment and should proceed. Project sanction generally requires at least 6 to 9 months of re-evaluation, and will require a review of all stipulations attached to the permits.

If permits are secured prior to September 1 of a calendar year, then ice road construction could begin before the end of the same calendar year. For example, if the NEPA Record of Decision (ROD) is acquired by September 1, 2019 and all other relevant permits are acquired by that date, then construction could begin in 4Q of the same year and 2019 would be defined as Execute Year 1. This application considers 4Q of 2019 as Execute Year 1. Hilcorp is submitting the ITA application with sufficient time to secure the LOA by November 1, 2019.

However, if permits are secured after September 1 of calendar year 2019, construction would be delayed to the next winter season and Execute Year 1 would be the following calendar year (2020). Either schedule is possible, depending on when approvals are secured. However, the time of the year that execution can begin will not change, since island construction can only begin when it is cold enough to build ice roads to access the mine site and proposed island location.

2.2. Project Execution Phase

This request for rulemaking and LOA covers the Project Execution Phase which includes all construction activities and initial operations. The Project Execution period begins as soon as the project has been sanctioned by the owners. Once all governmental agencies have approved the Project, activities could progress to the Execution Phase as summarized in Tables 1-3 and 2-1. These tables also show whether takes are being requested in this ITR for each phase. A description of the duration and seasonal windows of each major activity is given below.

Table 2-1. Liberty Timeline and Indication of Marine Mammal Take Requested[1]

ACTIVITY	TIMING	TAKES REQUESTED?
CONSTRUCTION OPERATIONS		
Summer & Winter Access	Year 1 - Year 3	
Annual Ice Road (#1)	Year 1 - Year 3, January – mid-May	Yes
Support Ice Roads (#2 - #4)	Year 1 – Year 4, December – mid-April	Yes
Sea-going Barges	Year 2 - Year 4, June - November	No
Small Marine Vessels	Year 2 - Year 4, June - November	No
Island Construction[2]	Year 2, February – September[3]	
Pile Driving and Slope Shaping	Year 2, July – August[3]	Yes
Facilities Construction	Year 2, August - Year 4, May	No
Pipeline Construction	Year 3, January - May	Yes
DRILLING OPERATIONS		
Summer & Winter Access	Year 2 - Year 4	
Annual Ice Road (#1)	Year 2 - Year 4, January – mid-May,	Yes
Sea-going Barges	Year 2 - Year 4, June - November	No
Small Marine Vessels	Year 2 - Year 4, June - November	No
Rig Mobilization and Well Drilling	Year 2 - Year 5	Yes
First Oil/Commissioning	Year 3, December - Year 4, May	No

Source: BOEM 2017

[1]This petition is only requesting takes though first 5 years due to increase activities at the site (for example, increased number of ice roads and traffic which would diminish after year 5; future LOAs may depend on acoustic monitoring as described in Section 13.

[2]No takes are being requested for mine site development.

[3]Would occur in Year 3 only if island construction occurs over two winter seasons as ice conditions allow.

2.2.1. Detailed Engineering and Construction

This Project has been studied for many years, so considerable volumes of data have been gathered, and an extensive amount of engineering analyses, environmental investigation, and planning has been completed and documented (Hilcorp 2017). In addition to the work specific to the LDPI location, there are lessons that have been learned from four prior island developments in the Beaufort Sea. All of this information has been used to design the proposed project.

Construction of the LDPI is planned for 40 to 48 months from early in 1Q Execute Year 2 through installation of the last process modules in 2Q Execute Year 4 (see Table 1-3 and 2-1). The project schedule and sequence is seasonal, as it relies on ice roads and the sea ice as a work platform. If certain aspects of the project are delayed by a month, it may mean a year delay in the construction schedule. Project construction is planned in the following sequence once the execution phase begins after approvals and sanction.

- Q4 Execute Year 1 through Q3 Execute Year 2: Build ice roads, build LDPI, haul gravel, install sheet pile wall, and shore protection.
- Q4 Execute Year 2 through Q2 Execute Year 3: Build ice roads, install subsea pipeline bundle and build LDPI infrastructure.
- Q3 Execute Year 2 through Q2 Execute Year 4: Install LDPI process facilities, drilling unit.
- Q1 Execute Year 3: Drilling unit commissioning and start up. All wells would be completed by end of 2Q Execute Year 5.
- Late Execute Year 3 or Early Execute Year 4: Commission and start-up process facilities. First oil is expected 1Q Year 4.

3. SPECIES AND ABUNDANCE OF MARINE MAMMALS IN THE BEAUFORT SEA

The marine mammal species under NMFS jurisdiction that may occur in the Beaufort Sea include eight whale species and four species of seals (see Table 3-1). One whale species, the bowhead (*Balaena mysticetus*) is listed as endangered under the ESA. The bowhead whale and the Beaufort Sea stock of beluga whales (*Delphinapterus leucas*) are the most commonly occurring cetaceans in the Beaufort Sea. Individuals from the eastern North Pacific stock of gray whales (*Eschrichtius robustus*) have been observed in the central and eastern Beaufort Sea but are not very common. Any humpback whales (*Megaptera novaengliae*) encountered in the Chukchi or Beaufort seas could be derived from either the endangered Western North Pacific (WNP) DPS or the threatened Mexico DPS (Wade *et al*. 2016). Humpbacks in the Aleutian Islands and Bering Sea region have a 2.2 percent probability of being from the WNP DPS and 11.3 percent probability of being from the Mexico DPS. However, humpback whales are considered rare in the eastern Bering Sea. Therefore, either DPS has less than a 1 percent probability of occurring in the extreme eastern Beaufort Sea. For these reasons, the humpback whale, narwhal (*Monodon monoceras*), killer whale (*Orcinus orca*), harbor porpoise (*Phocoena phocoena*), and the minke whale (*Balaenoptera acutorostrata*) are considered rare or extralimital to the eastern Beaufort Sea and therefore extremely unlikely to be encountered in the Foggy Island Bay area. Abundance estimates of these five extralimital species are not provided in Table 3-1 as takes of these species from Project activities are considered extremely unlikely. Similarly, their status and distribution is only briefly discussed in Section 4.3.

The ringed (*Phoca hispida*), bearded (*Erignathus barbatus*) and spotted seal (*Phoca largha*) are the most commonly occurring seal species in the Beaufort Sea. On January 22, 2018, the Supreme Court rejected the appeal of the bearded seal listing, thus the species remains listed as threatened under the ESA. On February 12, 2018, the 9th Circuit Court of Appeals upheld the listing of ringed seals as threatened under the ESA. Ribbon seals (*Histriophoca fasciata*) occur mainly in the Chukchi Sea and western part of the Beaufort Sea. Therefore, encounters in the Foggy Island Bay area are not expected to occur.

Table 3-1. Abundance, Habitat, and Status of Beaufort Sea Marine Mammals During Open-Water

SPECIES	ABUNDANCE[1]	HABITAT	ESA[2]	IUCN[3]
WHALES				
Bowhead whale (Bering- Chukchi-Beaufort Stock)	16,091	Pack ice, open water coastal and offshore	Endangered	LC
Gray whale (eastern Pacific population)	20,125[4]	Coastal, lagoons	Not listed	LC
Beluga (Beaufort Sea Stock)	32,453	Offshore, ice edge, coastal, lagoons.	Not listed	NT
Minke whale	Rare/Extralimital	Shelf, coastal	Not listed	LC
Humpback whale (WNP DPS)	Rare/Extralimital	Shelf, coastal	Endangered	EN
Humpback whale (Mex DPS)	Rare/Extralimital	Shelf, coastal	Threatened	NT
Narwhal	Rare/Extralimital	Offshore, ice edge	Not listed	NT
Killer whale	Rare/Extralimital	Variable habitats	Not listed	DD
Harbor Porpoise	Rare/Extralimital	Variable habitats	Not listed	--
SEALS				
Ringed seal (Beaufort Sea Stock)	300,000[5]	Landfast (but not bottom fast) and pack ice, open	Threatened	LC
Bearded seal (Bering and Chukchi Sea)	273,676[6]	Pack ice, open water	Threatened	LC
Spotted seal (eastern and central Bering Sea)	391,000[7]	Pack ice, open water, coastal haulouts	Not listed	DD
Ribbon seal (eastern and central Bering Sea)	61,000[8]	Pack ice, open water	Not listed	DD

[1] Abundance estimates are derived from the most recent Marine Mammal Stock Assessment Reports (Muto *et al.* 2016; Caretta *et al.* 2016; Allen and Angliss 2015), and are considered minimum estimates unless otherwise noted. Abundance estimates are not provided for species that are rare or extralimital to the Beaufort Sea.
[2] Endangered Species Act of 1973
[3] IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Codes for IUCN classifications version 3.1: EN = Endangered; NT = Near Threatened; LC = Least Concern; DD = Data Deficient, and -- = not yet assessed. http://www.iucnredlist.org/apps/redlist/static/categories_criteria_3_1#categories.
[4] Estimate based on 2006/2007 data (Laake *et al*. 2012) presented in Caretta *et al.* (2016)
[5] The estimate presented in Kelly *et al*. (2010a) is based on estimates from surveys by Bengtson *et al*. (2005) and Frost et al. (2004) in the late 1990s and 2000. This is likely an underestimate, and is based on surveys of a portion of the range and are greater than 8 years old. A reliable minimum population estimate (N_{min}) for the total population in the Alaskan Chukchi and Beaufort Sea regions is not available (Allen and Angliss 2015; Muto *et al.* 2016).
[6] Reliable abundance estimates are currently not available (Allen and Angliss 2014). Based on studies by Ver Hoef *et al.* (2010), Fedoseev (2000) and Bengtson *et al.* (2005), Cameron *et al*. (2010) estimated about 125,000 bearded seals in the Bering Sea and 27,000 bearded seals in the Chukchi Sea cited in Muto *et al*. (2016).
[7] N_{min} based on Angliss and Allen (2015), different from Angliss and Allen (2014) due to updated information.
[8] Frequencies of sightings data from the 2007 surveys and information on ice distribution and the timings of seal haulout behavior were analyzed to develop a population estimate in the areas surveyed however, N_{min} cannot presently be determined (Allen and Angliss 2015).

4. AFFECTED SPECIES AND STOCKS STATUS AND DISTRIBUTION

4.1. Cetaceans

The most common cetacean species found in the Action Area are the Bering-Chukchi-Beaufort (BCB) stock of bowhead whale (*Balaena mysticetus*), the eastern North Pacific stock of gray whale (*Eschrichtius robustus*), and the Beaufort Sea stock of beluga whale (*Delphinapterus leucas*) (Allen and Angliss 2015). These are the only cetaceans likely to occur in the proposed Action Area (BOEM 2017).

4.1.1. Bowhead Whales

Bowhead whales are circumpolar, ranging throughout high latitudes in the Northern Hemisphere. Four stocks of bowhead whales are recognized worldwide by the International Whaling Commission for management purposes (Allen and Angliss 2015). The largest of these four stocks is the Western Arctic or BCB stock (Allen and Angliss 2015). The Alaska Eskimo Whaling Commission (AEWC) has co-managed this stock with the U.S. government since the 1980s.

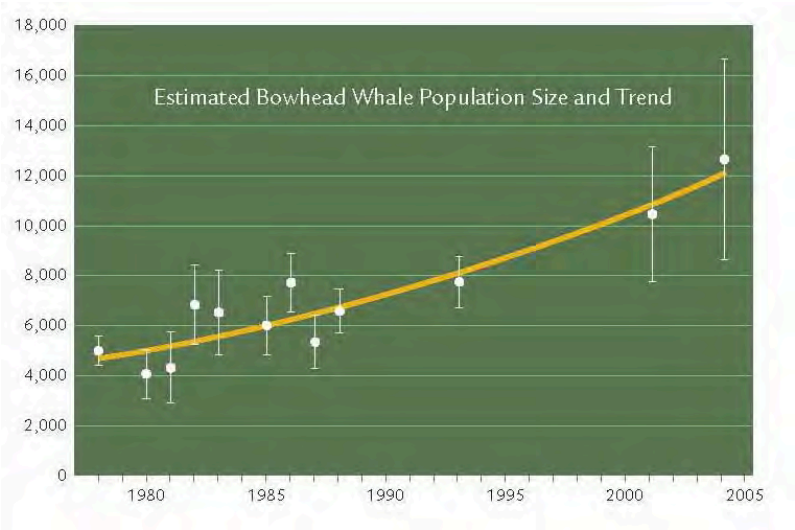
Distribution: The BCB stock of bowhead whales migrates annually from wintering areas (December to March) in the Bering Sea, through the Chukchi Sea in the spring following open ice leads (April through May) to their summer feeding grounds in the Mackenzie River Delta, Canadian Beaufort Sea. Most bowheads arrive in the coastal areas of the eastern Canadian Beaufort Sea and Amundsen Gulf in late May and June, but some remain in the offshore pack ice of the Beaufort Sea until about mid-July. The stock then feeds in the Canadian Beaufort Sea, where they spend much of the summer (June through early to mid- October) before returning to the Bering Sea in the fall to overwinter (Braham *et al.* 1980, Braham and Breiwick 1984, Moore and Reeves 1983, Rugh *et al.* 2003, Quakenbush *et al.* 2010, Allen and Angliss 2015). Starting about mid- August through late October, bowheads migrate to the west through the Alaskan Beaufort Sea to their wintering grounds in the central and western Bering Sea (Quakenbush *et al.* 2010).

Late summer and autumn aerial surveys have been conducted in the Alaskan Beaufort Sea since 1979 and provide useful information on long-term bowhead whale migration and distribution patterns (Ljungblad *et al.* 1986, 1987; Moore *et al.* 1989; Monnett and Treacy 2005; Treacy *et al.* 2006; Clarke *et al.* 2012, 2013a, and 2013b). The main bowhead migration corridor is located over the continental shelf, typically within 34 mi (54.7 km) of shore during years with light to moderate ice conditions (Treacy *et al.* 2006). Data demonstrate that bowhead whales tend to migrate west in deeper water (farther offshore) during years with higher-than-average ice coverage as compared to years with less ice. Bowhead whale sightings are also lower in heavy ice years. During the fall migration, most bowheads migrate west in water ranging from 50 to 656 ft deep (15 to 200 m) (Miller *et al.* 2002, Clarke *et al.* 2012) and only a few whales have been observed shoreward of the barrier islands in the Alaskan Beaufort Sea. In 2013, nearshore sightings appeared to be more common (Clarke *et al.* 2014). The Aerial Surveys of Arctic Marine Mammals (ASAMM) surveys in 2016 (Clarke, pers. comm., emails dated September 1, 2016 and October 2, 2016) reported large numbers of bowhead whales on the shelf but still outside of the barrier islands bordering Foggy Island Bay.

Although most bowheads feed in the Canadian Beaufort Sea, feeding activity has also regularly been documented at Point Barrow and, less frequently, in other areas of the Alaskan Beaufort Sea (Richardson and Thomson 2002; Koski *et al.* 2008, [Bowhead Whale Feeding Ecology Study {BOWFEST} and ASAMM annual reports available from the NMFS Marine Mammal Laboratory (MML) web page: http://www.afsc.noaa.gov/NMML/cetacean/]). Satellite tagging data showed that some whales move back and forth between the Alaskan and Canadian Beaufort Sea during the summer feeding season (Quakenbush *et al.* 2010).

Abundance: Commercial whaling decreased the bowhead whale population to approximately 3,000 individuals (Woodby and Botkin 1993). Prior to commercial whaling, abundance of the BCB stock was estimated at from 10,400 to 23,000 whales. Since the ban on commercial whaling, the bowhead population has increased steadily. As shown on Figure 4-1, analysis of data collected during 1978-2001 and 2003-2005 using ice-based counts, acoustic locations, and aerial transects shows the increasing population trend (George *et al.* 2004; Koski *et al.* 2010).

Figure 4-1. Estimated Bowhead Whale Population Size and Trends



Source: Allen and Angliss (2013).

In 2011, the North Slope Borough (NSB) successfully completed a new ice-based count of bowhead whales; this study estimated the population at approximately 16,892 animals, with an annual growth rate of 3.7 percent (Givens *et al.* 2013).

Status: Over the last four decades the BCB stock size has steadily increased. George *et al.* (2004) reported a 3.4 percent increase from 1978 to 2001. During this period, abundance doubled from roughly 5,000 to 10,000 whales (LGL 2012). In 2001, the BCB stock size was estimated at 8,250 individuals (Allen and Angliss 2013), growing to 12,631 in 2004 (Koski *et al.* 2010), and to 16,892 whales in 2011 (Givens *et al.* 2013, Muto *et al.* 2016). Although the bowhead whale population is recovering, the species is currently listed as endangered under the ESA and depleted by the MMPA (Allen and Angliss 2014).

Occurrence in the Action Area: Generally, bowhead whales are considered unlikely to be present in Foggy Island Bay nearshore of the barrier islands (BOEM 2017). For this reason, behavioral observations are largely absent given that the whales use the areas outside the barrier islands that are not within the

proposed Action Area. In 1997, aerial surveys flown by BPXA near the proposed Action Area showed that the primary fall migration route of bowhead whales was offshore of barrier islands, not within the Action Area; however, a few bowheads were observed in lagoon entrances between the barrier islands and in the lagoons immediately inside the barrier islands (BPXA 1998).

From 1979-2016, the Aerial Surveys for Arctic Marine Mammals (ASAMM) funded by BOEM and conducted by NOAA occurred annually in the summer and fall in the western Beaufort Sea. ASAMM surveys have found that most bowhead whales occur offshore, although in the past few years some animals have been observed in nearshore areas though still seaward of barrier islands outside of Foggy Island Bay *(Clarke et al.* 2013a and b; 2014; 2015). Few bowheads have been observed near the Action Area during ASAMM surveys since they began. There is some concern that this may be a result of effort-related bias in that ASAMM surveys through 2014 generally did not occur inside of the barrier islands. However, other aerial surveys, ice-based observations, passive acoustic monitoring, and satellite telemetry also support the absence of bowhead whales inside of the barrier islands and in the Action Area.

More recently the ASAMM surveys were extended into Foggy Island Bay between 146W and 150W during 2016 and 2017 (pers. comm. J. Clarke [Leidos] ASAMM Project Lead, December 18, 2017). The 2016 survey resulted in 494 km of transect lines in Block 1a flown. Sightings were limited to six small unidentified pinnipeds (none of which were seen on transect) and 18 polar bears (not including polar bears observed on or in the immediate vicinity of Cross Island). The pinnipeds were seen very close to shore in and just east of Foggy Island Bay. There were no bowhead whales observed in the Action Area, or anywhere within Foggy Island Bay during the 2016 surveys. Also, in regards to the ASAMM surveys since ~ 2009, if whales had been observed inside the barrier islands, it is highly likely that the survey transect lines would have been expanded (pers. comm., M. Ferguson, NMFS, December 15, 2017).

Using all data available, Clarke *et al*. (2015) identified three biologically important areas (BIAs) for bowhead feeding in the U.S. Arctic region: a) Barrow Canyon in May; b) Smith Bay to Point Barrow, generally shoreward of the 20-m isobaths from August to October; and c) the western Beaufort continental shelf, out to approximately the 50-m isobaths from September to October. None of the bowhead feeding BIAs are in the Action Area or even in waters as shallow as the Action Area. Historically, very few bowhead whales have been recorded during the summer season close to shore (Smultea *et al.* 2014) and waters less than 15 ft (4. 5 m) deep are considered too shallow to support these whales. Over three decades of aerial surveys by BOEM, no bowhead whale was recorded in waters less than 16 ft (5 m) deep (Clarke and Ferguson 2010).

A number of activities other than the ASAMM surveys have occurred within Foggy Island Bay that required the issuance of ITAs under the MMPA and subsequent mitigation measures necessitating the use of Protected Species Observers (PSOs). The documentation from surveys have also provided information on the species and abundance of marine mammals likely to be observed in and near Foggy Island Bay and the immediate Action Area.

Aerial surveys occurred near the proposed LDPI in 1997 (BPXA 1998) showing that the primary fall migration route was offshore of the barrier islands outside the development area. No bowheads were seen in the Action Area; however, a few bowheads were observed in lagoon entrances between the barrier islands and in the lagoons immediately inside the barrier islands (BPXA1998). Because survey coverage in the nearshore areas was more intensive than in offshore areas the importance of nearshore areas relative

to offshore areas for bowhead whales was likely overestimated. Even so, only a small number of bowheads came within 6 mi (10 km) of the LDPI area (summarized in BOEM 2017). Based on available data, there is relatively high confidence that waters inside the barrier islands are not bowhead whale habitat.

Acoustic monitoring of the fall bowhead whale migration offshore of Northstar has occurred since 2000 (Kim and Richardson 2016). From 2001 – 2004, ten Directional Autonomous Seafloor Acoustic Recorder (DASARs) were used to estimate the distribution of calling bowhead whales in response to industrial sounds produced by Northstar activities. While the array of DASARs has changed in number and location since 2005, the primary objective was to monitor the location, bearing and distribution of whale calls. Table 4-1 shows the whale call detection rate based on the 15-year study at Northstar.

Table 4-1. Year-to-Year Comparison of Bowhead Whale Call Counts Near Northstar

Year	Total calls detected at C/EB	Length of DASAR recording season (days)	Mean # calls detected per day
2001 (EB)	1624	25	65
2002 (EB)	4317	24	180
2003 (EB)	21,726	30	724
2004 (EB)	26,546	27	989
2005 (EB)	951	29	33
2006 (EBa)	331	18	18
2007 (EBa)	9076	36	250
2008 (C)	39,550	30	1337
2009 (C)	6859	33	205
2010 (C)	340	28	12
2011 (C)	14,440	34	424
2012 (C)	14,246	42	336
2013 (C)	21,994	27	807
2014 (C)	21,634	31	684
2015 (C)	5,167	34	152

Source: Kim and Richardson (2016)
Note: EB and C refer to recording locations.

Acoustic recorders were deployed at Northstar in 2015 at locations where similar recorders had been deployed during all autumn migration seasons since 2001. Site C/EB is located about 9 mi (15 km) offshore, northeast of Northstar in water approximately 75 ft (23 m) deep. The 2015 bowhead call detection rate at site C/EB averaged 152 calls/day and was the fifth lowest in the study's 15 years. However, the periods of peak daily call detection in 2015 were consistent with previous years in terms of seasonal timing despite relatively low call numbers. This was the case, even compared to the largest peak of call counts around the third week of September in 2003, 2004, 2008, and 2012. In 2015, encroaching ice around Northstar forced early retrieval of the DASARs on September 22nd, when larger peaks might possibly have occurred. Kim and Richardson (2016) reported that unidentified impulsive transient sounds similar to "pop" sounds were recorded in 2008, 2009, and 2013-2015 and likely originated in the northeast corner of Northstar Island. These "pop" sounds were only recorded by the near-island DASARs and not by offshore DASARs (i.e., site C/EB). Whether these unidentified types of sounds result in

behavioral effects on marine mammals nearby has not been studied. In 2013, 2014 and 2015, the nearshore DASAR also detected some unidentified that were detected in 2008 and 2009 (Kim and Richardson 2016).

From July 8, 2008 through August 25, 2008, BPXA conducted a 3D seismic survey in the Liberty Prospect, Beaufort Sea. During the August survey a mixed-species group of whales was observed in one sighting near the barrier islands that included bowhead whales (Aerts *et al.* 2008). No other project specific surveys have recorded bowhead whales in the Foggy Island Bay region. During 2008 and 2010 aerial surveys were conducted from early July through early October as part of oil and gas operations in Harrison and Prudhoe bays (west of the Action Area). Only a few bowheads were observed prior to mid-August, and none of these whales were observed close to shore (Christie *et al.* 2010; Brandon *et al.* 2011). Bowhead whales were more commonly observed later in the season at distances of more than 15 mi (24 km) from shore.

During the 2013 ASAMM aerial surveys, more bowhead whales were observed in nearshore shelf waters (but still outside the barrier islands) than would be expected based on historical data for areas surveyed (Clarke *et al.* 2014). However, bowhead whale sightings did not occur approaching the barrier islands or in Foggy Island Bay.

During the 2014 open water season, BPXA conducted a two-dimensional (2D) high-resolution (HR) shallow geohazard survey followed by seabed sonar mapping surveys in the Proposed Action Area (summarized in BOEM 2017). In association with this operation, marine mammal monitoring surveys were conducted. The surveys began on July 16 and were completed by August 30, 2014. During that time, no bowheads were seen in the proposed Action Area (Smultea *et al.* 2014). However, bowhead whales were observed during the 2014 ASAMM surveys near the proposed Action Area seaward of barrier islands on four days during the BPXA surveys: 20 July, 2, 6, and 17 August (Smultea *et al.* 2014). Again, bowhead whales have been observed outside the barrier islands during most years but not inside in the proposed Action Area.

BPXA also conducted a marine mammal monitoring survey during their three-dimensional (3D) ocean bottom sensor seismic operations in the North Prudhoe Bay area during the 2014 open-water season (beginning July to mid-September). The survey location was in the U.S. Beaufort Sea approximately 30 miles (48 km) west of the proposed Action Area. No bowheads were seen during the survey (Lomac-MacNair *et al.* 2015). However, bowheads were observed during the 2014 ASAMM surveys in the region further from the BPXA survey area (Clarke *et al.* 2015).

In 2015, Hilcorp conducted a marine mammal monitoring survey during their shallow geohazard and strudel scour survey operations in the Proposed Action Area in Foggy Island Bay during the open water season. Observations for marine mammals were conducted July 9 through July 19, 2015. No observations of bowhead whales were made in Foggy Island Bay during the survey (Cate *et al.* 2015).

Other, non-industry reports of whales in areas, have come from traditional knowledge reports during past several decades from subsistence hunters. Whalers from Nuiqsut, operating out of Cross Island about 18 miles northwest of LDPI, have observed whales near the barrier islands during scouting efforts, but rarely inside of the islands near the LDPI (exact locations of historical records are largely absent). In an

interview for the University of Alaska Fairbanks Oral History Program[7], Vincent Nageak notes that bowhead whales would travel eastward passing Cross Island on the seaward side. Recent landings have been reported north and west of the barrier islands (see Figure 3.3.3-4, BOEM 2017), considerably outside of proposed Action Area.

In summary, there have been few bowhead whales documented near the proposed Action Area given the barrier islands separate Foggy Island Bay from the offshore areas of the Beaufort Sea (BOEM 2017). In addition, the shallow water depths between the barrier islands and the shoreline, especially around the Proposed Action Area, would likely preclude bowhead feeding. Based on available data, bowhead whale occurrence in Foggy Island Bay is considered very limited and whales are not expected to be found within the proposed Action Area (BOEM 2017).

4.1.2. Gray Whales

There are currently two populations of gray whales in the North Pacific Ocean: the eastern North Pacific population, which lives along the west coast of North-America, and the western North Pacific population, which is believed to occur mainly along the coast of eastern Asia (Rice *et al.* 1984, Swartz *et al*. 2006) and spends the summer months near Sakhalin Island, Russia (Maminov and Blokhin 2004, Nambu *et al.* 2010, Berzin *et al.* 1990, Weller *et al.* 1999, Cooke *et al.* 2008).

Distribution: The eastern North Pacific population annually migrates from warm water wintering lagoons in coastal Baja California and Mexico to summer foraging areas in the Bering and Chukchi seas off northern Alaska and Russia (Pike 1962, Rice and Wolman 1971, Bogoslovskaya *et al*. 1981). In northern Alaska, they forage primarily between Cape Lisburne and Point Barrow, most often in shallow coastal habitats (Moore *et al.* 2000). Most gray whales in the eastern North Pacific population forage from late May to early October in the Chukchi, Beaufort, and northwestern Bering seas (Rice 1998, Moore *et al.* 2003) then move to their breeding and calving areas in Baja California and Mexico (Rice and Wolman 1971, Rice *et al.* 1981, Allen and Angliss 2015). Typically, gray whales inhabit shallow water, remaining closer to shore than any other large cetacean throughout the year; they are considered common summer residents in the nearshore waters of the western Beaufort Sea. However, gray whale calls have been recorded throughout the winter in the Beaufort Sea near Barrow, Alaska, suggesting that some gray whales remain in Arctic waters during the winter months (Stafford *et al.* 2007).

Gray whale observations are recorded and reported in The Bowhead Whale Aerial Survey Project (BWASP)/ASAMM aerial surveys (https://www.afsc.noaa.gov/nmml/cetacean/bwasp/). Several gray whale observations were reported during both vessel-based and aerial surveys in the Beaufort Sea in 2006 and 2007 (Jankowski *et al.* 2009; Lyons *et al.* 2009).

Abundance: Though populations have fluctuated greatly, the eastern North Pacific gray whale stock has significantly recovered from the effects of commercial whaling, and was delisted from the ESA in 1994. Rugh *et al.* (2005) estimated the 1997 gray whale population at 29,758 ± 3,122. A decline was detected in winter 2001-2002, and the population was estimated at 18,178 ± 1,780. The most current population estimate of 19,126 for the eastern North Pacific gray whale stock is taken from the 2006/2007 southbound survey is (Laake *et al.* 2012).

[7] http://jukebox.uaf.edu/site7/interviews/2237

Status: NMFS does not consider the eastern Pacific stock of gray whales to be endangered or to be a strategic stock.

Occurrence in Action Area:

Historically, few gray whales have been observed in the Beaufort Sea east of Point Barrow. Hunters at Cross Island (near Prudhoe Bay) took a single gray whale in 1933 (Maher 1960). During the extensive BWASP aerial survey program, only one gray whale was sighted in the central Alaskan Beaufort Sea from 1979 to 2007 (BPXA 2009). Gray whales were mostly observed in waters around Point Barrow. Small numbers of gray whales were observed on several occasions in the central Alaskan Beaufort Sea: in the Harrison Bay area (Treacy 2000); in the Camden Bay area (Christie *et al.* 2010); and one single sighting near the Northstar Production Island (Williams and Coltrane 2002). Several single gray whales have been observed farther to the east in the Canadian Beaufort Sea (Rugh and Fraker 1981), indicating that small numbers of whales travel through the Alaskan Beaufort Sea during some summers, passing by Foggy Island Bay. From July 8, 2008 through August 25, 2008, an estimated 16 cetaceans and 13 pinnipeds were seen in 4 and 13 sightings, respectively, from two seismic source vessels in the bay (see Section 4.1.1; Aerts *et al.* 2008). One of the cetacean sighting consisted of eight individuals of two different species: bowhead and gray whales.

During the 2014 open water season, BPXA conducted a two-dimensional (2D) high-resolution (HR) shallow geohazard survey followed by seabed sonar mapping survey in the proposed Action Area. In association with this operation, marine mammal monitoring surveys were conducted. The surveys began on 16 July and were completed by 30 August 2014. No gray whales were seen in the survey area (Smultea *et al*. 2014).

BPXA also conducted a marine mammal monitoring survey during their three-dimensional (3D) ocean bottom sensor seismic operations in the North Prudhoe Bay area during the 2014 open-water season (beginning July to mid-September). The survey location was in the U.S Beaufort Sea approximately 30 miles (48 km) west of the proposed Action Area. No gray whales were seen during the survey (Lomac-MacNair *et al*. 2015).

In 2015, Hilcorp conducted a marine mammal monitoring survey during their shallow geohazard and strudel scour survey operations in the proposed Action Area in Foggy Island Bay during the open water season. Observations for marine mammals were conducted July 9 through July 19, 2015. No observations of gray whales were made in Foggy Island Bay during the survey (Cate *et al.* 2015).

In 2016, two gray whales were seen during the ASAMM surveys both west of Cross Island (J. Clarke, email October 2016). Cross Island is 18 mi (29 km) northwest of the LDPI in the proposed Action Area.

Given the infrequent occurrence of gray whales in the Beaufort Sea in summer, the probability of encountering gray whales in the Project Area is low. No gray whales will occur in Foggy Island Bay during the winter and spring periods, and sightings during summer and fall are infrequent to rare therefore proposed activities at the LDPI should not impact gray whales.

4.1.3. Beluga Whales

Five beluga whale stocks are present in Alaska including the Cook Inlet, Bristol Bay, eastern Bering Sea, eastern Chukchi Sea, and Beaufort Sea stocks (O'Corry-Crowe *et al.* 1997, Allen and Angliss 2015). Both

the eastern Chukchi and Beaufort Sea stocks are thought to overlap in the Beaufort Sea, but most individuals that could be observed in the Project Area are likely from the Beaufort Sea stock.

O'Corry Crowe *et al.* 2018 studied genetic marker sets in 1,647 beluga whales. The data set covered over 20 years and encompassed all of the whales' major coastal summering regions in the Pacific Ocean. The genetic marker analysis of the migrating whales revealed that while both the wintering and summering areas of the eastern Chukchi Sea and eastern Beaufort Sea subpopulations may overlap, the timing of spring migration differs such that the whales hunted at coastal sites in Chukotka, the Bering Strait (i.e., Diomede), and northwest Alaska (i.e., Point Hope) in the spring and off of Alaska's Beaufort Sea coast in summer were predominantly from the eastern Beaufort Sea population (Figure 5 of the paper). Earlier genetic investigations and recent telemetry studies show that the spring migration of eastern Beaufort whales occurs earlier and through denser sea ice than eastern Chukchi Sea belugas. The discovery that a few individual whales found at some of these spring locations had higher likelihood of having eastern Chukchi Sea ancestry or being of mixed-ancestry, indicates that the Bering Strait region is also an area where the stocks mix in spring. Citta *et al.* (2016 as referenced in O'Corry-Crowe *et al.* 2018) also observed that tagged eastern Beaufort Sea whales migrated north in spring through the Bering Strait, earlier than the eastern Chukchi belugas, so they had to pass through the Chukchi primary wintering area. Therefore, the eastern Chukchi stock is not expected to be present in the action area at any time in general, but especially during summer or fall, when beluga exposures would be anticipated for this project. All beluga takes described in Section 6 are assumed to be from Beaufort Sea stock.

Distribution: The general distribution pattern for beluga whales shows major seasonal changes (Davis and Evans 1982). During the winter, they occur in offshore waters associated with pack ice. Both the eastern Chukchi and Beaufort Sea stocks winter in the Bering Sea (Suydam *et al.* 2010) Allen and Angliss 2015). In the spring, individuals from the Beaufort Sea stock migrate to warmer coastal estuaries, bays, and rivers where they molt, and give birth to and care for their calves (Allen and Angliss 2015). Seaman *et al*. (1985) noted that in spring, the Beaufort and Chukchi sea stocks use open leads in the sea ice to migrate from their wintering grounds in the Bering Sea, moving north to their respective summer grounds in the Beaufort and Chukchi seas.

Most animals of the Beaufort Sea stock migrate to the Mackenzie River estuary in the Canadian Beaufort Sea arriving in April or May, with some animals arriving as early as March or as late as July (Seaman and Burns 1981; Braham and Krogman 1977; Marquette 1976, 1977, and 1979; Frost *et al.* 1983a). They typically remain in the estuary during July and August to molt, feed, and calve. Later in the summer, the whales spread out, foraging in waters of the eastern Beaufort Sea, Amundsen Gulf, and other northern waters (Davis and Evans 1982, Seaman and Burns 1981).

Early in the summer, belugas from the eastern Chukchi Sea stock remain in coastal areas or shallow lagoons such as Kasegaluk Lagoon (Frost and Lowry 1990, Frost *et al.* 1993). After about mid-July, they move offshore to forage in the ice-packed deeper waters along and beyond the continental shelf. Five of 23 belugas fitted with satellite tags in Kasegaluk Lagoon (captured in late June and early July 1998-2002) were tracked north into the Arctic Ocean, venturing into 90 percent pack ice at 79-80°N latitude (Suydam *et al.* 2005). This suggests that a significant proportion of the eastern Chukchi Sea population may be found at these high latitudes during the mid- to late-summer period. In the fall, the Chukchi and Beaufort Sea stocks both return to their wintering grounds in the Bering Sea (Kleinenberg *et al.* 1964).

Belugas are often seen migrating in large groups (Braham *et al.* 1977), that likely consist of smaller, permanent social units, such as nursing groups or family units (Brodie 1989). Belugas feed on a variety of fish and invertebrates; their diet varies by season and location (Burns and Seaman 1985). In the summer, belugas feed on a variety of schooling and anadromous fish, particularly Arctic cod. Most foraging takes place over the continental shelf and in nearshore estuaries and river-mouths (Brooks 1954, 1955, 1956, 1957; Lensink 1961; Frost *et al.* 1983b; Lowry *et al.* 1985). Offshore habitats are not extensively utilized during the summer, but they may be utilized during autumn. These changes in habitat use by the whales correspond with the sharp decrease in abundance of anadromous fish in coastal waters during autumn (Seaman *et al.* 1985).

Abundance: The most recent population estimate for the Beaufort Sea beluga whale stock is 39,258 individuals; the eastern Chukchi Sea stock is estimated at 3,710 (Allen and Angliss 2014). The current population trend of the Beaufort Sea stock of beluga whales is stable or increasing (Allen and Angliss 2014).

Status: Beluga whale stocks that inhabit the Arctic are neither listed under the ESA nor considered depleted or strategic under the MMPA.

Occurrence in Action Area: Beluga whales typically migrate in deep offshore waters along the ice edge north of the Alaskan coast (Seaman and Burns 1981, Burns and Seaman 1985) in the central and eastern Beaufort Sea. Burns and Seaman (1985) suggest that beluga whales are strongly associated with the ice fringe and that the route of the autumn migration may be mainly determined by location of the drift ice margin. Relatively few beluga whales have been observed in the nearshore areas (on the continental shelf outside of the barrier islands) of Prudhoe Bay. However, groups of belugas have been detected nearshore in September (Clarke *et al.* 2011a) and opportunistic sightings have been recorded from Northstar Island and Endicott. These sightings are part of the fall migration which generally occurs farther offshore although a few sightings of a few individuals do occur closer to the shore, and occasionally inside the barrier islands of Foggy Island Bay. Behavior inside the islands is not well documented. However, the major foraging areas are east and west of Foggy Island Bay at mouths of rivers but belugas are opportunistic feedings and therefore could be picking up limited prey along their migratory path. Based on sightings it is not believed that beluga whales spend a long period of time inside of Foggy Island Bay during migrations.

During the 2008 seismic survey in Foggy Island Bay, three sightings of eight individuals were observed at a location about 3 mi (4.8 km) east of the Endicott Satellite Drilling Island (Aerts *et al.* 2008). Historically, no belugas have been observed in the proposed Action Area during ASAMM surveys; most belugas are observed along the continental shelf. This may be, at least in part, because the transect pattern flown during these surveys is offshore outside the barrier islands. Reports from the ASAMM aerial surveys during 2013 recorded a greater number of belugas nearshore than had been historically recorded (Clarke *et al.* 2014). Belugas have also been seen immediately north of the proposed Action Area near the barrier islands during the ASAMM surveys (Clarke *et al.* 2015) and are occasionally encountered within the barrier islands. The ASAMM surveys were extended into Foggy Island Bay during 2016 and 2017. No beluga whales were observed inside the barrier islands during 2016; however due to their size it is possible some were missed during these surveys. Results of the 2017 surveys are

being compiled at this time (pers. comm., J. Clarke [Leidos], ASAMM Project Lead, December 15, 2017).

Small numbers of belugas may move closer to shore as they migrate westward (Miller *et al.* 1997), and are occasionally seen inside of the barrier islands of Foggy Island Bay as indicated during surveys in 2014 and 2015. However, the number of belugas that enter the bay is still considered exceedingly small especially when considering the large number of whales that migrate past Foggy Island Bay each fall.

In 2014, during a BPXA 2D HR shallow geohazard survey in July and August, monitoring for marine mammals (Smultea *et al*. 2014) recorded eight groups of approximately 19 individual beluga whales, five of which were juveniles, were seen in the area. It is believed that the animals observed in 2014 remained within the area for a week (Smultea *et al*. 2014). In 2014, there were 2,638 mi (4,245 km) of PSO effort during the marine mammal monitoring and mitigation program conducted over July and August, resulting in a sighting rate of 0.004 whales per km surveyed, and PSOs could reportedly detect belugas as far as 1.2 mi (2,000 m) from the vessel (Smultea *et al*. 2014).

During the following summer of 2015, Cate et al. 2015 also observed belugas in Foggy Island Bay near the Liberty Project site. During the open water season July 9 through July 19, 2015, shallow geohazard and strudel scour survey operations in the proposed Action Area. Monitoring surveys recorded 27 marine mammal encounters of 30 individual animals over a period of two days. Of these sightings, five were beluga whales and the rest were pinnipeds although it was thought that the same beluga was seen on multiple occasions (Cate *et al*. 2015). Also in 2015, acoustic monitoring was conducted in Foggy Island Bay between July 6 and September 22, 2015, to characterize ambient sound conditions and to determine the acoustic occurrence of marine mammals near Hilcorp's Liberty prospect in Foggy Island Bay (Frouin-Jouy *et al*. 2015). Two recorders collected underwater sound data before, during, and after Hilcorp's 2015 geohazard survey (July 6-Sept. 22). Detected marine mammal vocalizations included those from beluga whales and pinnipeds. Belugas were detected on five days by passive-recorders inside the bay during the three-month survey period (Frouin-Jouy *et al.* 2015).

Using all data available from aerial surveys, ice-based observations, passive acoustic monitoring, and satellite telemetry, Clarke *et al.* (2015) evaluated Biologically Important Areas (BIAs) for belugas in the Arctic region and identified three. Both the spring (April-May) and fall (September-October) migratory corridor BIAs for belugas are far north of the proposed Action Area because sightings of belugas from aerial surveys in the western Beaufort Sea are primarily on the continental slope, with relatively few sightings on the shelf (Clarke *et al.* 2015). This supports findings of Frost *et al.* (1988); Hazard (1988); and Clarke *et al.* (1993). The main fall migration corridor for beluga whales is believed to be ~62 mi (100 km) north of the Project Area (Richard *et al.* 1997, 2001). Clarke *et al.* (2015) also identified one combined BIA for belugas important for both reproduction and feeding; between Cape Lisburne and Icy Cape in the Chukchi Sea. No reproductive and feeding BIAs were identified in the Beaufort Sea for belugas.

Based on these available datasets discussed above, beluga whales do occur in the Action Area but in a limited number of groups and in small numbers. No belugas are expected in or near the Action Area during winter and spring (that is, during the ice-covered season) and, based on available information, a small number of belugas can be expected in nearshore waters and inside the barrier islands during the summer and fall (BOEM 2017).

4.2. Pinnipeds

The most common seal species in the Beaufort Sea are the bearded seal (*Erignathus barbatus*), ringed seal (*Phoca hispida*), and spotted seal (*P. largha*) (Frouin-Mouy *et al.* 2015).

4.2.1. Bearded Seals

Bearded seals have a circumpolar distribution throughout the Arctic. They occur over the continental shelf waters of the Bering, Chukchi, and Beaufort seas (Burns 1981). Bearded seals are closely associated with sea ice, and specifically with pack ice during their breeding, whelping, nursing, molting and resting periods. Seasonal movements and distribution of bearded seals are linked to seasonal changes in ice conditions.

Bearded seals generally move north in late-spring and summer as the ice edge melts and retreats; seals then move south in the fall as sea ice forms to remain associated with their preferred ice habitat (Johnson *et al.* 1966, Burns 1967, Fay 1974, Burns and Frost 1979, Burns 1981, Simpkins *et al.* 2003, Frost *et al.* 2008). They winter in the Bering Sea along the ice front, but as the ice recedes in the spring, bearded seals migrate from their winter grounds in the Bering Sea north through the Bering Strait (mid-April to June) to areas along the margin of the multi-year ice in the Chukchi Sea or to nearshore areas of the central and western Beaufort Sea (Allen and Angliss 2015).

Pupping occurs on top of the ice from late-March through May, primarily in the Bering and Chukchi seas. Some pupping occurs on moving pack ice in the Beaufort Sea. Bearded seals do not form herds, but loose aggregations of animals may occur. Spring surveys along the Alaskan coast indicate that bearded seals prefer areas of 70 to 90 percent sea ice cover, and are typically more abundant 20 to100 nautical miles (nmi) (37 to 85 km) from shore than within 20 nmi of shore. However, high concentrations of bearded seals have been observed nearer to shore in areas to the south of Kivalina (Bengtson *et al.* 2005; Simpkins *et al.* 2003). Studies indicate that bearded seals generally prefer areas of water that are less than about 200 ft (61 m) deep along the continental shelf (Stirling *et al.* 1977; 1982).

During summer bearded seals are present in both the Chukchi Sea and, to a lesser extent the Beaufort Sea in high ice coverage areas along the pack ice edge (Burns 1981, Simpkins *et al*. 2003, Bengston *et al*. 2005, Allen and Angliss 2015). As the ice re-forms in the fall and winter, most seals move south following the advancing ice edge through the Bering Strait and into the Bering Sea, where they overwinter (Burns and Frost 1979; Frost *et al.* 2005, 2008; Cameron and Boveng 2007, 2009). This southward migration is less noticeable and less predictable than the northward movements in late spring and early summer (Burns 1981; Kelly 1988). Some bearded seals may overwinter in the Chukchi and Beaufort seas.

<u>*Abundance*</u>: There is no reliable estimate of bearded seal abundance in Alaskan waters (Allen and Angliss 2014, Cameron *et al.* 2010) but research programs have recently developed new survey methods and partial, but useful, abundance estimates. Aerial surveys of the eastern Beaufort Sea conducted in June during 1974–1979 resulted in an average estimate of 2,100 individuals uncorrected for animals in the water (Stirling *et al*. 1982). Because the survey area covered roughly half of the ice-covered continental shelf of the western Beaufort Sea, the actual estimated number of bearded seals in the Beaufort Sea is thought to be 1.5 times greater or ~3,150 animals(Cameron *et al.* 2010).

In spring of 2012 and 2013, U.S. and Russian researchers conducted aerial abundance and distribution surveys of the entire Bering Sea and Sea of Okhotsk (Moreland *et al.* 2013). The data from these image-based surveys are still being analyzed, but Conn *et al.* (2014), using a very limited sub-sample of the data collected from the U.S. portion of the Bering Sea in 2012, calculated an abundance estimate of approximately 299,174 (95 percent CI: 245,476-360,544) bearded seals in those waters. These data do not include bearded seals in the Chukchi and Beaufort seas. However, using the 2012 Bering Sea abundance estimate by Conn *et al.* (2014) Muto *et al*. (2016) provided a partial N_{min} of 273,676 bearded seals in the U.S. sector of the Bering Sea.

Status: NMFS listed the Alaska stock, which are part of the Beringia DPS, as threatened under the ESA, effective 26 February 2013[8]. The ruling was vacated by a U.S. District Court, District of Alaska, in 2014[9] and re-instated by the U.S. Court of Appeals for the Ninth Circuit on October 24, 2016[10]. On January 22, 2018, the Supreme Court rejected the appeal of the bearded seal listing, thus the species remains listed as threatened under the ESA.

Occurrence in Action Area: Bearded seals are associated with pack ice, and only rarely using shorefast ice (Burns and Harbo 1972). Therefore, during the summer months when the Bering Sea is ice-free, the most favorable bearded seal habitat is found in the central or northern Chukchi Sea along the margin of the pack ice. Also, in Alaskan waters, bearded seals occur over the continental shelves of the Bering, Chukchi, and Beaufort seas where they feed on benthic prey (Burns 1981; Kelly 1988). In winter, most bearded seals in Alaska occur in the Bering Sea, though smaller numbers of year-round residents remaining in the Beaufort and Chukchi Seas, mostly around lead systems, and polynyas (BOEM 2017). Suitable habitat is more limited in the Beaufort Sea where the continental shelf is narrower and the pack ice edge frequently occurs seaward of the shelf and over water too deep for seals to forage. Their preferred habitat in the western and central Beaufort Sea during the open water period is the continental shelf seaward of the scour zone. Consequently, there are believed to be fewer bearded seals in the Beaufort Sea and near the proposed Action Area than in the Chukchi or Bering Seas since benthic habitat is limited in the Beaufort Sea. Because of the extensive shelf size in the Chukchi Sea, the summer distribution of bearded seals in the Chukchi Sea remains large, and conversely, the narrow shelf in the Beaufort Sea supports fewer bearded seals leading to a smaller resident population of bearded seals in the Beaufort Sea. Water depths at the Liberty Site are approximately 19 ft (6 m) deep and the sea floor is often scoured clean of benthic organisms nearer to shore and away from boulder patches. Moreover, the proposed action is surrounded by shorefast ice throughout the winter and early spring, and positioned several kilometers south of any lead systems making it unusable as winter habitat for bearded seals. Still, bearded seals have been observed in the Project Area in Foggy Island Bay. They are considered

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[9] On July 25, 2014, an Alaska federal court vacated a NMFS rule declaring a DPS of bearded seals as "threatened" under the ESA, saying the listing was based upon speculation and that NMFS has failed to show that the Beringia DPS of Alaska's bearded seals faced a significant threat of extinction prior to 2090, and even the data supporting a threat at that point is speculative. As such, he deemed the NMFS categorization arbitrary and capricious, remanding the rule back to the agency.

[10] The "Opinion", U.S. Court of Appeals for the Ninth Circuit, Case No. 14–35811, D.C. No. 4:13-cv-00018-RRB; Alaska Oil and Gas Association, American Petroleum Institute, State of Alaska, North Slope Borough, Inupiat community of Arctic Slope, Northwest Arctic Borough, Arctic Slope Regional Corporation, NANA Regional Corporation, Inc. vs. the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Filed October 24, 2016. 30 pp.

opportunistic feeders whose diet varies with age, location, season, and changes in prey availability (Kelly 1988) and to some extent must be foraging in the area.

Aerial and vessel-based surveys associated with seismic programs, barging, and government surveys in this area between 2005 and 2010 reported several sightings (Green and Negri 2005, 2006; Green *et al.* 2007; Funk *et al.* 2008; Hauser *et al.* 2008; Savarese *et al*. 2010; Brandon *et al.* 2011; Clarke *et al.* 2011a). Eight sightings of bearded seals occurred during the 2014 shallow geohazard seismic and seabed mapping surveys in July-August 2014 (Smultea *et al.* 2014). Frouin-Jouy *et al.* (2015) also detected pinniped vocalizations on 10 days using nearshore recorders and on 66 days further from shore. Many pinniped detections were unidentified (Frouin-Jouy *et al.* 2015), but bearded seals were the only positively identified pinniped species in the dataset on two of these days.

Studies associated with the Northstar Project indicate that pups and other young bearded seals up to 3 years of age comprise 40 to 45 percent of the population (BPXA 2009), and that younger animals tend to occur closer to shore. Therefore, although all age and sex classes could be encountered, bearded seals encountered in the Northstar Project Area during the open-water period were likely to be young, non-reproductive animals. This is equally likely for the Action Area in Foggy Island Bay.

During the late winter/spring period, the Foggy Island Bay area is covered by landfast ice, which bearded seals tend to avoid because they prefer areas of moving ice and open water in depths of less than 656 ft (200 m) (Burns and Harbo 1972). Therefore, bearded seals are not expected to be encountered in or near the Action Area during winter and spring. Low numbers are anticipated during the open-water season.

4.2.2. Ringed Seals

Ringed seals are circumpolar in distribution; the subspecies (*Phoca hispida hispida*) is present in the Arctic Ocean and Bering Sea. They reside year-round in the Bering, Chukchi, and Beaufort seas off the coast of western and northern Alaska (Frost and Lowry 1981, King 1983, Smith 1987).

Distribution: Ringed seals tend to prefer large ice floes and often inhabit interior pack ice where sea ice covers over 90 percent of the water (Simpkins *et al.* 2003, Kelly *et al.* 2010b). In the Beaufort, Chukchi, and Bering seas ringed seals move seasonally coinciding with ice melting and retreating (Frost and Lowry 1984, Frost 1985, Kelly *et al.* 2010b, Harwood and Stirling 1992). There is increasing concern about the future of the ringed seal due to receding ice conditions and potential habitat loss.

Like the other ice seals, ringed seals are closely associated with sea ice during breeding, pupping, and molting. During the open-water season, ringed seals are widely dispersed as single animals or in small groups, and they are known to move into coastal areas (Smith 1987, Harwood and Stirling 1992, Frost *et al.* 2002). Satellite-tagging data revealed that ringed seals cover large distances between foraging areas and haulout sites during the open-water season (Kelly *et al.* 2010a, Herreman *et al.* 2012). The time that ringed seals spend on haulout sites is much shorter than the time they spend foraging in open water. For example, in July ringed seals spent 70 percent of the time in open water, increasing to greater than 90 percent in August (Kelly *et al.* 2010a). During the winter months, ringed seals occupy landfast ice and offshore pack ice of the Bering, Chukchi and Beaufort seas. In winter and spring, the highest densities of ringed seals are found on stable landfast ice; however, they do not use bottomfast ice closer to shore.

Abundance: The Alaskan stock of ringed seals are the most abundant marine mammals in the Beaufort, Chukchi, and Bering seas (Frost *et al.* 1988; Funk *et al.* 2011; Kelly *et al.* 2010a, b). However, there is currently no complete population estimate available for the entire Alaskan stock (Allen and Angliss 2014). Historic ringed seal population estimates in the area ranged from 1 to 1.5 million seals (Frost 1985) to 3.3 to 3.6 million (Frost *et al.* 1988). Frost and Lowry (1984) estimated 80,000 ringed seals in the Beaufort Sea during summer and 40,000 during winter, indicating that half of the population moves into the Chukchi and Bering seas in winter.

Surveys flown from 1996-1999 found the highest density of seals along the central Beaufort Sea coast in Alaska occurred between Kaktovik and Brownlow Point, possibly due to a productivity of zooplankton which was about four times greater there than in other areas of the eastern Beaufort Sea (Frost *et al.* 2004).

In early summer, the highest densities of ringed seals in the Beaufort Sea are found in nearshore shorefast ice, pack ice (Bengston *et al.* 2005), lead systems, polynyas, and shear zones, based on incidental sightings of seals during aerials surveys for bowhead whales (Monnett and Treacy 2005). During summer, ringed seals are found dispersed throughout open-water areas, though in some regions they move to coastal areas (Smith 1987; Harwood and Stirling 1992). In late summer and early fall, ringed seals often aggregate in open-water areas where primary productivity is thought to be high (Harwood and Stirling 1992).

The construction site for the Proposed Action lies well inside the shorefast ice zone, far from the edge of the shorefast ice, and in water depths of about 19 ft (6 m), indicating the location would be a very poor choice of winter habitat for ringed seals. Therefore, it is highly unlikely many, if any, ringed seals would be occur in the immediate vicinity of the Proposed Action during winter and early spring.

Because this area is often ice free during the summer, there is a strong likelihood some ringed seals would frequent the Proposed Action Area during the ice free period as food resources permit.

Status: NMFS listed the Arctic subspecies of ringed seals and the Beringia DPS of bearded seals as threatened under the ESA and depleted under the MMPA (NMFS 2012b), effective 26 February 2013[11]. In two separate decisions, the U.S. District Court for the District of Alaska vacated the Beringia DPS bearded seal listing and the Arctic subspecies of ringed seal listing (Alaska Oil and Gas Association v. Pritzker, Case No. 4:13-cv-00018-RPB; Alaska Oil and Gas Association v. NMFS, Case No. 4:14-cv-00029-RRB). NMFS appealed both decisions to the Ninth Circuit. On October 24, 2016, the Ninth Circuit reversed the district court's decision with regard to the bearded seal listing. The plaintiffs have requested rehearing *en banc* by the Ninth Circuit. On February 12, 2018, the 9th Circuit Court of Appeals upheld the listing of ringed seals as threatened under the ESA.

Occurrence in the Action Area: Because ringed seals are resident in the Beaufort Sea, and based on results of previous surveys in Foggy Island Bay (Aerts *et al.* 2008; Funk *et al.* 2008; Savarese *et al.* 2010; Brandon *et al.* 2011, Smultea *et al.* 2014), monitoring from Northstar Island (Aerts and Richardson 2009, 2010), and during aerial surveys flown for bowhead whales (Clarke *et al.* 2011a, 2011b), they are expected to be the most frequently encountered pinniped in the Action Area during any season of the year.

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During winter and spring, ringed seals are expected to be the only pinnipeds encountered near the Project Area within the land-fast ice zone. However, ringed seal behaviors remain poorly understood in Action Area because they spend so much of their time out of sight in their lairs or under the sea ice (reported in BOEM 2017). When submerged under the sea ice ringed seals excavate and maintain several breathing holes throughout the winter to provide air-access while hunting prey species (e.g. Arctic Cod) and to provide escape routes from polar bears and other predators (Frost *et al*. 2002).

A single pup is born in the spring (March-May), with the peak of pupping occurring in early April (Frost and Lowry 1981). Births occur in the lairs (Kelly 1988). These lairs provide thermal protection against cold temperatures, wind chill, and some protection from predators (Smith 1976, 1981; Smith and Stirling, 1975). Shore-fast ice is the best habitat for pupping. Seal mothers move young pups between lairs within their network of lairs (usually 4-6 per female). After a 5-8 week lactation period pups wean (Lydersen and Kovacs 1999; Lydersen and Hammill 1993), then their mothers mate sometime between April and May (Moulton *et al*. 2002b,c). Sometime after breeding activities conclude at about mid-May, ringed seals begin shedding their old pelts in a process known as molting. Molting for ringed seals occurs between mid-May to mid-July, and during this time they remain hauled out on the edge of the pack ice, or on remnant landfast ice until their old pelt dries out and sheds (Reeves 1998). Because of the need for dry skin during the molt, ringed seals refrain from entering the water and forgo foraging activities.

During summer and fall, Aerts *et al.* (2013) analyzed the distribution of marine mammals using data collected in 2008-2010, and found the distribution of seal species was due to food availability. More specifically Aerts *et al.* (2013) noted ringed seals spend 90 percent of their time foraging in the water during the summer and because of a highly flexible diet and high prey mobility, ringed seals lacked a clear distribution pattern. When not whelping, lactating, breeding or molting, ringed seals travel widely though their distribution remains strongly correlated with the presence of sea ice and with food availability (e.g. Simpkins *et al*. 2003; Freitas *et al*. 2008).

Therefore, despite low densities of seals in the Action Area, the entire life-cycle may occur for those individuals found inside the Action Area. Also, despite being the most abundant seal species in the Action Area, the number of expected seal encounters during the proposed Project is low. This is based on seal observation data from recent, similar shallow water surveys in the central Beaufort Sea (Aerts *et al.* 2008; Hauser *et al.* 2008; HDR Inc. 2012; Cate *et al.* 2015).

4.2.3. Spotted Seals

Spotted seals are coastal pinnipeds distributed along the continental shelf of the Bering, Chukchi, and Beaufort Seas, and the Sea of Okhotsk south to the western Sea of Japan and northern Yellow Sea.

Distribution: During spring when pupping, breeding, and molting occur, spotted seals are found along the southern edge of the sea ice in the Okhotsk and Bering seas (Quakenbush 1988, Rugh *et al.* 1997). In late April and early May, adult spotted seals are often observed basking on the ice in female-pup or male-female pairs, or in male-female-pup triads. Subadults may be observed in larger groups of up to two hundred animals. During the summer, spotted seals are found primarily in the Bering and Chukchi seas, but some range into the Beaufort Sea (Rugh *et al.* 1997, Lowry *et al.* 1998). At this time of year, spotted seals haul out on land part of the time, but also spend extended periods at sea. The seals are commonly seen in bays, lagoons and estuaries, but also range to areas far offshore. In summer, spotted seals are

rarely seen on the pack ice, except when the ice is very near to shore. As the ice cover thickens with the onset of winter, spotted seals leave the northern portion of their range and move into the Bering Sea (Lowry *et al.* 1998).

Spotted seals that inhabit the Beaufort Sea belong to the Bering DPS (Allen and Angliss 2015). From late fall through spring, spotted seal habitat use is closely associated with the distribution and characteristics of seasonal sea ice. The ice provides a dry platform away from land predators during the whelping, nursing, breeding, and molting periods (Boveng *et al.* 2009). In the Bering Sea, whelping typically occurs from late March to the end of April with most pups being born during early to mid-April, coinciding with the average period of maximum extent and stability of the seasonal sea ice (Krylov *et al.* 1964; Tikhomirov 1964, 1966; Burns 2002; Burns *et al.* 1981). Adult spotted seals begin molting immediately after breeding (Tikhomirov 1964, Burns 2002).

Herds of spotted seals break up when the usable sea ice disappears in early summer and the animals move toward ice-free coastal waters from Bristol Bay through western Alaska to the Chukchi and Beaufort seas. Unlike other ice seals, they use coastal haulouts for at least part of the summer. When sea ice begins to form in the fall, spotted seals move southward along the ice edge in the Bering Sea (Quakenbush 1988, Lowry *et al.* 1998, Simpkins *et al.* 2003).

Abundance: Spotted seals are most numerous in the Bering and Chukchi seas (Quakenbush 1988), although small numbers do range into the Beaufort Sea during summer (Rugh *et al.* 1997; Lowry et al. 1998). There is no reliable estimate of the size of the Alaskan stock of spotted seals. The most current estimate for the eastern and central Bering Sea is 141,479 animals. This number is derived from aerial surveys conducted by the National Marine Mammal Laboratory (NMML) in 2007 from the United States Coast Guard icebreakers that provided greater access to the central and eastern Bering Sea pack ice (cited in Allen and Angliss 2014).

Status: Because of concerns about changing ice conditions and associated potential habitat loss, NMFS conducted a status review of the spotted seal to determine if listing under the ESA was warranted (Boveng *et al.* 2009). Based on this status review, NMFS determined to not list the Bering Sea DPS of spotted seals under the ESA[12], because they are currently not in danger of extinction or likely to become endangered in the foreseeable future (NMFS 2009, 2013).

Occurrence in the Action Area: A small number of spotted seal haul-outs are (or were) located in the central Beaufort Sea in the deltas of the Colville River and, previously, the Sagavanirktok River. Spotted seals make foraging trips from coastal haulouts lasting about 9 days, followed by a rest period of one to two days (BOEM 2017). Historically, these sites supported as many as 400 to 600 spotted seals, but in the late 1990s numbers were significantly reduced (Johnson *et al.* 1999). In total, there are probably no more 20 to 30 spotted seals along the coast of the central Alaska Beaufort Sea during summer and early fall (BPXA 2009).

No spotted seals were observed or positively identified during the Northstar Project's marine mammal monitoring activities, although a few spotted seals might have been present (BPXA 2009). A total of 12 spotted seals were positively identified near the source-vessel during open-water seismic programs in the

[12] 78 *Federal Register* 41371.

central Alaskan Beaufort Sea, generally occurring near Northstar from 1996 to 2001 (Moulton and Lawson 2002). The number of spotted seals observed per year ranged from zero (in 1998 and 2000) to four (in 1999).

During a seismic survey in Foggy Island Bay, PSOs recorded 18 pinniped sightings, of which one was confirmed as a spotted seal (Aerts *et al.* 2008). Spotted seals were the second most abundant seal species observed by PSOs during Hilcorp's geohazard surveys in July-August 2014 (Smultea *et al.* 2014) and in July 2015 (Cate *et al.* 2015).

Given their seasonal distribution and low numbers in the nearshore waters of the central Alaskan Beaufort Sea, no spotted seals are expected in the Action Area during late winter and spring, and a few individuals could be expected during the summer or fall.

4.3. Uncommon or Extralimital Species

Humpback whales, killer whales, narwhal, harbor porpoises, and ribbon seals could occur in the Beaufort Sea, but are either uncommon or extralimital in the Foggy Island Bay area (Table 3-1). These species are not expected to be encountered during the proposed Project and therefore, takes are not being requested for these species.

Minke whales are relatively common in the Bering and southern Chukchi seas and have recently also been sighted in the northeastern Chukchi Sea (Aerts *et al.* 2013, Clarke *et al*. 2013a, 2014) but are unlikely to be encountered in Foggy Island Bay.

Humpback whales are uncommon in the Arctic Ocean. Subsistence hunters have identified humpback whales in low numbers around Barrow in the past and there have been several confirmed sightings of humpback whales in the northeastern Chukchi Sea in recent years but their occurrence is not regular or frequent (Hashagen *et al.* 2009; Aerts *et al.* 2013; Clarke *et al.* 2013a, 2014; Smultea *et al.* 2004). The first confirmed sighting of a humpback whale in the Beaufort Sea was recorded in August 2007 (Hashagen *et al.* 2009), when a cow and calf were observed 54 mi (87 km) east of Point Barrow. Point Barrow is approximately 218 mi (351 km) from Foggy Island Bay. Since any sighting of a humpback whale is considered extralimital, this species will not be discussed further in this petition, and no takes are being requested.

Killer whales are known to inhabit almost all coastal waters of Alaska, extending from southeast Alaska through the Aleutian Islands to the Bering and Chukchi seas (Allen and Angliss 2014). However, they have been infrequently observed in the Beaufort Sea (Leatherwood *et al.* 1986, Allen and Angliss 2014). Hunters from Barrow and biologists from the North Slope Borough report that a few killer whales are seen each year in the Point Barrow area (George *et al.* 1994). One group of 13 killer whales, including two calves, was seen in August of 2012 approximately 6.2 mi (10 km) northwest of Barrow (Clarke *et al.* 2013a).

Narwhal are common in the waters of northern Canada, west Greenland, and in the European Arctic, but rarely occur in the Beaufort Sea (COSEWIC 2004). Only a handful of sightings have occurred in Alaskan waters (Allen and Angliss 2014). George and Suydam (2009) summarized eight observations of 11-12 individuals by Alaska Native hunters in the Chukchi and Beaufort seas between 1989 and 2008. No

narwhals have been reported during the BWASP/ASAMM surveys conducted in the Beaufort Sea (unpublished data, reported in the Hilcorp 2015b).

Harbor porpoise occur from Point Barrow along the western Alaskan coast, along the Aleutians and throughout southeast Alaska (Allen and Angliss 2014) but are considered extralimital in the Beaufort Sea. Industry-sponsored monitoring between 2006-2010 reported six sightings of 11 harbor porpoises in the Beaufort Sea (Funk *et al.* 2008, 2011).

Ribbon seals are found in the North Pacific Ocean and parts of the Arctic Ocean, most often along the pack ice (Allen and Angliss 2014). Ribbon seals have been sighted in very low numbers in the northeastern Chukchi Sea (Aerts *et al.* 2013, Haley *et al.* 2010). No ribbon seals have been reported as part of the BWASP surveys conducted in the Beaufort Sea or during seismic survey program monitoring, although three animals were reported during a vessel-based marine mammal monitoring program near Prudhoe Bay in 2008 (Savarese *et al*. 2010).

Minke, humpback and fin whales, killer whales, harbor porpoises, and ribbon seals regularly occur in the Chukchi Sea but not in the Beaufort Sea. Narwhals, Steller sea lions, and hooded seals are considered extralimital to the proposed Action Area and will not be discussed in this petition. No takes are requested for any of these species.

5. TYPE OF INCIDENTAL TAKING AUTHORIZATION REQUESTED

Project work has the potential to generate underwater noise that may expose up to six species of marine mammals to Level A and Level B[13] harassment based on noise level criteria (Southall *et al*. 2007). NMFS has implemented a threshold of 120 dB re: 1 microPascal root mean square (rms) for animals exposed to non-impulsive sources as the criterion for when Level B harassment might occur. The activities described in Section 1.3 and summarized in Tables 1-3 and 2-1, have the potential to generate sounds that will be detectable underwater or in air at distances from the area of activity. The distances will depend on the nature of the sound source, ambient noise conditions, and the sensitivity of the receptor. At times, some of these sounds may cause localized avoidance or other reactions by small numbers of marine mammals. The type and significance of behavioral reaction depends on the species and activity of the animal at the time of reception of the stimulus, distance from the sound source, and the level of the sound relative to ambient conditions (Ellison *et al.* 2011).

No injurious or lethal takes have been documented during the intensive monitoring efforts conducted during similar Northstar construction and operations from 2000 to 2009 (BPXA 2009). In consideration of this fact and upon review of the proposed activities and associated monitoring and mitigation measures described in Chapters 11 and 13, Hilcorp does not anticipate that the proposed construction and installation of LDPI in Foggy Island Bay, Beaufort Sea, Alaska, will result in the taking of significant numbers of marine mammals. Although some whales and seals are likely to occur near the proposed activities, these activities are not anticipated to result in any more than negligible consequences for individuals or their populations. Furthermore, there would be no unmitigable adverse impact on the availability of seals or whales for subsistence uses. There was one documented seal mortality in the 1990s associated with a vibroseis program outside the barrier islands east of Bullen Point in the eastern Beaufort Sea (MacLean 1998). However, there have been no other seal mortalities at Northstar which is very similar to the proposed Liberty Development. While construction activities are not anticipated to result in serious injury or mortality of any marine mammals that may be in the Project Area, Hilcorp is requesting two takes for potential ringed seal mortalities over the 5-year period as a precautionary measure. These two takes are requested due to the higher level of activity (i.e., truck traffic) and increased number of ice roads during the construction phase of this Project. Construction activities includes mobilization of materials and equipment support island, pipeline, and facility construction.

To assess the potential effects of underwater and in-air noise on marine mammals, quantitative noise modeling of the proposed Project activities was conducted (SLR 2017). The complete noise report is attached to this request as Appendix A. In the models, sound sources were considered to be point sources, when in fact they are distributed sources. Modeling construction activities as point sources therefore, overstates the maximum sound levels that will occur close to the sound sources.

As described in Section 6 of this request, potential underwater noise exposure was assessed from source levels for proposed Project equipment. The noise assessment indicates that for most construction scenarios (with the exception of pile driving), short-term behavioral responses of marine mammals are not expected to occur outside of the immediate Project Area.

[13] Level A harassment may result in injury, whereas Level B only results in disturbance without the potential for injury.

Noise will be generated from several activities during construction including ice road and island construction (i.e., use of a ditchwitch to cut through ice), impact and vibratory sheet pile driving, impact pipe driving and slope shaping (i.e., use of an excavator at the edge of the island) (see Table 1-3). These are expected to be the dominant underwater sources for the Project. Vibratory sheet pile driving has the potential to generate noise above the marine mammal behavioral harassment threshold at distances of up to approximately 9 mi (14.8 km) from Liberty Island, if this activity occurs in the open water season between July 1 and 15 (see Figure 5 in Appendix A). The noise generated by vibratory pile driving propagates farther in the summer open water season than in the ice-covered season. During construction of Northstar, pile driving was not required during the summer open water season because it was already complete. Therefore, this request assumes that pile driving would occur for up to 4 months under ice-covered conditions and may only require up to 2 weeks (i.e., 15 days) in open water. In addition, slope shaping may be required during the open water season in Year 2 between July 15 and August 31 but is not expected to occur every day during that period. Noise generated during slope shaping would come from the use of an excavator moving gravel along the edge of the island in the water (see Section 1.3.3).

Greene *et al.* (2008) reported that vibratory and impact pile driving created the strongest sounds during Northstar construction in 2000. Further, Greene *et al.* (2008) measured received levels of sound and vibration in the strongest one-third octave band for different construction activities and reported median background levels less than 4.6 mi (7.5 km) away for underwater sounds, less than 1.7 mi (3 km) away for airborne sounds, and less than 6 mi (10 km) away for in-ice vibrations. During winter drilling operations, underwater sounds were reported north of Prudhoe Bay by Malme and Mlawski (1979) and at Northstar by Blackwell *et al.* (2004b). Exploratory drilling sounds reported by Malme and Mlawski (1979) were generally not detectable beyond approximately 1.1 mi (1.8 km) with tonal components of the sound reported at approximately 6.6 mi (10.6 km). Blackwell (2004a, b) concluded that winter drilling sounds from Northstar reached background (ambient) levels at approximately 6 mi (10 km) from the island when ambient sound levels were very low (wind speed less than one meter per second). Distances to ambient levels can vary greatly due to variables such as wind speed and wave action. However, Blackwell (2004a, b) also concluded that if ambient sound levels were closer to the median levels reported during the 2000 study, then the distance to background during drilling would have been halved (i.e., 2.5 – 3.1 mi [4-5 km]).

5.1. Compliance with "Small Numbers" and "Negligible Impact" Requirements of the MMPA

Upon request, Section 101(a) (5)(d) of the MMPA allows the incidental but not intentional taking of small numbers of marine mammals if certain findings are made (16 U.S.C. 1361 et seq.). NMFS authorizes incidental takes under the MMPA if the taking would: 1) be of small numbers; 2) have no more than a negligible impact on those marine mammal species or stocks; and 3) not have an unmitigable adverse impact on the availability of the species or stocks for subsistence uses[14]. The estimate of takes requested relative to these requirements is included in Section 6.5.3 of this application.

[14] See http://www.nmfs.noaa.gov/pr/permits/incidental/

6. ESTIMATES OF POTENTIAL MARINE MAMMAL EXPOSURES

Authorization to take by harassment is requested for six species of marine mammals including three cetacean species (bowhead, gray, and beluga whales) and three species of pinniped (bearded, ringed and spotted seals). This section includes: density estimates for each of these species; noise sources (including under ice, in open water, and in air); and discussion of the potential for PTS or behavioral responses associated with noise.

The estimated number of marine mammals that may be potentially exposed to noises exceeding NMFS' established thresholds was calculated based on marine mammal density estimates and project activities (SMRU 2017). The maximum distance to the Level A and Level B thresholds, and the total area ensonified at that distance, for each marine mammal functional hearing group is presented in detail in Appendix B and summarized here. Marine mammal responses to underwater noise in the LDPI area for the ice-covered and open-water seasons may be markedly different depending on what the animal is doing, time of year (i.e., season) or life-stage of the animal at the time of exposure. For example, a ringed seal exposed to a noise while in a lair during winter may remain in the lair whereas exposure during summer (open water) may result in a different response to the same noise level. In addition, noise attenuation is typically greater in ice conditions compared to open water. Therefore, whether an activity occurs during ice-covered or open water conditions has been taken into account in the exposure estimates. A more detailed description of how exposures were calculated is included in Section 6.5. Appendix B provides the Liberty Project Construction and Production Marine Mammal Acoustic Exposure Estimates used to develop this section of the petition.

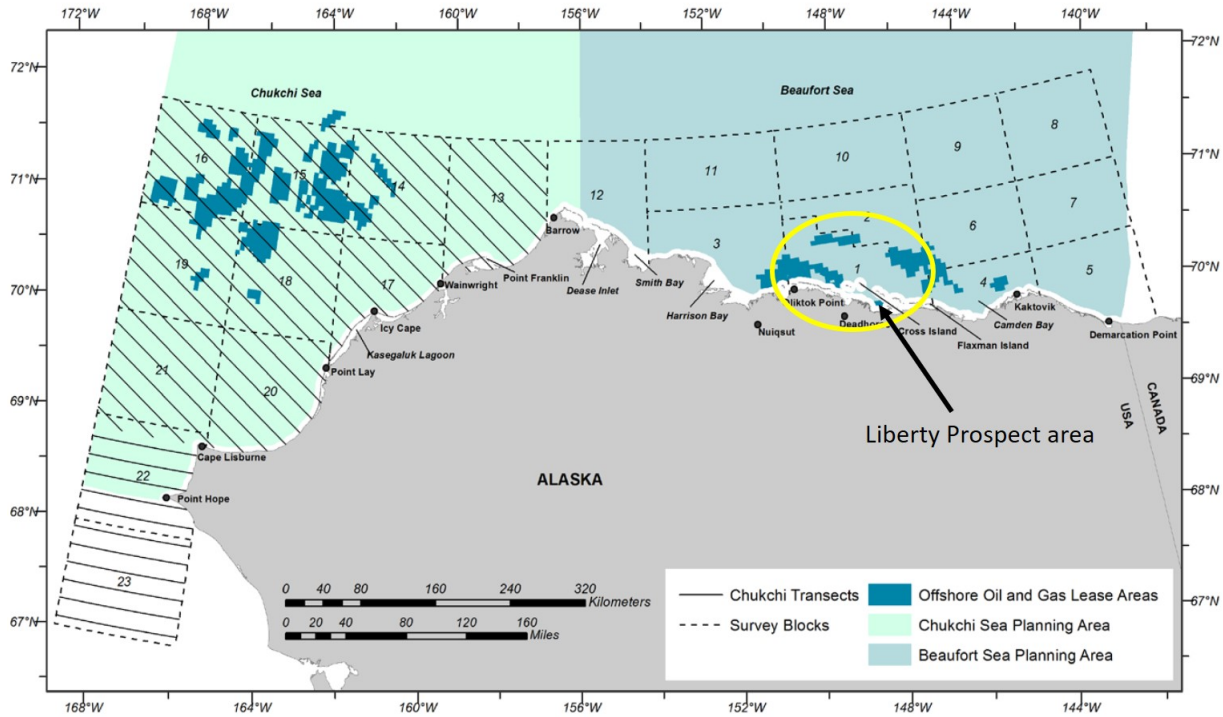
6.1. Marine Mammal Densities

6.1.1. Cetaceans

Extensive aerial surveys for Arctic marine mammals have been flown in the Beaufort Sea since the late 1970s. The BWASP surveys were conducted by BOEM (formerly the Minerals Management Service) during the fall months until 2010. In 2011, there was also one survey in the Beaufort in July under the Chukchi Offshore Monitoring and Drilling Area (COMIDA) surveys. Fall surveys thru October all became part of the ASAMM surveys analyzed in Clarke *et al.* (2011a, b). Therefore, the ASAMM survey program was developed to combine the BWASP and COMIDA surveys. ASAMM surveys are now flown during both summer and fall months.

All ASAMM surveys were conducted in an Aero Commander twin turbo prop aircraft, equipped with bubble windows (Clarke *et al*. 2012, 2013a, 2014, 2015). The ASAMM surveys are conducted within blocks that overlay the Beaufort and Chukchi Seas oil and gas lease sale areas offshore of Alaska (Figure 6-1), and provide sighting data for bowhead, gray, and beluga whales during summer and fall months. Aerial survey data collected prior to 2011 focused on bowhead whales and were only flown during the fall months of September and October. For bowhead and gray whales, survey data collected during the ASAMM aerial surveys in 2011, 2012, 2013, 2014 and 2015 have been considered in these density estimates (Table 6-1). In addition, data from the 2016 and 2017 ASAMM surveys are considered qualitatively in this petition as described in Section 4.1.1. Density estimates for beluga whales were

Figure 6-1. NMFS ASAMM Surveys in the Beaufort and Chukchi Seas Near LDPI



Note: Barrier Islands of Survey Block 1 are highlighted in yellow.
Source: http://www.afsc.noaa.gov/nmml/software/bwasp-comida.php; Clarke *et al.* (2015).

estimated using data available for 2012, 2013 and 2014. The ASAMM surveys provided sightings and effort data by month and season (summer and fall), as well as each survey block and, in some cases by depth strata (Figure 6-1; Clarke *et al.* 2012, 2013a, 2014, 2015).

Table 6-1. Summary of Aerial Survey Effort by Year, Season and Aircraft Type

Year	Seasons	Airplane	Reference
2011	Summer & Fall	Aero Commander	Clarke *et al*. 2012.
2012	Summer & Fall	Aero Commander	Clarke *et al*. 2013a.
2013	Summer & Fall	Aero Commander	Clarke *et al*. 2014.
2014	Summer & Fall	Aero Commander	Clarke *et al*. 2015.
2015	Summer & Fall	Aero Commander	Clarke *et al*. 2017

None of the effort and sighting data reported in the ASAMM aerial survey reports through 2014 extended all the way to the LDPI site. ASAMM surveys were generally flown outside the barrier islands until 2016 and 2017 when blocks inside the islands were surveyed. For this reason, density estimates may be overestimated for the Foggy Island Bay area. The data used for this petition represent the best available, systematically collected marine mammal observations for the region. Using the ASAMM data in this manner also follows an approach that has been used in previous IHA applications which selected only on-transect effort and sighting data from Survey Block 1 (Figure 6-1).

Species densities were calculated in a two-step approach: a sighting rate of whales per km for each species was calculated; and then the transect length was multiplied by the effective strip width (esw) using the modeled species-specific ESW for an aero commander aircraft calculated by Ferguson and

Clarke (2013). These modeled esw were specific to the aero commander airplane used in the 2011-2015 surveys and were estimated for bowhead, gray, and beluga whales based on the NMFS ASAMM surveys. Thus, whale density was calculated as follows:

$$Whales/km^2 = \frac{sightings/km}{(2 \times esw)}$$

Where esw is effectively the half-strip width and so must be multiplied by 2 in order to encompass both sides of the transect line.

For years 2012 and 2013, beluga whale data were reported by depth strata (specifically for depths 0 to 66 ft [0-20 m] and 69 to 164 ft [21-50 m]) between the longitudes 140°W – 154°W in the Beaufort Sea. In these years, the effort and sightings data were combined for the two depth strata and a combined density calculated for each season. Density estimates based on combined depth strata within survey Block 1 will be higher than is likely to occur within Foggy Island Bay. However, beluga sightings inside the bay from 2012-2015 suggest that beluga may occur in small numbers with some frequency . The resulting density likely overestimates true density in Foggy Island Bay and is conservative for the purpose of calculating take.

6.1.1.1. Bowhead Whales

During the ice-covered season (winter and spring) there will be few to no bowhead whales near the LDPI site. The bowhead population migrates west to the Bering Sea during the fall and does not migrate eastwards through the Beaufort Sea again until spring. During this eastward migration, most of the whales are distributed far offshore. A few whales may occur in the Central Beaufort Sea area throughout the summer, but most of the population passes through later during the summer and fall as they migrate west to over winter in the Bering Sea. Based on satellite tracking studies conducted 2006-2012 (Quakenbush *et al.* 2013) migrating (i.e., non-feeding) bowhead whales spend an average of two days in the Prudhoe Bay area. It is rare for bowhead whales to pass inshore of the barrier islands near Foggy Island Bay as described in Section 4.1.1.

Bowhead whale density was calculated following the methods outlined in Section 6.1.1. Using the results provided by Ferguson and Clarke (2013), the modeled esw estimated for bowhead whales observed during aerial surveys conducted from an Aero Commander airplane was 0.7 mi (1.15 km) (CV = 0.08). This results in a mean density estimate for survey Block 1 in summer of 0.004 bowhead whales/km^2 (range = 0.001-0.006), and a mean fall density for survey Block 1 of 0.010 bowhead whales/km^2 (range = 0.004-0.022) (Table 6-2).

Table 6-2. Estimated Bowhead Whale Density*

Year	Dates	On Transect Effort (km)	On Transect Sightings	Whales/km	Whales/km^2
2011 Summer Fall	Jul-Oct Sep-Oct	346 1130	1 24	0.003 0.021	0.001 0.009
2012 Summer Fall	19 Jul -31 Aug 1 Sep-18 Oct	1493 1696	5 14	0.003 0.008	0.001 0.004
2013 Summer Fall	Jul – Aug Sep-Oct	1582 1121	21 21	0.013 0.019	0.005 0.008
2014 Summer Fall	Jul – Aug Sep-Oct	1393 1538	17 79	0.012 0.051	0.005 0.022
2015 Summer Fall	Jul – Aug Sep-Oct	1262 1663	15 17	0.012 0.010	0.005 0.004
			Summer Average Summer Range		0.004 0.001-0.006
			Fall Average Fall Range		0.010 0.004-0.022

*Note: A summary of survey years, season, effort, number of on-transect sightings and sightings per effort unit (km flown), density of bowhead whales/km^2. The average density with their respective density ranges (i.e. min to max) for each season across all survey years have also been calculated.

6.1.1.2. Beluga Whales

Beluga whales are not present in the LDPI Project Area during the ice-covered season. In general, beluga whales are rarely seen close to shore in the Beaufort Sea due to their preference for shelf break habitat. Beluga whales migrate to the Bering Sea during the fall with most of both the Eastern Chukchi Sea and Beaufort Sea populations leaving the Beaufort Sea by November (Hauser *et al.* 2014).

Density estimates based on ASAMM surveys in Block 1 will be higher than is likely to occur within Foggy Island Bay. However, beluga whales are occasionally encountered within the barrier islands. As previously described, in July and August 2014, eight groups of 19 beluga whales (some were likely resights) were seen in Foggy Island Bay during shallow hazard surveys (Smultea *et al.* 2014), and five beluga whales were recorded by Protected Species Observers (PSOs) during shallow hazard surveys in Foggy Island Bay in July 2015 (Cate *et al*. 2015). In 2014, 4,245km of PSO effort occurred during the marine mammal monitoring and mitigation program between July and August, resulting in a sighting rate of 0.004 whales per km surveyed (Smultea *et al.* 2014). PSOs could reportedly detect belugas as far as 1.24 mi (2 km) away from the vessel.

Beluga density was calculated using sighting and effort data collected during ASAMM surveys in Block 1 for 2011 and 2015 or by densities of combined depth strata 0-20m and 20-50m for 140W – 154W in the Beaufort Sea for 2012 and 2013 (Table 6-3). The esw estimated by Ferguson and Clarke (2013) for beluga whales observed from an Aero Commander airplane was 0.38 mi (0.614 km [CV = 0.07]). This resulted in a mean summer density of 0.012 belugas/km^2 (range = 0.006-0.024), and a mean fall density of 0.002 belugas/km^2 (range = 0.001-0.005). The average densities were comparable to those sighting rates observed by Smultea *et al*. (2014). While the ASAMM surveys were recently (2016 and 2017) extended

into Foggy Island Bay between 146W and 150W (pers. comm. J. Clarke [Leidos] ASAMM Project Lead, December 18, 2017), no beluga whales were observed. Sightings were limited to six small unidentified pinnipeds (none of which were seen on transect) and 18 polar bears (not including polar bears observed on or in the immediate vicinity of Cross Island). For this reason, beluga density has been estimated using data through 2015.

Table 6-3. Estimated Beluga Whale Density

Year	Dates	On Transect Effort (km)	On Transect Sightings	Whales/km	Whales/km^2
2011	Jul-Oct	1476	0	0	0
2012* Summer Fall	Jul- Aug Sep-Oct	5001 4846	47 5	0.009 0.001	0.006 0.001
2013* Summer Fall	Jul – Aug Sep-Oct	4270 3372	75 2	0.018 0.001	0.010 0.001
2014 Summer Fall	Jul – Aug Sep-Oct	1393 1538	13 9	0.009 0.006	0.008 0.005
2015 Summer Fall	Jul – Aug Sep - Oct	1262 1663	37 3	0.029 0.002	0.024 0.001
			Average summer Range summer		0.012 0.008-0.014
			Average Fall Range Fall		0.002 0.000-0.005

* A summary of ASAMM survey years, season, effort, depth (where applicable) number of on transect sightings and sightings per unit effort, and density of beluga whales/km^2. The average density and density range (i.e. min to max) for each season has also be calculated. Data only available by depth strata 0-20 m and 20-50 m in 2012 and 2013. We combined the sightings and effort for each season in these years and calculated the density from the combined data.

6.1.1.3. Gray Whales

Gray whales are rarely encountered in the Beaufort Sea. Gray whales spend the winter on their breeding grounds in Baja Mexico and do not return north until the spring. During the summer, gray whales are mostly distributed in the shallow coastal waters of the Chukchi Sea. However, on occasion, gray whales are sighted in the Beaufort Sea. One gray whale was observed in Block 1 during the ASAMM survey in September 2014. This resulted in a sighting rate of 0.001 gray whales per km, and 0.000 gray whales/km^2 in survey Block 1. The modelled esw of 0.75 mi (1.20 km [CV =0.07]) was used for grey whales (Ferguson and Clarke 2013).

6.1.2. Pinnipeds

Data on pinniped density within Foggy Island Bay and surrounding areas are limited. All three species are present in the Project Area during the summer months and data on their presence and sighting rates are available from a series of monitoring programs that occurred within Foggy Island Bay and neighboring areas in 1996 (Harris *et al.* 2001), 2008 (Aerts *et al.* 2008, Hauser *et al*. 2008), 2012 (HDR 2012) and 2014 (Smultea *et al.* 2014). Of all the pinniped sightings during monitoring surveys in 1996 (Harris *et al.* 2001), 2008 (Aerts *et al.* 2008, Hauser *et al.* 2008), and 2012 (HDR 2012), 63 percent were ringed seals, 17 percent were bearded seals and 20 percent were spotted seals. Ringed seals and bearded seals are

present in the Beaufort Sea year-round, though ringed seals are the most abundant species within the LDPI Project Area.

6.1.2.1. Ringed Seals

Ringed seals are present in the nearshore Beaufort Sea waters and sea ice year-round, maintaining breathing holes and excavating subnivean lairs in the landfast (but not bottomfast) ice during the ice-covered season. During this ice-covered season, ringed seals' home ranges are generally < 500 ha (5 km^2) in area (Frost *et al.* 2002; Kelly *et al*. 2005).

Winter Densities

Ringed seals overwinter in the landfast ice in and around the LDPI Project Area. Relatively few data are available for ringed seal density in the southern Beaufort Sea during the winter months, but several studies on ringed seal winter ecology were undertaken during the 1980s (Kelly *et al.* 1986, Frost and Burns 1989). These reports, in addition to more recent data associated with the Northstar development (Frost *et al.* 2002; Williams *et al.* 2001b) provide information on both seal ice structure use (where ice structures include both breathing holes and subnivean lairs) and the density of ice structures (Table 6-4).

Both male and female ringed seals maintain a number of breathing holes and haul out in more than one subnivean lair during the ice-covered season. Kelly *et al.* (1986) found that of their tagged seals, the animals would haul out between one and multiple subnivean lairs. The distances between each lair could be as great as 4 km with numerous breathing holes in-between (Kelly *et al.* 1986). While Kelly *et al.* (1986) calculated the average number of lairs used by an individual seal to be 2.85 (SD=2.51) per animal, they also suggest that this is likely to be an underestimate.

To estimate ringed seal density during the winter an average structure density was divided by the average number of structures used by seals (Kelly *et al.* 1986). Thus, for the winter season ringed seal density has been estimated as the average ice structure density (1.45/km^2) divided by the average number of ice structures used by an individual seal (2.85, SD=2.51). This results in an estimated density of 0.510 ringed seals/km^2 (for example, 1.45/2.85 = 0.510). This density is likely to be overestimated due to suggested underestimate in structures per individual (the denominator used).

Table 6-4. Sea-ice Structure Density In and Around the LDPI Project Area

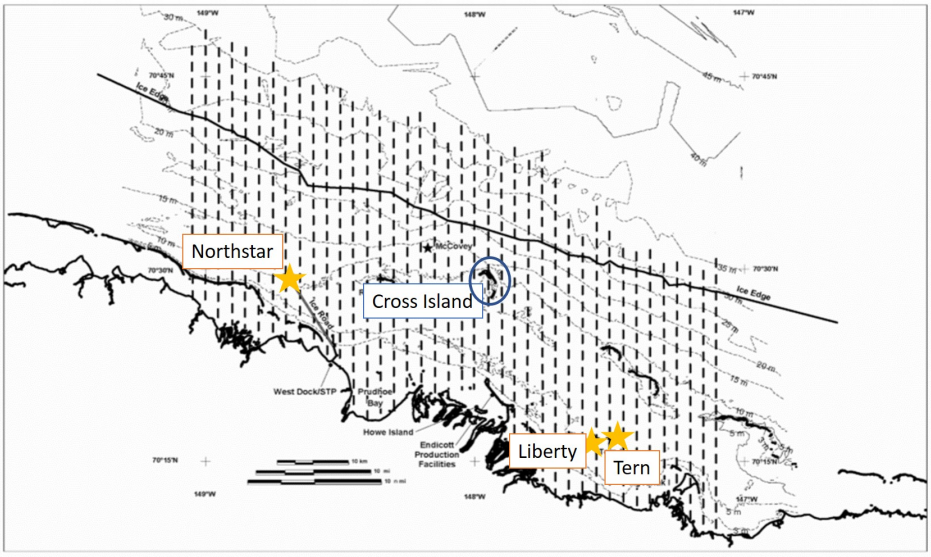
Year	Ice-structure density /km^2	Source
1982	3.6	Frost and Burns 1989
1983	0.81	Kelly *et al.* 1986
Dec 1999	0.17	Williams *et al.* 2001b
May 2000	1.2	Williams *et al.* 2001b
Average structure density/km^2	**1.45**	

Spring densities

The most informative data on ringed seal density for the LDPI Project Area are provided by spring aerial survey data. Aerial surveys have been flown over Foggy Island Bay and west of Prudhoe Bay during late May and early June (Figure 6-2; Moulton *et al.* 2002b, Frost *et al.* 2002, Richardson and Williams 2003), when the greatest percentage of seals have abandoned their lairs and are hauled out on the ice (Kelly *et al.*

2010a, b). These aerial surveys were flown as part of the industry monitoring programs for the development of Northstar production facility[15]. The data were available through previously published reports and peer review journal articles (Table 6-5).

Figure 6-2. Northstar and LDPI Locations in Relation to Aerial Survey May-June 2002



Note: Transects were flown twice. Similar surveys were flown in each year 1997-2001.
Source: Source: Richardson and Williams (2002).

Table 6-5. Year and Data Sources for Spring Aerial Strip Transects for Ringed Seals

Years of surveys	Survey sources
1996 -1999	Alaska Department of Fish and Game
1996 - 2002	Industry Northstar monitoring surveys

The average density of ringed seals used to estimate exposure and potential takes were based on sighting data conducted between 1996 and 2002. The most informative data on ringed seal density for the Liberty Project area are provided by spring aerial survey data. Aerial surveys have been flown over Foggy Island Bay and west of Prudhoe Bay during late May and early June (Moulton *et al.* 2002b, Frost *et al.* 2002, Richardson and Williams 2003), when the greatest percentage of seals have abandoned their lairs and are hauled out on the ice (Kelly *et al.* 2010). Because densities were consistently very low where water depth was <3m (and these areas are generally frozen solid during the ice-covered season) densities have been calculated where water depth was >3m deep (Moulton *et al.* 2002a,b, Richardson and Williams 2003). Based on the average density of surveys flown 1997 to 2002 the uncorrected density of ringed seals during the spring is expected to be 0.548 ringed seals/km^2. A summary of available density data and the uncorrected densities available for 1997 to 2002 are provided in Table 6-6.

As with all aerial surveys, animal densities are underestimated because animals are missed, or not counted. This is generally because they are either not available to be seen or are missed by the observer. Therefore, these density estimates represent minimum estimates during the time and location of the

[15] Foggy Island Bay and the vicinity were surveyed during this time frame was because the Liberty Project was also being considered for construction and operation.

surveys. As reported in Frost *et al.* (2002), habitat-related variables including water depth, location relative to the fast ice edge, and ice deformation has shown to result in substantial and consistent effects on the distribution and abundance of seals. Moulton *et al.* (2003a, 2005) also reported that environmental factors such as date, water depth, degree of ice deformation, presence of meltwater, and percent cloud cover had more conspicuous and statistically-significant effects on seal sighting rates than did any human-related factors. Thus, the intra- and interannual variability in survey conditions and ice characteristics is unavoidable; thus, identifying trends in abundance or estimating density is challenging.

Table 6-6. Estimated Densities of Ringed Seals During the Spring 1997-2002

Year	Density (no./km^2)
1997	0.43
1998	0.39
1999	0.63
2000	0.47
2001	0.54
2002	0.83
Average	**0.548**

Source: Moulton et al. 2002a,b, Richardson and Williams 2003

While the ringed seal densities used in this request are considered minimum estimates, it is important to note that using the Level B acoustic threshold of 120dB is a conservative approach to estimating take that could result in minor, behavioral harassment of seals due to noise generated from construction activities at the LDPI. Behavioral responses would be unlikely result in anything more than minor, biologically insignificant consequences for any individual animals. For example, Kelly *et al.* (1986) report that some ringed seals temporarily departed their lairs when sound sources were within 0.06 to 1.9 mi (97 to 3,000 m) but did return to their lairs later. Haul outs with and without disturbance were not significantly different and time spent in the water versus hauled out was significantly different. Based on the operational definition that minor and brief changes in behavior generally do not "rise to the level of taking", these types of behavioral responses would not constitute a take. Compared to results from studies of ringed seals at Northstar, the exposure estimates calculated for LDPI are likely an overestimate of actual takes. As described in Section 13, Hilcorp will monitor behavioral responses during construction operations at LDPI during each year of development to compare requested takes with observed behavioral responses.

Summer Densities

Following spring pupping, ringed seals tend to range considerable distances from their natal sites, thereby reducing summer densities in the Project Area. This is characteristic of all phocids. To estimate ringed seal density during the summer in the project Area, this request follows the approach presented by LGL in 2007, where the average ringed seal summer density was calculated from the combined 1997-2002 ringed seal densities in Moulton *et al.* (2003a) and Frost *et al.* (2002). The highest observed ringed seal density for the Prudhoe Bay and Liberty area was used as the maximum density. Because these density estimates were calculated from spring data and the number of seals is expected to be much lower during the open water season, the densities used for the proposed survey were (conservatively) estimated to be 50 percent of the spring densities (LGL 2007). Due to the lack of open water seal density data, this number is

considered to be realistic. Therefore, the density of ringed seals during the summer in the Project Area is estimated to be 50 percent of the expected spring density (0.548/km^2), or 0.27 ringed seals/km^2.

Fall Densities

Ringed seals remain in the water through the fall and in to the winter. However, due to the lack of available data on fall densities within the LDPI Project Area a conservative estimate has been made that assumes the same density of ringed seals as in the summer; 0.27 ringed seals/km^2.

6.1.2.2. Bearded Seals

Winter and Spring Densities (Ice-covered Season)

During the ice-covered season, some bearded seals remain in the Beaufort Sea. Their distinctive calls are detected throughout the year with an increase in call activity in January. A few bearded seals that remain are encountered in the landfast ice areas, however the majority migrate west into the Bering and the Chukchi Seas. Those that remain are generally encountered farther offshore (20-100 mi [32-161 km]) in the pack ice (NMFS 2012a).

At present, there is no official population estimate for bearded seals occupying the Beaufort Sea, particularly in the coastal areas during the winter and spring. Industry monitoring surveys for the Northstar development during the spring seasons in 1999 (Moulton *et al.* 2000), 2000 (Moulton *et al.* 2001), 2001 (Moulton *et al.* 2002a) and 2002 (Moulton *et al.* 2003a) counted 47 bearded seals (annual mean of 11.75 seals during an annual mean of 3,997.5 km^2 of effort, Table 6-7). While the numbers were deemed too low to calculate a reliable density estimate in each year, no other bearded seal estimates were available. Therefore, an estimated density using the four years of Northstar development data of 0.003/km^2 bearded seals is used in this request.

Table 6-7. Bearded Seal Sightings in the Central Alaskan Beaufort Sea

Year	No. of Sightings	Effort (km^2)	No. / km^2	Source
1999	20	3980	0.005	Moulton *et al.* 2000
2000	15	4245	0.004	Moulton *et al.* 2001
2001	3	4147	0.001	Moulton *et al.* 2002
2002	9	3618	0.002	Moulton *et al.* 2003a
Average	**11.75**	**3,997.5**	**0.003**	

Note: Includes the Northstar and LPDI Project Areas.

Summer and fall densities (Open water season)

Bearded seals are most commonly encountered in the Beaufort Sea during the open water season, though the species prefers waters farther offshore than the LDPI Project Area. Bearded seal density was calculated as a proportion of the ringed seal summer density based on the percentage of pinniped sightings during monitoring surveys in 1996 (Harris *et al.* 2001), 2008 (Aerts *et al.* 2008, Hauser *et al.* 2008), and 2012 (HDR 2012). During these surveys, 63 percent were ringed seals, 17 percent were bearded seals and 20 percent were spotted seals. Thus, the density of bearded seals during the open water season (summer and fall) was calculated as 17 percent of the ringed seal density of 0.27/km^2. This results in an estimated summer density for bearded seals of 0.05/km^2.

There is limited documented information available on the presence or density of bearded seals in the coastal areas of the Beaufort Sea during the fall. Therefore, a conservative assumption has been made that fall densities of ringed and bearded seals in Foggy Island Bay will be the same as the summer densities.

6.1.2.3. Spotted Seals

The spotted seal is a seasonal visitor to the Beaufort Sea and much less abundant. Only low numbers (~1,000) are expected to occur near the Alaskan Beaufort Sea coast. Spotted seals return to the Chukchi Sea and continue south to the Bering Sea at the onset of freeze up in the fall to spend the winter and spring in the Bering Sea. Thus, spotted seals are not present during the ice-covered season. To estimate a spotted seal density for the summer months of July and August, the approach used for bearded seals has been followed.

As described in Section 6.1.2, spotted seal density during the open water season (summer and fall) was calculated as 20 percent of the ringed seal summer density estimate (0.27 seals/km^2) in the LDPI Project Area. This results in an estimated density for spotted seals of 0.05/km^2.

6.1.3. Summary of Marine Mammal Densities Used in Take Calculations

Table 6-8 Summarizes the marine mammal densities used in the take calculations.

Table 6-8. Marine Mammal Densities

Species	Spring Average Density (animals/km2)	Summer Average Density (animals/km2)	Fall Average Density (animals/km2)	Winter Average Density (animals/km2)
Bowhead whales	0	0.004	0.010	0
Beluga whales	0	0.012	0.002	0
Gray whales	0	0.001	0.001	0
Ringed seals	0.548	0.270	0.270	0.510
Bearded seals	0.003	0.050	0.050	0.003
Spotted seals	0	0.050	0	0

6.2. Noise Sources and Assessment Scenarios

A list of construction and operational activities, equipment and scenarios with the potential for noise impacts to wildlife was developed by (SLR 2017) in consultation with Hilcorp, NMFS and BOEM. Based on the information presented in Table 1-3, source levels of construction activities were determined based on a combination of modeling and empirical data to estimate the range to the NMFS Level A and Level B noise exposure criteria during ice-covered and open water conditions as well as in air. In developing this list of project activities, source levels and spectra (indicating the source noise contribution at each frequency) for each noise source and scenario were determined based on a literature review of the best available science. This approach relies heavily on historical noise measurements from the Northstar

development and reference has been made to experience gained during construction and operation of the comparable Northstar production island in Prudhoe Bay (SLR 2017). The approach considers the generation and propagation of noise in both summer (July – August; open water) and in winter (November – March; ice-covered) conditions are provided in Appendix A (SLR 2017).

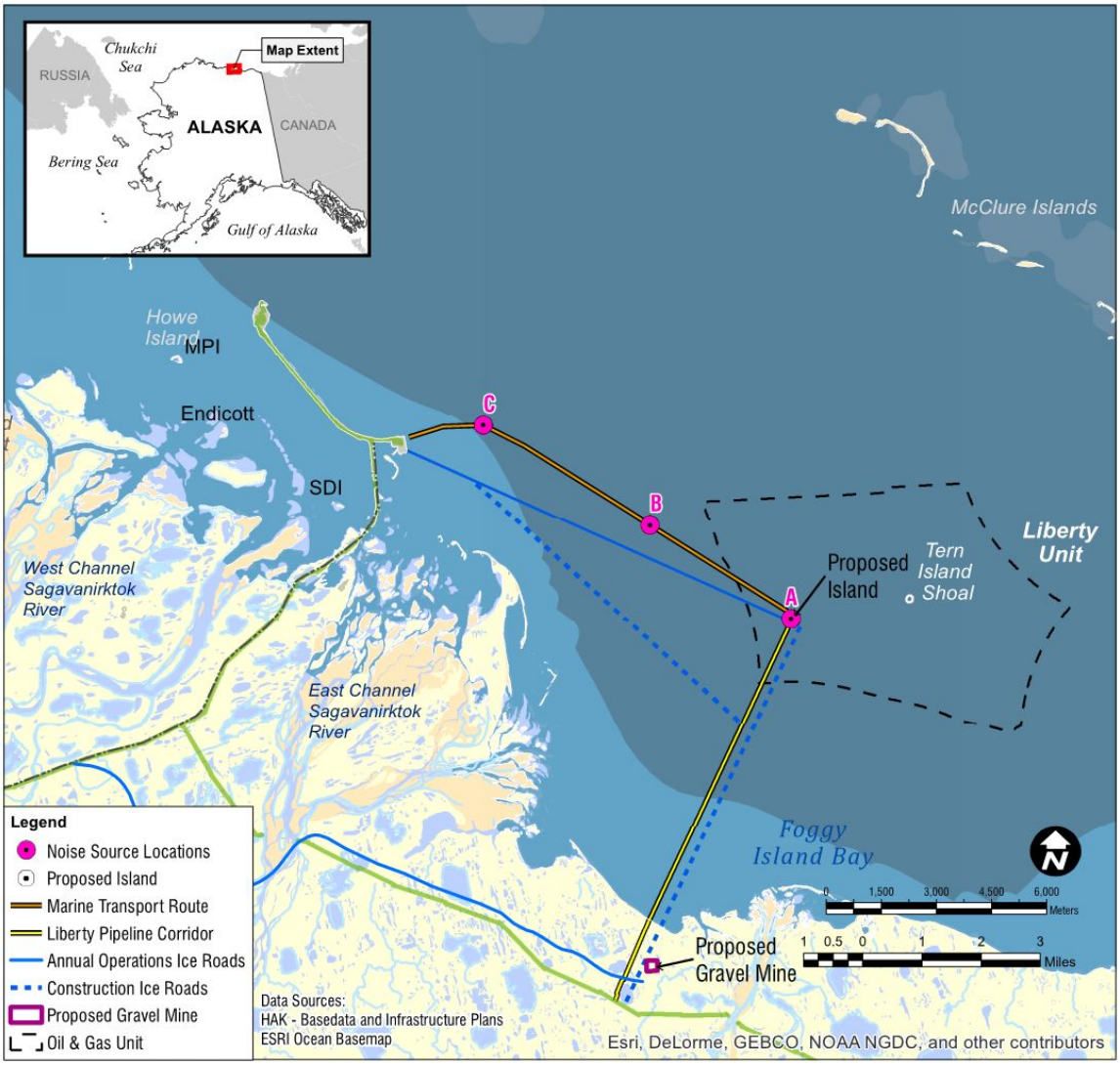
The Project-specific noise assessment scenarios by SLR (2017) prompted the following different assessment approaches:

- For underwater noise in the ice-covered season, an empirical approach has been used to determine noise propagation, based on measurements undertaken during comparable activities during construction of the Northstar Island in Prudhoe Bay. This approach is able to identify the extent of noise levels above NMFS current marine mammal behavioral disturbance thresholds based on overall unweighted noise levels. More severe PTS impacts have not been considered in the under-ice season, as these are anticipated to be negligible with reduced noise propagation under ice relative to in open water.
- For underwater noise in the open-water summer season, a detailed frequency-dependent noise propagation model has been utilized. This approach enables prediction of noise propagation over longer distances, accounting to some degree for site specific bathymetry and sea-floor characteristics. This frequency dependent approach also enables a review of the potential for PTS, by weighting the received noise level with consideration of the hearing sensitivity of the various species of interest. The detailed noise model predictions have been compared with empirical data from Northstar and also to a practical spreading loss model, as a check on the validity of the detailed model results.
- For in-air noise, commercial noise modeling software has been used to identify noise propagation and the extent of potential disturbance of marine mammals.

Full details of the source noise levels, references and spectra used to model noise propagation in air, in water and under ice are provided in Appendix A. It is noted that there are inherent limitations related to using historical noise measurements from the Northstar development, measured over ten years ago, in estimating source levels. At LDPI, noise generated may be different depending on the details of equipment used, substrate conditions, and propagation factors.

The locations of the various noise sources described in Table 1-3 are shown in Figure 6-3. Noise sources are approximated as either points or lines for modeling purposes. For example, sources located at the island are modelled as a single stationary point, whereas sources associated with ice road construction are represented as a line along the route. Ice road routes shown as “construction” ice roads may also be required during operations, e.g., for inspections.

Figure 6-3. Noise Source Locations



Source: SLR 2017

Point sources B and C on this map represent potential noise from vessels. The biological relevance of behavioral responses to noise exposure depends, at least in part, on how long the exposure and response persist. Responses to noise created by vessel traffic would be short term (e.g. vessels transiting). Based on these considerations, it is unlikely that potential behavioral effects from vessel traffic would result in anything more than minor, biologically insignificant consequences for any individual animal or for the population. As such, NMFS does not believe the limited observed effects would constitute a "take" under the definition of NMFS (2000) and that minor and brief changes in behavior generally do not "rise to the level of taking". Therefore, no takes are requested for vessel noise.

In consultation with Hilcorp, NMFS and BOEM, several other potential noise-generating activities were considered but have not been modeled. The additional activities considered and reasons for exclusion from the list of modeled activities are as follows:

- Underwater noise generated by helicopters – the broadband noise levels underwater due to helicopters flying at altitudes of 500 ft (150 m) or more are expected to be around 109 dB re 1µPa (Richardson *et al*. 1995), which is below the threshold of 120 dB re 1µPa assumed to lead to behavioral responses due to a continuous noise source. Helicopter noise is therefore modeled to determine in-air noise effects only.
- Bathymetry surveys – noise generated by bathymetry surveys has not been modeled, as these surveys take place independently of the LDPI Project development and would not be included in Hilcorp's application for an LOA.
- Noise from fixed wing aircraft or aircraft surveys of marine mammal density or polar bear dens or vessel movements associated with marine mammal monitoring efforts. If required, these activities may occur only a few times each year. Use of Unmanned Airborne Systems (UAS) as a sound source was not modeled. UAS would fly at 500 ft (152.4 m) (or other altitude determined appropriate for the specific platform chosen) and would only be used to monitor marine mammal presence. As described in Appendix B, a 0.005 mi^2 (0.014km^2) ensonified area was calculated for Level B thresholds for pinniped exposure to helicopter noise. Due to their smaller size and power requirements, airborne noise from UAS would be much lower than helicopters and the distance to Level B thresholds would be even smaller. The overall impact to marine mammals from UAS noise would be negligible.
- Noise generated during installation of conductor pipes by methods other than impact driving. Vibratory drilling for island sheet piles was evaluated and sound sources are slightly lower than impact sheet pile driving (see Appendix A). It is assumed that noise levels would be lower for pipe driving in the middle of the island. The need for impact driving would depend on local conditions. Alternatives to impact conductor pipe driving include vibratory driving, or drilling (auger). These alternatives would generate less noise than impact driving, and were therefore not modeled for the purposes of this request.

6.3. Distance to Predicted Noise Thresholds

Table 6-9 summarizes sound source levels (taken from the literature related to Northstar Island) and the predicted distances from the noise sources to the underwater behavioral impact thresholds for marine mammals for each of the project scenarios considered in the open water summer season and represents the maximum propagation direction (i.e., away from shore).

Vibratory sheet pile driving has potential to produce underwater noise above the behavioral effect threshold over the largest area from the island, within up to 1,280 ft (0.39 km) under ice-covered conditions and 11 mi (17.5 km) in open water. Vibratory sheet pile driving is assumed to be completed within 4 months under ice-covered conditions and only two weeks in open water (July 1 – 15), thus minimizing the potential for behavioral effects on marine mammals. Slope shaping may also be required between July 15 and August 31 of Year 2 and has been considered for in this noise exposure estimate.

It is noted that during construction of Northstar Island, pile driving was not required during the open water season. Disturbance to marine mammals would be minimized if the construction schedule mirrors that of Northstar, with pile driving occurring only during the ice-covered season.

As described in Appendix A, values of the effective broadband attenuation factor based on the noise transmission loss between the source and the maximum behavioral threshold radius range between about 14 and 17, with an average of 15 which corresponds to the practical spreading loss factor. Noise propagation towards shore attenuates with a factor of up to 18.

Differences in the calculated effective attenuation factor for each scenario are related to the different frequency characteristics of each source, combined with frequency-dependent propagation effects. Overall, the detailed model predicted attenuation factors are very similar to measured long distance attenuation factors from Northstar (14 to 18). This indicates that the overall broadband noise levels in the frequency range modeled are dominated by higher frequency components, and the shallower water at LDPI does not provide significantly more attenuation of the overall broadband noise levels in this range than is provided by the water surrounding Northstar Island. Drilling and production noise from Northstar was also measured in open water. Being lower in level than vessel noise, drilling and production noise could only be detected above the background at distance out to about 2 km (1.2 mi), giving fewer data points for calculation of the propagation loss. Two sets of measurements in different years resulted in highly variable measured attenuation factors of 32.6 and 6.3. It is noted that during construction of Northstar Island, pile driving was not required during the open water season. This report considers the possibility that pile driving may occur after ice-breakup (between July 1 and 15) but disturbance to marine mammals would be minimized if the construction schedule mirrors that of Northstar with the completion of pile driving during the ice-covered season. Additionally, cetaceans (bowhead and beluga whales) are not expected to be near this area this early in July.

Table 6-9. Scenario Sound Source Levels, Distance to Behavioral Disturbance Thresholds and Associated Ensonified Areas

Scenario	Underwater Noise (Ice-Covered)			Underwater Noise (Open Water)			Airborne Noise		
	Average Sound Pressure Level (dB re 1μPA at 1m	Distance to Threshold (km)	Ensonified Area (km²)	Received Level (RMS)[1](dB re 1μPA at 1m)	Distance to Threshold (km)	Ensonified Area (km²)	Overall Source Sound Pressure Level at Distance (dB re 1μPA @ m)	Distance to Threshold (km)	Ensonified Area (km²)
Ice Road Construction and Maintenance (Graders, Augers, Water Pumps)	189.1	0.17 (558 ft)	0.09 (22 acre)	n/a	n/a	n/a	Graders 64.7 (@100 m) Augers 67.9 (@100 m) Water pumps 72 (@100 m)	< 0.02 (66 ft)	0.001 (0.03 acre)
Pipeline and Island Construction	Trucks on ice road 179.1 Backhoe 177.7 Ditchwitch 169.6	0.21 (689 ft)	0.14 (35 acre)	n/a	n/a	n/a	Trucks on ice road 74.8 (@100 m) Backhoe 78 (@10 m) Ditchwitch 76.3 (@100 m)	< 0.02 (66 ft)	0.001 (0.03 acre)
Vibratory sheet Piling, Island Perimeter[2]	221.0	0.39 (1,280 ft)	0.48 (119 acre)	185	14.8 (48,556 ft)	**North**–264 (65,000 acre) **East**–229 (57,000 acre) **South**–102 (25,000 acre) **West**–109 (27,000 acre) **SW**–64 16,000(acre)	81 (@100 m)	0.02 (66 ft)	0.001 (0.03 acre)

Table 6-9 (con't). Scenario Sound Source Levels, Distance to Behavioral Disturbance Thresholds and Associated Ensonified Areas

	Underwater Noise (Ice-Covered)			Underwater Noise (Open Water)			Airborne Noise		
Scenario	**Average Sound Pressure Level (dB re 1μPA at 1m**	**Distance to Threshold (km)**	**Ensonified Area (km²)**	**Received Level (RMS)[3]**	**Distance to Threshold (km)**	**Ensonified Area (km²)**	**Overall Source Sound Pressure Level at Distance (dB re 1μPA @ m)**	**Distance to Threshold (km)**	**Ensonified Area (km²)**
Slope shaping, armament installation	n/a	n/a	n/a	167	1.16 (3,806 ft)	4.2 (1,038 acres)	64.7 (@100 m)	< 0.02 (66 ft)	0.001 (0.03 acre)
Impact sheet piling	*235.7*	*0.09 (295 ft)*	*0.03 (7.4 acre)*	*210*	*2.5 (8,202 ft)*	*19.6 (4,843 acre)*	*93 (@160 m)*	*0.1 (328 ft)*	*0.031 (7.4 acre)*
Impact pipe driving (conductor pipe), island interior	*171.7*	*n/a*	*<0.01 (<2.5 acre)*	*196*	*0.31 (1,017 ft)*	*0.3 (74 acre)*	*93 (@160 m)*	*0.1 (328 ft)*	*0.031 (7.4 acre)*
Helicopter (take-off, landing)	n/a	n/a	n/a	n/a	n/a	n/a	84 (@300 m)	0.07 (230 ft)	0.014 (3.6 acre)
Drilling & Production[3]	170.5	0.23 (755 ft)	0.17 (42 acre)	151	0.06 (197 ft)	0.01 (2.5 acre)	80 (@200 m)	0.03 (98 ft)	0.003 (0.7 acre)
Production only[4]	154.5	0.04 (131 ft)	0.01 (2.5 acre)	153	0.05 (164 ft)	0.01 (2.5 acre)	80 (@ 200 m)	0.03 (98 ft)	0.003 (0.7 acre)

Source: SLR 2017 and SMRU 2017 (Appendices A and B).
Distance is provided for underwater noise in both ice-covered and open water conditions as well as airborne noise, where appropriate.
Impulsive sounds are in italics (threshold of 160 d B_{rms} re 1μPa). All other sounds are non-impulsive (threshold of 120 dB_{rms} re 1μPa).
n/a indicates that the distance does not apply or the estimated range or area of exposure is too small to be of consequence.
[1]Different propagation coefficient for each source means a different source will dominate at different distances. Please see Appendix B of the Noise Report attached here as Appendix A.
[2]Since vibratory sheet piling will occur near the periphery of the constructed island, the area ensonified will depend on the side of the island where vibratory sheet piling is occurring.
[3] The predicted Level B harassment distances for drilling and production are larger under ice as compared to open water due to higher assumed source levels for the under ice scenario (Blackwell *et al*. 2004b, Blackwell and Green 2006). A possible reason for the higher source levels for interior island sound sources under ice is because the island substrate is well coupled to the ice layer, and this may result in more efficient transfer of sound into the water below the ice than occurs when the island is surrounded by open water
[4]Production includes managing the flow of oil, water, and gas and maintaining equipment to ensure long and reliable service. May include overhauls of rotating equipment.

6.3.1. Thresholds for PTS Onset Due to Peak Noise Level – Open Water

Table 6-10 summarizes the predicted distances from the source to the peak noise thresholds corresponding to the onset of PTS, for all activities and marine mammal groups considered. Only impact sheet pile or impact pipe driving through gravel around the boundary of the island produces impulsive noise with the theoretical potential to exceed the peak noise PTS onset thresholds. The highest threshold distance for PTS onset is 33 ft (10 m) from the source being identified for low-frequency cetaceans and phocid pinnipeds. The practical potential for PTS due to impulsive peak noise level exposure is even less, occurring only if an animal is underwater within about 33 ft (10 m) of the impact piling rig. Exposure to PTS will be mitigated as described in Section 11. Note that the source levels used for this activity were measured in a similar situation (piling through gravel) – sheet piling directly into the water column would be expected to produce higher noise levels. The attenuating effect of the gravel is incorporated in the source levels used.

Table 6-10. Distance to PTS Onset Thresholds for Peak Noise Level

Scenario – Open Water	Source Location(s)	Maximum Distance from Source to PTS Onset Threshold (L_{pk}, flat)	
Impact sheet pile driving	Island	Low-frequency cetaceans	<10 m
		Mid-frequency cetaceans	0
		Phocid pinnipeds	<10 m

Source: SLR 2017 (Appendix A, Table 13)
Note: For other scenarios the noise level at source is less than the peak noise threshold, so no exceedance is possible.

6.3.2. PTS Onset Thresholds Due to Cumulative Noise Exposure – Open Water

To estimate the potential for PTS due to cumulative sound exposure following NMFS 2016 guidelines, an indication of the possible duration of noise generating activities in any 24-hour period is required. Tables 6-11 and 6-12 show the potential durations for non-impulsive and impulsive activities that have been assumed for the purpose of this assessment. Construction is expected to occur in 12-hour shifts, 24 hours per day. The active production of noise (or acoustic usage factor) would be less than the full work day duration. Activity durations in Table 6-11 have therefore been reduced from 24 hours to reflect the anticipated duration of active noise generation as follows:

- Slope shaping, armament installation (using a backhoe or bucked dredge) – 40 percent usage factor from U.S. Department of Transport guidelines for construction equipment acoustic usage factors (U.S. DOT 2006). If needed, this may occur between July 15 and August 31 of Year 2 but is not expected to occur every day during that period.
- Vibratory sheet pile driving – up to 20 piles per day may be driven to a depth of 25 ft. Pile penetration speed can vary depending on ground conditions, but a minimum sheet pile penetration speed is 20 inches (0.5 m) per minute to avoid damage to pile or hammer (NASSPA 2005). For this project, the anticipated duration is based on a preferred penetration speed greater than 40 inches (1 m) per minute, resulting in 7.5 minutes to drive each pile. During sheet pile driving at Northstar Island, it was observed that "a typical vibra-hammer operation lasted for 1 minute or less" (Shepard *et al.* 2001). If needed, this may occur July 1 – 15 of Year 2.

In practice, the durations of each activity would vary on different days, and would frequently be less than indicated in Table 6-11.

Table 6-11. Non-impulsive Activity Durations for Cumulative Noise PTS Assessment

Scenario – Open Water	Duration (per 24 h)	Comments
Slope shaping, armament installation	9.6 hours	40 percent usage factor
Vibratory sheet pile driving[1]	2.5 hours	20 piles per day, 7.5 minutes per pile
Drilling and production	24 hours	24 h production
Production only	24 hours	

[1]If needed, this may occur between July 15 and August 31 of Year 2 but is not expected to occur every day during that period.

[2]Duration for exposure is 15 days during the open water season.

The estimated durations and schedules for impulsive activities are detailed in Table 6-12. For these activities, durations have been estimated in consultation with Hilcorp and with reference to monitoring undertaken during similar activities at Northstar.

Table 6-12. Impulsive Activity Durations for Cumulative Noise PTS Assessment

Scenario	Duration (per 24 h)[1]	Comments
Impact sheet pile driving	Maximum 40 minutes per day, anticipated duration < 20 minutes per day.	Delmag D62-22 hammer, 35-50 strikes per minute (Greene *et al*. 2008). Approximately 2 minutes and 100 strikes per pile[3].
Impact pipe driving	2 hours[2] 4400-6300 strikes per day	20 percent impact hammer usage factor from US Dot (2006) over a 10.5-hour period from Blackwell *et al*. (2004a). Delmag D62-22 hammer, 35-50 strikes per minute.

[1]Over 15 days during the open water season.
[2]20 percent usage factor over 10.5 hrs. is approximately 2 hrs.
[3]Assume 20 piles per day.

Impact sheet pile driving – observations from Northstar by Greene *et al.* (2008) indicate impact pile driving was required only to finish off each pile after vibratory driving into the frozen material of old Seal Island. Since LDPI will be a newly constructed gravel island, driving sheet piles should be easier than was the case at Northstar. Therefore, impact sheet pile driving may not be required at LDPI and is included in this scenario as a precaution.

Impact pipe driving – a total of 16 conductor pipes would be set at LDPI, driven to 160 ft (49 m) depth with impact hammers. Blackwell *et al*. (2004a) observed impact pipe driving at Northstar. On most days, one conductor was driven in a day over a period of 5 to 8.5 hours. The longest day of observation was 10.5 hours in which time two pipes were driven. The observation period each day included all pipe driving time, but driving was never continuous during the entire observation period.

As described in the recent Technical Guidance (NMFS 2016), for PTS to occur due to cumulative noise exposure an individual animal would need to remain in proximity to the noise source for a sufficiently long time. For Level A takes, only four of the noise sources had the theoretical ability to cause Permanent Threshold Shift (PTS, or hearing damage) using a Sound Exposure Level (SEL) metric, which is considered to be a Level A take. The range to these thresholds for these four noise sources are reproduced in Table 6-13. Because the thresholds are based on 24 hour cumulative SEL which measure the amplitude of a noise exposure over time, the threshold can be achieved by a different combination of

duration and distance (which is related to the amplitude of the exposure) (see also Tables 16 – 18 of Appendix A for additional information on distances and durations related to PTS). For example, during impact sheet piling, a pinniped would need to remain within 1,706 ft (0.53 km) of the noise source for 40 minutes to experience PTS. A range of exposure time and distance over which the threshold might be reached for species that may occur within the area are presented in Table 6-13. NMFS Level A SEL criteria take account of hearing sensitivity and therefore SLR (2017) results vary by different marine mammal hearing group (SMRU 2017).

Table 6-13. Distance to Cumulative PTS (Level A) Thresholds and Ensonified Area

	Slope Shaping [2] (9.6 hrs)		Vibratory Sheet Piling (2.5 hrs)		Impact Sheet Piling (40 mins)		Impact Pipe Driving (2 hrs)	
Marine Mammal Hearing Group and Species	**Distance to Threshold (km)**	**Ensonified area (km²)**	**Distance to Threshold (km)**	**Ensonified area (km²)**	**Distance to Threshold (km)**	**Ensonified area (km²)**	**Distance to Threshold (km)**	**Ensonified area (km²)**
Low frequency cetaceans (bowhead, gray whales)	<0.01 (33 ft)	n/a	0.05 (164 ft)	n/a	1.94 (6,365 ft)	11.8 (2916 acre)	0.87 (2,854 ft)	2.38 (588 acre)
Mid frequency cetaceans (belugas)	n/a	n/a	<0.01 (33 ft)	n/a	0.06 km (197 ft)	0.01 (2.5 acre)	0.03 km (98 ft)	0.002 (<0.5 acre)
Phocid Pinnipeds (bearded, ringed, spotted seals)	<0.01 (33 ft)	n/a	0.02 (66 ft)	n/a	0.53 km (1,706 ft)	0.87 (215 acre)	0.24 km (787 ft)	0.18 (45 acre)

Sources: SLR 2017 (Appendix A); SMRU 2017 (Appendix B)
n/a indicates that the estimated range or area of exposure is too small to be of consequence.
[1]Under open water conditions.
[2] The noise source for slope shaping is an excavator, similar to a grab or bucket dredge and the noise source location is at the edge of the island. While slope shaping activities may exceed the Level A threshold, the distance to that threshold is less than 10 m (33 ft). Animals are not expected to occur within 10 m of the island during construction, particularly for any given amount of time that could cause PTS. Therefore, Level A exposures during slope shaping are not included in the take estimate.

6.3.3. Discussion of Potential for PTS – Open Water Scenarios

For most of the activities considered, the assessment confirms that there is no realistic potential for PTS in marine mammals due to either impulsive peak noise levels or cumulative noise exposure. A theoretical potential for PTS in open water has been identified only for four construction scenarios including vibratory pile driving, impact pile driving and impact pipe driving. While slope shaping activities may exceed the Level A threshold, the distance to that threshold is less than 10 m (33 ft). Animals are not expected to occur within 10 m of the island during construction, particularly for any given amount of time that could cause PTS. Therefore, the Level A exposures during slope shaping are not considered in the take estimates. Additionally, both vibratory pile driving and slope shaping would require an individual animal to remain underwater in close proximity to the source for extended periods of time for the theoretical potential of PTS to become actualized. As described previously, only two weeks of potential pile driving (July 1 – 15) may occur during open water. Slope shaping may be needed between approximately July 15 and August 31 of Year 2 during open water but is not expected to occur every day

during that period. It is assumed that, similar to Northstar, most island construction will occur under ice-covered conditions. Therefore, the information presented for PTS onset is considered a worst-case scenario.

The potential for PTS due to impulsive peak noise levels is more limited than the potential for PTS due to cumulative noise exposure, even for impact pile driving. For the species of concern, the potential for PTS in open water due to impulsive peak noise level exposure is predicted only within 33 ft (10 m) of impact sheet pile driving around the boundary of the island. This theoretical potential for PTS due to peak noise level applies to low frequency cetaceans (bowheads and gray whales) in addition to phocid pinnipeds (bearded, ringed, and spotted seals), but does not apply to belugas. In practice, elimination of any potential for PTS due to peak noise level would be readily achievable through routine mitigation measures.

The only scenarios with theoretical residual potential for PTS are the cumulative noise effects of the impact pile driving and impact pipe driving scenarios. The residual potential for PTS for each of the marine mammal groups of interest is summarized as follows, for the underwater open water activities associated with the LDPI Project:

- Bowhead, gray whales (low-frequency cetaceans) – There is theoretical potential for PTS during impact sheet pile driving in the open water season, if animals remain within 2,350 to 4,000 ft (770 to 1,220 m) of the noise source throughout the work day, with active impact sheet pile driving occurring for 10 to 20 minutes in total. During impact driving of conductor pipes, PTS may occur if animals remain within about 2,850 ft (870 m) for the full work day with 2 hours of active impact driving. In practice, these species are extremely unlikely to be present this close to Liberty Island, in areas with water depths less than around 25 ft (7.6 m). Therefore, the theoretical potential for PTS in low frequency cetaceans is unlikely to be realized.
- Beluga whales (mid-frequency cetaceans) – There is potential for PTS during impact sheet pile driving in the open water season, but only if animals remain in very close proximity to the island (within 200 ft or 60 m) for the full work day. Again, this theoretical potential for PTS is unlikely to be realized.
- Bearded, ringed, and spotted seals (phocid pinnipeds) – There is potential for PTS during vibratory sheet pile driving in the open water season if animals remain within 690 to 1,080 ft (210 to 330 m) of the noise source throughout the work day, with active impact sheet pile driving occurring for 10 to 20 minutes in total. During impact driving of conductor pipes, PTS may occur for animals remaining within about 790 ft (240 m) for the full work day with 2 hours of active impact driving.

The only scenarios with theoretical potential for PTS onset are impact pile driving and impact pipe driving, if these activities occur in the open water season. In practice, the potential for PTS would depend on the likelihood of particular species being present within the identified distances from the noise source, and on the behaviour of the individual animal in response to noise. In particular, PTS would not occur if an animal moved away from the noise source, or if an animal did not remain underwater for the full duration of active noise generation. Cetaceans are unlikely to be present within the identified distances, and are even less likely to stay within those distances for long periods, especially when strong anthropogenic sounds are present. In addition, the island will block propagation of construction noise.

Taking this into account, animals would have to stay within the bay on same side of the island as the noise source for an extended period to be affected. This makes the potential for PTS even less likely.

6.4. Airborne Noise Modeling

6.4.1. Airborne Noise Modeling Methodology

The following process (as described in SMRU 2017) has been used to assess Project-related airborne noise:

- Develop a 3D computer model of the project area taking into account topography, ground surfaces and absorption effects;
- Incorporate the various Project noise sources in the model;
- Use the model to predict the maximum environmental noise contribution for each assessment scenario; and
- Identify scenarios that are predicted generate noise above the identified threshold, and the areas affected.

6.4.2. Airborne Noise Sources and Assessment Scenarios

Airborne noise impact has been assessed for the various identified scenarios, as shown in Table 6-14. For each scenario, the noise impact is assessed by comparing the maximum sound pressure level to the threshold. As only the maximum sound pressure level is being assessed (for example, the maximum noise level during a vehicle drive-by), the duration of exposure is not considered.

The species of interest for the airborne noise component are bearded seals, ringed seals and spotted seals. For some scenarios, the identified distances may be within the activity footprint, so no actual behavioral response is possible.

Table 6-14. Airborne Noise Assessment Results Summary

Scenario	Season	Location(s)	100 dB_{rms} Noise Contour Radius
Ice road construction and maintenance	Ice-covered	Construction ice roads	< 15 m (49 ft)
Pipeline construction	Ice-covered	Pipeline & ice roads	< 15 m (49 ft)
Island construction	Ice-covered	Construction ice roads Island Gravel mine	< 15 m (49 ft) < 15 m (49 ft) < 15 m (49 ft)
Vibratory sheet pile driving	Any	Island	15 m (49 ft)
Impact pile driving	Any	Island	100 m (328 ft)
Slope shaping, armament installation	Open water	Island	< 15 m (49 ft)
Helicopter	Any	Island (on ground) Vessel route (300 m elevation)	67 m (220 ft) n/a
Drilling and production	Any	Island	30 m (98 ft)

Note 1: NMFS interim guidance behavioral thresholds are RMS 100 dB re 20µPa (airborne noise).
Note 2: For some scenarios, the identified distances may be within the activity footprint, so no actual behavioral response is possible.

6.4.3. Noise Modeling Method

Noise modeling software SoundPLAN Version 7.4 has been used to calculate noise emissions and propagation for this project. The ISO 9613-1 (ISO 2015) and ISO 9613-2 (ISO 2012) algorithms have been used to calculate propagation and attenuation including effects such as:

- Geometric spreading;
- Ground attenuation;
- Atmospheric absorption;
- Barrier attenuation (due to terrain); and
- Moderate downwind or inversion conditions.

6.4.4. Noise Modeling Inputs

Terrain elevation data and scenario layouts were provided by Hilcorp. Full details of noise sources that have been included in the model for each scenario are attached in Appendix A. Details in Appendix A include source sound power level, height, and data source. Typical octave-band frequency spectrum shapes have been identified for each source type.

Equipment noise levels for stationary or quasi-stationary noise sources such as pile drivers, generators, and excavators are based on the energy average sound level (L_{eq}). Noise levels for mobile equipment such as trucks and transportation vessels are based on the maximum pass-by sound pressure level (L_{max}).

Ground attenuation over the sea was calculated using a reflective surface parameter (G=0) for both open water and ice-covered conditions. Ground attenuation over land for open water scenarios was calculated using a partially absorptive surface parameter (G=0.5), corresponding to arctic tundra with densely scattered bodies of water. Ground attenuation over land for ice-covered scenarios was also calculated using a partially absorptive surface parameter (G=0.5), corresponding to old snow cover.

Meteorological parameters typical of open water and ice-covered seasonal conditions were used in the computer model calculations. Predicted sound levels for open water scenarios were calculated for a temperature of 40°F (4.4^{o}C) and a relative humidity of 70 percent. Predicted sound levels for ice-covered scenarios were calculated for a temperature of -20°F (-29°C) and a relative humidity of 70 percent. Assumed downwind or inversion conditions produce downward refraction of air-borne sound, resulting in enhanced sound propagation between the source and receptor.

All calculations results correspond to un-weighted sound pressure levels at 5 ft (1.5 m) above ground level.

6.4.5. Airborne Noise Modeling Results

Sound propagation predictions have been conducted for each of the identified scenarios. Prediction results are summarized in Table 6-14 in terms of the radius around the noise source with noise above the 100 dB re: 20microPa rms threshold. The noise model was designed to predict environmental noise levels, and was not designed to predict levels in very close proximity to the sources. As such, a specific radius is not provided for scenarios where the 100 dB rms noise level contour lies within 50 ft (15 m) of the source.

All results presented in Table 6-14 correspond to propagation over ice or water, where the ground is modeled as "hard" (G=0). "Hard" ground reflects sound and therefore promotes sound propagation. Soft ground or snow is more absorptive and less reflective. The hard ground assumption is therefore a worst-case scenario for airborne noise propagation.

The potential underwater and airborne noise levels during construction and operation of the LDPI Project are summarized in Table 6-14. The impact pile driving scenario has the largest 100 dB noise contour radius of 330 ft (100 m). The second largest 100 dB noise contour radius is 220 ft (67 m) for the helicopter during take-off and landing. The helicopter does not generate noise above 100 dB_{rms} on the ground while flying at an elevation of 1,000 ft (300 m). The 100 dB noise contour radius is predicted to be 100 ft (30 m) for drilling and production, and 50 ft (15 m) or less for all other scenarios.

6.5. Exposure Estimates for Marine Mammals

6.5.1. Level A Exposures

SLR (2017; Appendix A) reported that Level A exposures were only possible during the open water season and are therefore only calculated during that period. As reported in SMRU 2017 (Appendix B) given the small estimated range and long exposure time needed to reach the Level A exposure threshold for vibratory sheet piling (Table 6-13), it was not deemed plausible that a marine mammal would be exposed to a Level A exposure from those activities. While slope shaping activities may exceed the Level A threshold, the distance to that threshold is less than 10 m (33 ft). Animals are not expected to occur within 10 m of the island during construction, particularly for any given amount of time that could cause PTS. All pile driving activities would be completed during the winter in ice-covered conditions and potentially approximately two weeks during open water (i.e., July 1 – 15th).

Level A exposures were calculated by taking the density for a given species during the period of impact sheet pile driving (summer average density from Table 6-8), times the area encompassing the 40 min. Level A exposure threshold for that species (from Table 6-13), times the number of days of exposure. This was added to the exposures estimated for conductor pipe driving. Note that the areas in Table 6-13 are halved for sheet pile driving to account or the shadowing effect of the island:

0.004 bowheads/km^2 X 5.91 km^2 X 15 days = 0.708 (rounded to 1 bowhead), plus
0.004 bowheads/km^2 X 2.38 km^2 X 15 days = 0.14 (rounded to 1 bowhead).

Therefore, as shown in Table 6-15, the total estimated Level A exposures for bowhead whales is two. Appendix B-1 provides a calculation table for all level A takes.

Table 6-15. Estimated Level A Exposures for Cetaceans During Year 2 (pile driving) of the 5-Year Period With No Mitigation

Species	Level A Exposures*	Percent of Population
Bowhead whale	2	0.012
Beluga whale	2	0.006
Gray whale	0	<0.001

* Exposures and potential 'takes' would only occur during year 2, open water season.

It should be noted that there have never been any injurious or lethal takes documented during the monitoring efforts that have occurred during Northstar construction and operations from 2000 to 2009 (BPXA 2009). While one mortality was documented in the 1990s during a vibroseis program outside the barrier islands east of Bullen Point in the eastern Beaufort Sea (MacLean 1998), there is no evidence that the activities at LDPI site will have different results than Northstar or other coastal operations that are now in service, given the proposed mitigation and monitoring at the site (see Sections 11 and 13). Therefore, as a precautionary measure, Hilcorp requests two takes for ringed seals over the 5-year period to account for potential (although unlikely) mortalities associated with ice road construction. These takes are considered separate from the takes requested for potential PTS during pile driving if that occurs during open water (see Table 6-19).

6.5.1.1. Cetaceans

Exposure to noise levels that exceed Level A thresholds for cetaceans are only projected to occur during Year 2 when impact sheet piling and impact pipe driving could occur during open water (see Table 2-1). Most sheet piling will occur during the ice-covered season, with only 15 days occurring during the open water season. Based on scheduling, these 15 days of sheet piling would occur on the SW side of the island. It is assumed that during Year 2, cetaceans will not occur in the shallow waters southwest of the island between the island and the mainland, during July 1-15 when the vibratory sheet piling is scheduled. All exposures exceeding Level A thresholds and that might result in a Level A exposure are less than 0.012 percent of the species' populations (Table 6-15).

6.5.1.2. Pinnipeds

As with cetaceans, exposures to noise exceeding the Level A harassment thresholds for pinnipeds are only expected to occur in Year 1 during impact sheet piling/impact pipe driving and with no mitigation measures in place (see Table 6-16). All estimated Level A exposures are less than 0.001 percent of the species' populations. In addition, to be precautionary, Hilcorp is also requesting two takes for potential ringed seal mortality associated with ice road construction.

Table 6-16. Estimated Level A Exposures for Pinnipeds During the Five-Year Period With No Mitigation

Species	Level A Exposures	Percent of Population
Ringed seal	3	0.001
Spotted seal	2	0.0005
Bearded seal	2	0.0007

6.5.2. Level B Exposures

An estimate of exposures of marine mammals to noise levels that exceed Level B thresholds for each species was estimated by multiplying the season-specific density estimate (Table 6-8) for each species expected to be present in Foggy Island Bay with the area ensonified to the Level B threshold for the activities expected to occur on a given day. Because of the small number of potential Level A exposures, and to be conservative, the number of potential Level A exposures have not been subtracted from the Level B exposure estimates on the days that they may co-occur only during Year 2. The noise source with the largest area ensonified to the Level B threshold for a given day is termed the "dominant" noise source. This "dominant" noise source may not necessarily be the noise source with the highest amplitude. This is due to the different thresholds for impulsive (160dB$_{rms}$) and non-impulsive (120 dB$_{rms}$) noise. Because the non-impulsive threshold is 40 dB lower, the threshold can cover a much larger area. Based on the LDPI DPP (Hilcorp 2017) and noise modeling results (SLR 2017), the dominant noise source for each day of the 5-year period was identified and multiplied by the seasonal density of marine mammals (see Figure 6-4).

To estimate exposures of marine mammals to noise levels that may exceed Level B thresholds, the following calculation was used.

$$TAE \times D = TE$$

TAE = Total Area Ensonified (Table 6-9); based on dominant noise source during that period)

D = Species Density (Table 6-8; variable by season)

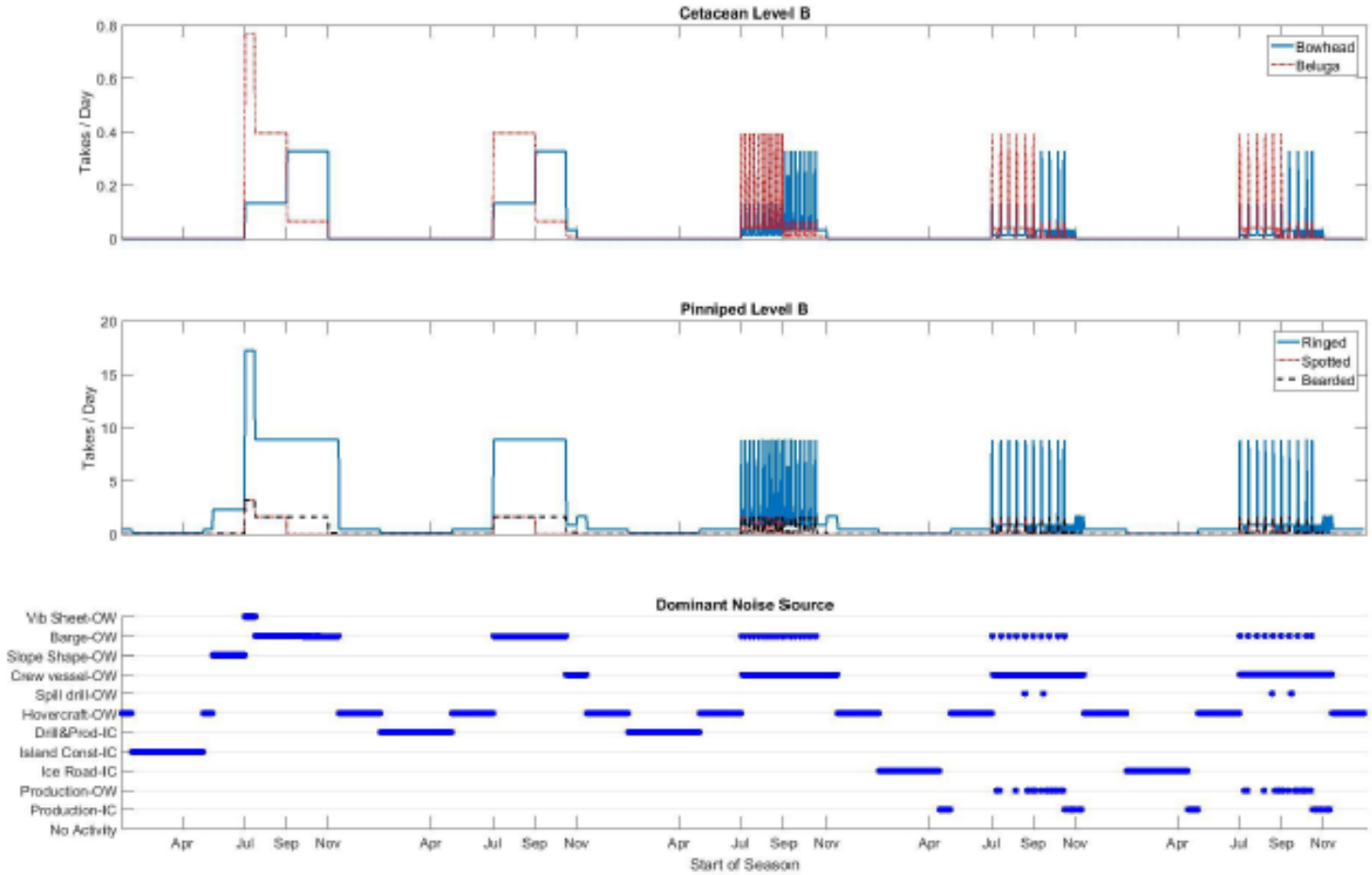
TE = Total Estimated Exposure Per Day by Species

For example, to calculate the estimated exposure of ringed seals in Year 2, the dominant noise source that may exceed Level B thresholds includes slope shaping which may occur between July 15 and August 31 when open water conditions exist.

$$4.23 \text{ km (TAE)} \times 0.27 \text{ (summer ringed seal density per km}^2\text{)} = 1.14$$

To calculate the total number of potential takes during Year 2, the "dominant" noise source during each day was selected, then this same calculation applied to estimate potential take per day. These numbers were summed for the entire year to estimate total take for Year 2. Finally, total takes for each year were added for a total during the 5-year period.

Figure 6-4. Plot of Level B Potential Exposures/Day and the 'Dominant' Noise Sources Driving Estimated Potential Exposures



Source: (SMRU 2017)

Note: Top trace are cetaceans, middle trace are pinnipeds and bottom trace are noise sources, ranked from smallest area (bottom) to largest area (top). The blue lines indicate time periods when that noise source is dominant during the 5-year period. The two-letter code after each noise source indicates when the activity occurs (OW=open water; IC=ice-covered). The start of each season is indicated on the x-axis, where changes in density can occur

During Year 2, when the island is scheduled to be constructed, Level B exposures are dominated by vibratory sheet pile activities that are scheduled to occur mid-March through mid-July. During this period, it is assumed that 15 days of sheet pile driving will occur in open water conditions. In addition, slope shaping may be necessary between July 15 and August 31 but would not likely occur every day. Level B thresholds may be exceeded during slope shaping and have been included in the exposure estimates presented in Tables 6-17. In Years 3, 4 and 5, noise that exceeds the acoustic threshold for Level B harassment during open water generally occurs from drilling and production; field measurements for these activities will be collected using passive acoustic monitoring as proposed in Section 13.

6.5.2.1. Cetaceans

For each cetacean species the number of animals exposed to sound levels sometimes associated with Level B behavioral responses is less than 0.1 percent of each species population or stock abundance for years 1 and 2 and less than 0.01 percent for the remaining three years (Table 6-17).

Table 6-17. Estimated Level B Acoustic Exposures for Cetacean Species That May Occur in the LDPI Project Area

Species	Population Size	Estimated Exposures/Takes	Percent of Population
Bowhead whale	16,091		
Yr 1		0	0
Yr 2		5	0.03
Yr 3		1	0.006
Yr 4		1	0.006
Yr 5		1	0.006
Beluga whale	32,453		
Yr 1		0	0
Yr 2		12	0.04
Yr 3		1	0.003
Yr 4		1	0.003
Yr 5		1	0.003
Gray whale	20,125		
Yr 1		0	0
Yr 2		0	0
Yr 3		0	0
Yr 4		0	0
Yr 5		0	0

As stated previously being exposed to this level of noise does not automatically imply that harassment has occurred. The MMPA and its implementing regulations do not have a clear operational definition of "take by harassment". There is recognition that minor and brief changes in behavior generally do not have biologically significant consequences for marine mammals and do not "rise to the level of taking" (NRC 2005). Also, Southall *et al.* (2007) emphasized the need to distinguish minor, short-term changes in behavior with no lasting biological consequences from biologically significant effects on critical life functions such as growth, survival, and reproduction. The biological relevance of a behavioral response to noise exposure depends, at least in part, on how long the response persists. Southall *et al.* (2007) noted that "a reaction lasting less than 24 hours is not regarded as particularly severe unless it could directly affect survival or reproduction." Based on these considerations, it is highly unlikely that the potential

behavioral effects from this Project would result in anything more than minor, biologically insignificant consequences for any individual animal or for the population.There is compelling evidence that factors other than received sound level, including the activity state of animals exposed to different sounds, the nature and novelty of a sound, and spatial relations between the sound source and receiving animals (i.e., the exposure context) strongly affect the probability of a behavioral response (Ellison *et al.* 2011). As such, the limited observed effects would not constitute a "take" under the definition of NMFS (2000) that minor and brief changes in behavior generally do not "rise to the level of taking".

The Northstar studies have shown that any disturbance and displacement effects on seals and whales that do occur are subtle and localized (Moulton *et al.* 2003b, 2005; Blackwell *et al.* 2004a, 2004b; Williams *et al.* 2006b; Richardson and Williams 2002, 2003; Richardson 2008; BPXA 2009; McDonald *et al.* 2012; Richardson and Kim 2013). These very limited effects have not resulted in any documented biologically significant consequences for many (if any) individual seals and whales, and have had no documented population consequences. Northstar data provide evidence that the activities planned for LDPI will not result in significant, population-level effects resulting from the potential of incidental take.

As previously stated, Southall *et al.* (2007) emphasized the need to distinguish minor short-term changes in behavior with no lasting biological consequences from biologically significant effects on critical life functions such as growth, survival, and reproduction. The biological relevance of a behavioral response to noise exposure depends, at least in part, on how long it persists. There is general recognition that minor and brief changes in behavior generally do not have biologically significant consequences for marine mammals and do not "rise to the level of taking" (NRC 2005). It should be emphasized that there is no established criterion for determining how large a displacement or change in calling behavior would need to occur before a bowhead whale should be considered "taken by harassment" (BPXA 2009).

NMFS has concluded that minor and brief changes in behavior generally do not "rise to the level of taking" (NMFS 2000). Offshore displacement of the migration route of a given whale by 1.2 or 1.9 mi (2 or 3 km), or even 3.1 mi (5 km), is well within the natural range of variability and placed in context it is unlikely that this would have negative consequences for an individual whale (Ellison *et al.* 2011). An exception could occur if the whales were displaced from an area of particular significance to bowheads. However, there is no evidence that bowheads migrate through, congregate or feed within the barrier islands of Foggy Island Bay. Generally, the eastward spring migration is considerable north of the islands, and the westward-fall migration remains outside the islands. In addition, subsistence records do not show a directed harvest in the area (see Section 8). Even if whales were exposed to elevated noise levels from construction activities at LDPI and a 'displacement' effect could be determined, there is no evidence from Northstar or other Beaufort Sea development projects to suggest that these changes are biologically significant (BPXA 2009).

NRC (2005) suggested that biologically significant effects for migrating animals might be possible if either the path length or the duration of migration were increased into the upper quartile of the normal time or distance of migration (BPXA 2009). NRC (2005) further noted that, if the effect of the activity extends for only a small duration or along only a small part of the migration path, such data alone might be sufficient to determine that the effect is not biologically significant.

Apparent displacements evident at Northstar (at most a few km) increased the duration or distance of migration by only a very small percentage (BPXA 2009). Southall *et al.* (2007) noted that "a reaction

lasting less than 24 h and not recurring on subsequent days is not regarded as particularly severe unless it could directly affect survival or reproduction". Based on these considerations, it was determined that the apparent effects found in the Northstar studies would result in biologically insignificant consequences for any individual bowheads or for the population and as such the limited observed effects would not constitute a "take" under the NMFS[16] definition. It is not believed that any exposure to elevated noise levels within Foggy Island Bay from development at the LDPI would result in biologically significant consequences for any individual cetacean of any species.

6.5.2.2. Pinnipeds

Due to higher densities, the majority of estimated Level B takes for the LDPI Project involve pinnipeds. Still, estimated pinniped takes per year are less than 0.5 percent of the species' population and during most years, the number of takes as a percentage of abundance approached zero. Ringed seals comprised the majority of takes for the project with 81 percent of all estimated pinniped takes. Bearded seals comprised 12 percent of the total estimated takes and spotted seals comprised 7 percent of the estimated takes.

Ice road construction and ice-road activities would commence during winter and be completed prior to March 1 ringed seal denning season. Potential takes during early winter (November through February, and prior to lairing) are significantly reduced as a result. Takes are estimates of the number of individuals potentially exhibiting a meaningful behavioral response during a day and therefore overall take estimates may include repeated takes of the same animal on different days.

6.5.3. Non-Auditory Effects of Vessel or Vehicle Traffic and Presence of Humans

Potential non-auditory effects associated with this project and evaluated here include presence of vessels (including disturbance or potential for ship strike) or vehicles, and disturbance to marine mammals in the presence of humans. Vessel strikes are major sources of direct mortality or injury to large marine mammals, like whales. Between 1975 and 2002, 292 ship strike reports of large whales were reviewed by Jensen and Silber (2003). From these reports, eleven species were confirmed victims of ship strikes. Finback whales are the most often reported species hit (75 records of strike), followed by humpback (44 records), North Atlantic right (38 records), gray (24 records), minke (19 records), southern right (15 records), and sperm whales (17 records). Far fewer reports exist of strikes to blue (eight records), Bryde's (three records), sei (three records) and killer whales (one record). According to the ship strike database, (Jensen and Silber 2003) show that 48 ship strikes (16.4 percent) resulted in injury and 198 (68 percent) were fatal. Importantly, the average vessel speed in 58 of the reported strike cases was 18.6 knots, with speed ranges falling into one of three categories: 13 to 15 knots, 16 to 18 knots and 22 to 24 knots (Jensen and Silber 2003). Based on these reports, ship strikes of smaller cetaceans and pinnipeds are much less common, possibly due to their smaller size and more agile nature. Low vessel speed, in combination with the timing and location of activities, could reduce potential impacts resulting in mortality to whales.

As described in the 2012 Biological Opinion for Northstar (NMFS 2012c), "between 1976 and 1992, only three ship strike injuries were documented out of a total of 236 bowhead whales (0.01 percent) examined

[16] "Small takes of marine mammals incidental to specified activities; oil and gas exploration drilling activities in the Beaufort Sea, Notice of issuance of an incidental harassment authorization" at *Federal Register* 66 FR 9291, 7 February 2001.

from the Alaskan subsistence harvest (George et al. 1994)". Bowhead whales have been documented to allow slow moving vessels that do not change direction or speed suddenly to approach within several hundred meters, indicating some level of tolerance of vessel presence (Wartzok *et al*. 1989; Richardson *et al.* 1995; and Heide-Jørgensen *et al.* 2003 as cited in NMFS 2012c).

Proposed mitigation measures are described in detail in Section 11.1 and include: reducing vessel speed to 5 knots (kn) within 900 ft (274 m) of whales; avoiding multiple changes in direction; reducing vessel speed when visibility is poor; not approaching within 2624 ft (800 m) of a North Pacific right whale or within 3 nm (5.6 km) of Steller sea lion rookeries or major haulouts; avoiding North Pacific right whale critical habitat or if necessary, reducing vessel speed if critical habitat cannot be avoided; and finally, not allowing tow lines to remain in the water or trash to be thrown overboard (see Section 11.1).

Ocean-going barges and other larger vessels associated with Liberty would be inshore of the bowhead whale migration corridor, and would not overlap with their migration in August/September (heading east towards the Canadian Beaufort Sea) or November (heading west and south) (see Section 4.1). Small crew vessels would be operating between shore and LDPI within Foggy Island Bay where bowhead whales are not known to occur. Emergency oil spill response vessels operated by ACS would also be in the Project vicinity conducting exercises during open water season as described in more details in Section 1.3.7.

During the spring and fall, most beluga whales in the central and eastern Beaufort Sea migrate along the ice edge in deep offshore waters more than 60 mi north of the coast migration (Clarke *et al*. 2012a, 2013). While beluga whales may occur within Foggy Island Bay (see Section 4.1.3), the potential for ship strike of these cetaceans is not likely to result in take due to proposed mitigation measures including the slow vessel speeds, avoidance of groups of whales, and the fact that belugas would likely avoid vessel interactions by swimming away. As stated in the NMFS 2014 Biological Opinion for Foggy Island Bay geohazard surveys, despite the fact that observers routinely sight bearded and ringed seals during oil and gas exploration activities, there have been no incidents of ship strike with bearded or ringed seals documented in Alaska (BOEM 2011). Bearded and ringed seals are not likely to be at risk for vessel strike also due to reduced vessel speed. Also, bearded seals are more likely to be farther out from shore that where vessels may be transiting, further reducing the risk of any interaction.

Ringed seals may be present in the project area during the ice-covered season (approximately November through late June) when ice roads may be used during construction activities. As described in Section 11.2.1, ice road construction would commence as early in winter as possible and be completed before March 1 to avoid the potential for injury or serious mortality of seals in lairs due to vehicle crushing. As described in Section 4.2.2, ringed seals begin to establish lairs in late March. In addition, subsistence advisors would walk ice road corridors prior to ice road construction, checking for lairs so they can be avoided (see Section 11.2.1 for more detail). Regarding potential disturbance due to vehicle or human presence, Williams *et al.* (2006b) concluded that within a few meters of the Northstar Island oil development, ringed seal breathing holes and lairs were established in the landfast ice before and during construction activities. Many of these structures were maintained by seals for up to 163 days, despite the presence of low-frequency industrial noise and vehicular use of ice roads. Considering proposed mitigation measures to avoid seals and based on existing literature and history in region described here, the potential for injury or mortality to ringed seals from crushing is highly unlikely assuming ice road construction and activities will commence before March 1 of each year. Also, as evident from Northstar

summarized by Williams *et al.* (2006b), disturbance to seals from vehicle presence would not result in biologically significant effects constituting take. However, to be precautionary, takes associated with disturbance due to increased noise associated with a higher number of ice roads and increased ice road use during construction years have been included in the exposure estimate.

6.5.4. Take Request by Year and Species

Based on the project scenarios, noise sources and locations shown in Table 1-3, and the timing of activities shown in Table 2-1, along with the exposure estimates described in Sections 6.5.1 and 6.5.2, Hilcorp requests the following number of annual level A takes by species as shown in Table 6-18. The abundance of the populations, as summarized in Section 3, is also provided with the calculated percent of the population. The percentage of all species annually requested to be taken by Level A harassment is less than 0.001 percent of the population for all species.

Level A exposures, and potential takes, may only occur in Year 2 during the 15 days that impact sheet piling and impact pipe driving will take place during the open water season and provided there are no mitigation measures in place. No gray whales are expected to be taken by activities at the LDPI however 2 takes are requested in Year 2 to be precautionary, and to ensure compliance with the MMPA in case of an unforeseen occurrence of gray whales in area. Hilcorp anticipates there will be no more than a negligible impact on small numbers of marine mammals during the LDPI development from exposure to noise levels that may exceed Level A thresholds.

It is clear from recorded sighting data that a potential Level A take for any cetacean including beluga whales is highly unlikely. The estimated number of potential Level A takes for bowhead and beluga whales is two whales in Year 2 as the distance to a 2.5-hour Level A threshold is <33 ft (10 m) for both species during open water conditions (Table 6-10). Reaching two Level A takes during any year is an unlikely scenario for several reasons. This exceeds any number of bowhead whales recorded inside Foggy Island Bay in any given year (MMS 2002a,b). While bowhead whales have been seen at a distance of 7 mi (11 km) from the LDPI island, they have not been recorded (during aerial surveys or from subsistence whalers' observations) inside the Level A threshold distance (MMS 2002a,b). Similarly, beluga whales have been observed within Foggy Island Bay but not within the Level A threshold zone for pile driving activities, and not for extended periods of time. Therefore, the take requests are considered very conservative and likely overestimate the number of bowhead or beluga whales potentially impacted by activities of the LDPI Project. Notably, these estimated takes assume no mitigation will be applied to further reduce this number. With mitigation measures in place, Hilcorp does not believe there will be any Level A takes of bowhead or beluga whales. At a minimum, the estimated two Level A takes per year should never be reached during any given year (see Chapter 11).

Table 6-18. Requested Number of Level A Takes as Percent of Population Per Year

Species	*Population Size	Requested Level A Takes	Percent of Population
Bowhead whale	16,091		
Yr 1		0	0
Yr 2		2	0.012
Yr 3		0	0
Yr 4		0	0
Yr 5		0	0
Beluga whale	32,453		
Yr 1		0	0
Yr 2		2	0.006
Yr 3		0	0
Yr 4		0	0
Yr 5		0	0
Gray whale[1]	20,125		
Yr 1		0	0
Yr 2		2	0.01
Yr 3		0	0
Yr 4		0	0
Yr 5		0	0
Ringed Seal[2]	300,000		
Yr 1		0	0
Yr 2		5	0.001
Yr 3		0	0
Yr 4		0	0
Yr 5		0	0
Bearded Seal	253,676		
Yr1		0	0
Yr2		2	0.0005
Yr3		0	0
Yr4		0	0
Yr5		0	0
Spotted Seal	391,000		
Yr1		0	0
Yr2		2	0.0007
Yr3		0	0
Yr4		0	0
Yr5		0	0

[1]Level A exposures for gray whale were estimated to be 0. However, takes in Year 2 are being requested to be precautionary. Similarly, Level A takes for bowhead whales and beluga whales were estimated at 1 each however, to be precautionary, 2 takes for each species is being requested for Year 2.
[2]In addition to the takes listed in this table for Level A, Hilcorp is requesting two takes for potential ringed seal mortality during construction due to the increased number of ice roads and general increase in truck traffic during this period.

As shown in Table 6-19, the proportion of each species' population requested for annual potential Level B takes is less than 0.5 percent for all species. Potential Level B takes are expected in all five years covered in this request, with the highest number of potential Level B takes also occurring during Year 2 due to the pile driving activities. Potential Level B takes are predicted to be highest during the open water season which is anticipated to last approximately 15 days (~July 1 – 15 depending on ice cover). Very few potential takes are expected during the winter and spring. Slope shaping may also occur between July 15 and August 31 of Year 2 and may contribute to Level B exposures. Most potential Level B takes occur, in part, due to their temporal overlap with higher marine mammal densities. For beluga whales,

exposures for Years 3-5 have been increased due to the possibility that whales could occur in small groups as reported by Smultea *et al.* (2014). Annual estimate Level B takes were increased by 2.5 to account for group size. While no takes of gray whales are expected, one Level B take for Years 2 - 5 each has been requested to ensure compliance with the MMPA and NMFS requirements. Based on these considerations, it is highly unlikely that any potential behavioral response due to noise from this project would result in anything more than minor, biologically insignificant, consequences for any individual animals or for the population. Nevertheless, Hilcorp is requesting Level B take authorizations as described in Table 6-19.

Table 6-19. Requested Number of Level B Takes as Percent of Population Per Year

Species	Population Size	Requested Level B Takes	Percent of Population
Bowhead whale	16,091		
Yr 1		0	0
Yr 2		5	0.03
Yr 3		1	0.006
Yr 4		1	0.006
Yr 5		1	0.006
Beluga whale	32,453		
Yr 1		0	0
Yr 2		20[1]	0.0006
Yr 3		20[1]	0.0006
Yr 4		20[1]	0.0006
Yr 5		20[1]	0.0006
Gray whale[2]	20,125		
Yr 1		0	0
Yr 2		1	0.005
Yr 3		1	0.005
Yr 4		1	0.005
Yr 5		1	0.005
Ringed Seal	300,000		
Yr 1		2	0
Yr 2		336	0.11
Yr 3		21	0.007
Yr 4		21	0.007
Yr 5		13	0
Bearded Seal	253,676		
Yr 1		1	0
Yr 2		58	0.02
Yr 3		1	0
Yr 4		1	0
Yr 5		1	0
Spotted Seal	391,000		
Yr 1		0	0
Yr 2		58	0.02
Yr 3		1	0
Yr 4		1	0
Yr 5		1	0

[1] The requested beluga takes for Year 2 was 12 animals, and 1 animal in each of Years 3 – 5. However, the requested beluga takes for Years 2 through 5 account for the potential to encounter small groups of whales. Therefore, while the estimated exposure for belugas is less than 1 for most years, the take request considers group size into account based on sighting data described in Section 6.1.1.2.

[2]Take of gray whales was estimated to be 0 for Years 2 – 5 due to the fact that gray whales are rare in this area. However, to be precautionary the take estimate includes 1 whale per year during Years 2-5.

7. Anticipated Impact of the Activity on Species and Stocks

The potential impacts of LDPI construction activities on marine mammals involve both non-acoustic and acoustic effects. Based on Richardson *et al.* (1995) and BXPA (2009), the effects of noise on marine mammals are highly variable and can be categorized as follows:

- The noise may be too weak to be heard at the location of the animal; in other words, lower than the prevailing ambient noise level, the hearing threshold of the animal at relevant frequencies, or both.
- The noise may be audible but not strong enough to elicit any overt behavioral response depending in part on movements and behavior of whales (Ellison *et al*. 2011). This has been demonstrated upon exposure of bowhead whales to low levels of seismic, drilling, dredge, or icebreaker sounds.
- The noise may elicit reactions of variable conspicuousness and variable relevance to the well-being of the animal. These can range from subtle effects on respiration or other behaviors (detectable only by statistical analysis) to active avoidance reactions.
- Upon repeated exposure, animals may exhibit diminishing responsiveness (habituation), or disturbance effects may persist or exhibit increasing responsiveness (sensitization). The latter are most likely with sounds that are highly variable in characteristics, unpredictable in occurrence, and associated with situations that the animal perceives as a threat.
- Any anthropogenic noise strong enough to be heard has the potential to reduce (mask) the ability of marine mammals to hear natural sounds at similar frequencies including calls from conspecifics, echolocation sounds of odontocetes (used for navigation and other functions), and environmental sounds such as ice or surf noise. Intermittent sounds, such as those from impact hammers, may cause strong masking for only a fraction of the time when compared to continuous sounds.
- Very strong sounds have the potential to cause temporary (TTS) or permanent (PTS) reduction in hearing sensitivity. Effects of strong sounds of varying durations on hearing thresholds of pinnipeds and odontocete cetaceans have received considerable study in recent years (e.g., Kastak *et al.* 1999; Schlundt *et al.* 2000, 2006; Finneran *et al.* 2002, 2003, 2005, 2007; Southall *et al*. 2007; Lucke *et al.* 2009). Received sound levels must far exceed the animal's hearing threshold for there to be any TTS. The TTS threshold depends on duration of exposure; the sound level necessary to cause TTS is higher for short sound exposures than for long sound exposures. Received levels must be even higher to risk permanent hearing impairment (PTS), especially for non-impulse noise.

Additionally, evidence from the 2000 Northstar monitoring report suggests that seals did not appear to be affected by pile driving to an extent that resulted in significant changes in behavior. The following excerpt is from the Northstar report:

> "Seals in the moat were exposed to received sound levels up to 154 dB re 1 mPa (rms) when they dove close to the bottom (see Chapter 7). Despite this, no strong avoidance reactions were observed. Levels received by seals at or near the surface of the water were presumably weaker because of pressure release effects (Urick 1983; Greene and Richardson 1988). However, there was no indication that seals sighted in the moat were reluctant to dive, or that they were doing so for shorter periods than usual, as compared with observations of ringed seals from vessels either underway or stationary (JWL and

> MTW, pers. obs.). The juvenile seal observed on 21 June spent more than two minutes swimming (and submerging) in the moat edge nearest to the conductor driving site. Other seals observed in the moat dove and resurfaced at similar intervals during periods with and without pipe driving" (Williams and Richardson 2001).

The following considers the potential impact to marine mammals from the LDPI Project through potential auditory impact, masking, disturbance, and consideration of the "small-numbers" and "negligible impact determination" required by the MMPA. Factors other than received sound level, including the activity state of animals exposed to different sounds, the nature and novelty of a sound, and spatial relations between sound source and receiving animals (i.e., the exposure context) strongly affect the probability of a behavioral response (Ellison *et al.* 2011).

7.1. Hearing Impairment and Non-auditory Injury

Permanent or temporary hearing impairment or threshold shifts (PTS or TTS) could occur when marine mammals are exposed to very strong sounds or to less strong sounds for a prolonged period. When animals are in close proximity to the sound source there is a potential for PTS or TTS. These threshold shifts can occur on a temporary or permanent level, depending on the intensity of the sound and length of time to which the animal is exposed to the sound. NMFS' revised acoustic guidelines (NMFS 2016) take into account the most recent scientific data on TTS. Typically, TTS includes impacts to middle-ear muscular activity, increased blood flow, and general auditory fatigue (Southall *et al*. 2007). At the TTS level, animals do not experience a permanent change in hearing sensitivity and exhibit no signs of physical injury.

Hearing impairment might occur in marine mammals exposed to strong, underwater sounds. However, except for limited data available from captive marine mammals who could not move away from the sound source, there is little definitive evidence that any of these effects occur even for marine mammals in close proximity to sound sources in the wild although non-auditory physical effects (e.g., stress) might result. The proposed Project will have the possibility to result in the Level B harassment of pinnipeds and cetaceans due to increases in noise levels associated with pile driving (primarily vibratory sheet pile driving) and possible slope shaping. Level B harassment is temporary in nature, and the impacts associated with the potential harassment resulting from this project will be temporary. Mitigation measures discussed in Chapter 11, however should prevent Level A takes of all species should animals approach the LDPI during construction.

Given the brief duration of exposure of any marine mammal in combination with the proposed monitoring measures, auditory impairment or other non-auditory physical effects is unlikely to occur during the proposed LDPI Project. It is not expected that any of the potential marine mammal responses as a result of increased noise levels around the LDPI will have any impacts on the life-history of the animals such as decreased survival or fitness resulting in a decrease in recruitment rates. Cetaceans do not calve in the area and the area is not a major feeding area for any cetacean. Potential impacts to pinnipeds will be monitored and recorded. However, based on previous similar studies at Northstar, pinniped densities are not expected to change in the Action Area as a result of construction activities at the LDPI. Effects on reproductive rates or survival of seals in the vicinity of Northstar have not been documented and are not expected at the LPDI site. Despite the unlikelihood of any impact affecting fitness or survival, marine

mammal responses to potential noise or disturbance will be recorded as part of the monitoring program (see Section 13.3).

7.2. Masking

Natural and artificial sounds can disrupt behavior by masking. The masking of communication signals by anthropogenic noise may be considered as a reduction in the communication space of animals (Clark *et al.* 2009). The frequency range of the masking sound is important in determining any potential behavioral impacts. The most intense underwater sounds of the proposed Project are those produced by sheet pile driving.

Erbe *et al.* (2016) reviewed the current state of understanding of masking in marine mammals, including anti-masking strategies for both receivers and senders. When a signal and noise are received from different directions, a receiver with directional hearing can reduce the masking impact. This is known as spatial release from masking, and this ability has been found in dolphins, killer whales and harbor seals. Further, animals may attempt to counteract masking by increasing the source level of their vocalizations in the presence of noise. Given the hearing abilities of marine mammals, it is likely that most, if not all, species have this ability to some extent (Erbe *et al.* 2016).

The probability that pile driving associated with the proposed Project would result in masking acoustic signals important to the behavior and survival of marine mammal species is low. Vibratory sheet pile driving is only expected to occur for approximately two and a half hours per day. It is possible that vibratory pile driving resulting from the Project may mask acoustic signals important to the behavior and survival of marine mammal species, but the short-term duration (up to 15 days) during the ice-free season and limited affected area would result in insignificant impacts from masking. Any masking event that could possibly rise to Level B harassment under the MMPA would occur concurrently within the zones of behavioral harassment already estimated for vibratory and impact pile driving or slope shaping, and which have already been taken into account in the exposure analysis.

7.3. Disturbance Reactions

Temporary changes in an animal's typical behavior or avoidance of the affected area is the most common response of marine mammals to increased noise levels (Richardson *et al.* 1995). Avoidance responses may be initially strong if the marine mammals move rapidly away from the source or weak if animal movement is only slightly deflected away from the source. Elevated noise levels could displace marine mammals from the immediate proximity of the sound source; this behavioral response might protect animals from potentially harmful sound exposures.

The biological significance of many of these behavioral disturbances is difficult to predict, especially if the detected disturbances seem to be minor. Responses to continuous sound, such as vibratory pile installation, have not been documented as well as responses to pulsed sounds. With both types of pile driving or slope shaping, it is likely that the onset of pile driving could result in temporary, short term changes in an animal's typical behavior or avoidance of the affected area (Richardson *et al.* 1995). However, the biological significance of many of these behavioral disturbances is difficult to predict, especially if the detected disturbances appear minor. The exposures to sound levels that exceed potential behavioral thresholds (therefore potential Level B takes) considered in this application would be short-

term, localized and would have no biological significance to reproduction and survival rates or population trends.

The most likely effects of early winter activities (November through February, and prior to denning) could be temporary and localized disturbance to a small number of adult and subadult ringed seals. This disturbance could result from the increased ice road construction, traffic on the ice, spill response training, emergency evacuation training, and exposure to noise and vibration from island activities. However, Hilcorp has committed to beginning ice road construction and activities during mid-winter, and has targeted March 1 as the latest date for initiation of ice road construction. So while seals may be displaced for a few hours and up to a distance of 320 ft (100 m) at most from the immediate area of some activities (Williams *et al.* 2006a, 2006b, 2006c, Kelly *et al.* 1986), ice road construction would be commenced prior to the mid-March through April pupping season.

In late fall or early winter as soon as ice begins to form, ringed seals start to construct and maintain a series of breathing holes (Smith and Stirling 1975; Frost and Burns 1989, as reported in Williams *et al*. 2006a). Pups are typically born in lairs between mid-March through April, and mothers nurse their pups in the lairs for five to eight weeks (Smith 1973; Hammill *et al.* 1991; Lydersen and Hammill 1993, Williams *et al.* 2006c). Ice-road construction is scheduled to begin prior to March 1 to avoid this pupping period (see Mitigation, section 11.2). Seals avoid this area during pupping so it is logical to assume that that avoidance would continue after pupping season is over.

Data from a study conducted for Northstar Island Production Facility documented that of 181 ringed seal lairs, 118 (65 percent) were actively used by late May (Willliams *et al.* 2006c). Northstar is located 6 mi (9.5 km) from the mainland on a manmade gravel island in 39 ft (12 m) of water; this region is covered by landfast ice, an important overwintering and spring breeding habitat for ringed seals (Kelly *et al*. 2010b). Williams *et al.* (2006 a, 2006b, 2006c) concluded that within a few meters of the Northstar Island oil development, ringed seal breathing holes and lairs were established in the landfast ice before and during development and construction activities. Despite the presence of low frequency industrial noise and vibration due to construction and use of ice roads, many of these structures were maintained by seals for up to 163 days (Williams *et al.* 2006c) or nearly the entire winter pupping and nursing period, without abandonment. While the construction and use of ice roads may result in disturbance from vibration or noise, these studies indicate that ringed seals may tolerate this kind of activity. It is worth noting that Northstar studies showed no evidence of displacement of seal structures beyond the immediate vicinity of the thickened ice itself. Until birthing lairs are occupied in March, seals are mobile, and they simply avoid the ice roads themselves. They may take advantage of stress fractures that form next to ice roads, which might facilitate construction and maintenance of breathing holes, but there is no evidence of seals avoiding anything beyond the thickened ice itself (B. Streever, pers. comm.).

7.4. Small Numbers Consideration

Tables 6-18 and 6-19 indicate the number of animals potentially exposed to elevated noise levels from the LDPI Project, and that could result in a Level A or Level B take by harassment. The number of exposures to noise levels that exceed Level A take without mitigation for bowhead whales is two (Table 6-19) which

is 0.01 percent of Potential Biological Removal[17]. Potential Biological Removal (PBR) is 161 for the western Arctic bowhead stock (Muto *et al.* 2016) and therefore considered "small".

For pinnipeds, the analyses provided in Table 6-18 show that <0.0005 percent of the minimum estimate of the total stock for all pinnipeds have the potential to be impacted through exposures of elevated noise that exceed Level A harassment thresholds as a result of activities at the Project site. All exposures that could exceed Level A thresholds occur in the first year (SMRU 2017). This is a level considered small and negligible by NMFS. Level B take estimates are well less than 0.2 percent for all species, all years and are zero or approach zero for all species except ringed seal (0.11 percent). Generally, ringed seals have the greatest likelihood of being disturbed by the proposed activities at the LDPI construction site (Table 6-19), but the absence of obvious effects on seal abundance in the vicinity of Northstar suggests that ringed seals are tolerant of disturbances and that, therefore, the estimates for potential take levels are high.

Also there are multiple reasons why the calculated estimate of Level A and Level B ringed seal "takes", when compared to N_{min} (N_{min} equals the best population estimate for this species [N_{best}]) should be considered inflated and a worse-case scenario. Frost (1985) estimated 1 to 1.5 million ringed seals in Alaska waters, of which 250,000 were estimated in shore-fast ice. The minimum abundance estimate of 300,000 ringed seals (Tables 3-1 and 6-19) was presented in Kelly *et al.* (2010a) and is based on estimates from surveys by Bengtson *et al.* (2005) and Frost *et al.* (2004) in the late 1990s and 2000. This estimate is considered an underestimate, as it is based on surveys of a portion of the range (the Beaufort surveys were within 40km of shore and did not include offshore ice), and is more than 8 years old (Muto *et al.* 2016). It is very consistent with the estimate of Kelly (2010a) for nearshore waters but does not include the offshore ice where ringed seals are most abundant. Therefore, a reliable estimate of N_{min} for the total population in the Alaska Chukchi and Beaufort Sea regions is not available (Muto *et al.* 2016). The 300,000 number is used as an estimate of N_{best} recognizing it is an underestimate and results in an over-estimate of the potential percentage of the population that may be affected from exposure to noise from the project that may result in Level B takes.

Also, it is very likely that the numbers of animals authorized to be taken for all species represents likely multiple sightings of a smaller number of seals over a period of 24 hours rather than a new individual each time. Generally, the estimated number of takes never exceeds 0.5 percent of N_{best} for any species except for ringed seals (Table 6-19). This is insignificant, or at least "small" from a biological perspective. NMFS considers the theoretical net productivity rate (r_{MAX}) for this stock to be 12 percent (Wade and Angliss 1997). There is no indication that the temporary, potential behavioral disturbance of 0.11 percent of seals (less than 5 percent of r_{MAX}) during the open water season at these levels would not have any effect on populations, population recruitment or survival.

Finally, in requesting a "take" authorization it should be noted that there is general recognition that minor and brief changes in behavior generally do not have biologically significant consequences for marine mammals and do not "rise to the level of taking" (NRC 2005). The biological relevance of a behavioral response to noise exposure depends, at least in part, on how long it persists. Based on these

[17] Defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population.

considerations, it is highly unlikely that the potential behavioral effects from this project would result in anything more than minor, biologically insignificant, consequences for any individual animals or for the population. As such the limited observed effects would not constitute a "take" given that minor and brief changes in behavior generally do not "rise to the level of taking". However, for the purpose of the current application, Hilcorp is requesting authorization for Level A and B takes by acoustical harassment of marine mammals to account for any unforeseen events leading to such takes and to ensure compliance with the MMPA. The take calculations assume takes of individual animals instead of repeated takes of a smaller number of individuals and are based on the loudest (i.e., 'dominant') noise sources within each scenario for the maximum duration. Therefore, the request for takes are considered very conservative.

Based on this analysis all Level A takes for each species is significantly less than 0.01 percent of N_{min} for that stock or population (Tables 6-18 and 6-19). All Level B takes are either less than 0.01 percent of N_{min} or are at a level that is significantly under r_{MAX} (i.e., birth and death rates are constant because the population is unlimited by resources) for the species. Therefore, Level B takes are at a level that would have no effect on population recruitment or survival. In conclusion, only small numbers of marine mammals are likely to be affected as a result of the proposed activities at the LDPI Project site.

7.5. Negligible Impact Consideration

In 1999 NMFS adopted criteria for making a Negligible Impact Determination (NID) for MMPA 101(a)(5)(E) permits[18]. Negligible impact is defined as "an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival"[19]. Generally, the NID is calculated as 10 percent of PBR which is equivalent to 0.01 percent of N_{min} for an endangered species. Therefore, a negligible impact finding is based on the complete lack of likely adverse effects (as generally applied through loss of individuals through serious injury or mortality) on annual rates of recruitment or survival (i.e., population-level effects).

The PBR standard has been more recently been used to estimate impacts to marine mammals from non-fishery related activities. However, an estimate of the number of Level A harassment takes alone is generally not enough information on which to base an impact determination. In addition to considering estimates of the number of marine mammals that might be "taken" through non-serious, non-injurious behavioral harassment, other factors need be considered such as the nature of any responses (their intensity, duration), the context of any responses (critical reproductive time or location, migration, etc.), as well as the number and nature of estimated Level A or Level B harassment takes, the number of estimated mortalities, effects on habitat, and the status of the species. This discussion applies to the six species listed in Table 3-1.

Pile driving and associated with the proposed LDPI Project have the potential to temporarily disturb or displace marine mammals. Specifically, the activities may result in elevating noise levels at or above thresholds for either a Level A (only during Year 2) or Level B harassment take for all species from sound generated from activities at the LDPI Project site during the open-water season between approximately July 1 – August 31. Potential takes could occur if individuals of these species are present in the ensonified zone when pile driving or slope shaping is under way.

While the potential for Level A takes have been calculated for this Project, serious injury, PTS, or mortality would be extremely unlikely for all authorized species. Any pinnipeds potentially exposed to Level A take thresholds would have to be in very close proximity to the Project site. By implementing mitigation described in Section 11, there should be no exposures to marine mammals that exceed Level A thresholds for the duration of time required to result in Level A take. No take of any marine mammal should result in serious injury or mortality.

Only one pinniped mortality has ever been reported from ice-road construction activities as discussed throughout this application. The pile-driving activities and other construction activities analyzed for this request (including ice road construction) are similar to numerous construction activities conducted in similar locations (including Northstar) where no serious injuries or mortality of marine mammals occurred. Despite this, to be precautionary, Hilcorp is requesting two takes for ringed seals over the 5-year period to account for potential (although unlikely) mortalities associated with ice road construction.

No long-term adverse consequences from behavioral harassment have been reported at the Northstar facility or at other offshore and nearshore North Slope facilities. Even repeated exposure to noise levels

[18] At *Federal Register* 64 *FR* 28800
[19] Definition at 50 CFR 216.103

that potentially exceed Level B harassment levels of some small subset of the overall stock is unlikely to result in any significant realized decrease in fitness for the affected individuals and would not result in any adverse impact to the individual or the stock as a whole.

For the Northstar facility, behavioral responses to noise within and beyond 0.62 mi (1 km) were generally limited to reduction in calls (whales), possible minor deflection (whales), movement away from noise (summarized in BPXA 2009). These responses were considered to be short-term effects having no negative consequences for biologically important life functions. Therefore, BPXA (2009) did not consider any behavioral response beyond this distance relevant in estimating the number of whales and ringed seals potentially taken (BPXA 2009). Further, it should be noted that behavioral reactions do not occur throughout the zone ensonified by industrial activity. In most cases that have been studied, including work on bowhead, gray and beluga whales, the actual radius of effect is considerably smaller than the radius of detectability (reviewed in Richardson and Malme 1993; Richardson *et al*. 1995; Nowacek *et al*. 2007; Southall *et al*. 2007). Finally, mitigation will reduce or eliminate the potential for Level A and Level B exposures from noise related activities at the LDPI construction site (see Chapters 11 and 13).

In summary, the takes requested for this activity would result in no more than a negligible impact to any of the marine mammal species that may be exposed to elevated noise levels during this Project. This is based on:

1. Estimates of take are inflated due to precautionary measures and assumptions built into the methods for estimating take;
2. Animals occurring within the Level A and Level B ensonified zones are considered to be in each zone simultaneously, i.e., the area where Level A and Level B zones overlap counts the animal in each area and would therefore present the worst-case scenario or maximum number;
3. One day equates to any length of time whether it is a partial day or a 24-hour period. All marine mammal individuals potentially occurring in the Project Area are assumed to be incidentally taken as defined by the MMPA;
4. The low probability of serious injury or mortality to species; and
5. The anticipated incidents of Level B harassment likely consisting of, at worst, temporary modifications in behavior.

The results of studies of impacts from industrial activities on marine mammals at Northstar (Moulton *et al. 2*005; Richardson 2008, 2011; Richardson and Thompson 2002; Richardson and Williams 2002, 2003; Williams *et al.* 2006a) have demonstrated that the potential effects of project construction activities would have only short-term effects on individual marine mammals. Moulton *et al.* (2005) and Williams *et al.* (2006a) also showed that effects of the Northstar oil development on local distribution of ringed seals are no more than slight, and are small relative to the effects of natural environmental factors. Moulton *et al.* further stated that an understanding of the prevailing environmental effects is essential when assessing potential anthropogenic impacts of industrial activity on ringed seals. NMFS (2012c) summarized known impacts to all marine mammals from Northstar development and production in their most recent environmental assessment and concluded no significant impacts. Therefore, the specified activities at LDPI are not expected to be any different than those at Northstar, will not alter recruitment or survival and would, therefore, not result in population-level impacts therefore resulting in no more than a negligible effect on species potentially occurring in the area as authorized under the MMPA.

8. ANTICIPATED IMPACTS ON SUBSISTENCE USE

On the North Slope "subsistence" activities are assigned the highest cultural values by the Inupiat and provide a sense of identity as well as being an important economic pursuit. Subsistence integrates nutritional and spiritual relationships to the land through the pursuit, collection, and sharing of natural resources. Subsistence connects hunters, families, and communities together for simple sharing and complex cultural celebrations including religious and social occasions; the most important ceremony, Nalukataq, celebrates the bowhead whale harvest (Bacon *et al.* 2009). Other values included an emphasis on the community, its needs, and its support of other individuals. As such, subsistence connects community members and relatives through food sharing and cooperative hunting and harvesting efforts within the community (Unger 2014). This sharing, trading, and bartering of subsistence foods also structures relationships among communities, while at the same time the giving of such foods helps maintain ties with family members elsewhere in Alaska (Heinrich 1963; Courtnage and Braund 1984).

Inupiat hunters emphasize that all marine mammals are sensitive to noise, and take pains to make as little extraneous noise as possible when hunting. Seals are also said to be cautious of any unusual visual stimulus, especially if it is in motion. At the same time, seals are said to be curious and will sometimes investigate unusual objects, and can be attracted by imitating the normal, non-vocal sounds that seals make on the ice. In general, seals are sensitive to their surroundings, are especially responsive to sound, and may avoid unusual sounds.

Bowhead whale hunting is at the center of Inupiat spiritual and emotional life (Courtnage and Braund 1984). The importance of the whale hunt is more than emotional and spiritual. The organization of the crews does much to delineate important social and kin ties within communities and to define community leadership patterns as well. The structured sharing of the whale helps determine social relations both within and between communities (Courtnage and Braund 1984). This close relationship between the people, their social organization, and the cultural value of subsistence hunting may be unparalleled when compared with other areas in the U.S. (Bacon *et al.* 2009).

Bowhead whales have shown avoidance or other behavioral reactions to underwater noise from industrial activities, but often tolerate the weaker noise received when the same activities are occurring farther away (BPXA 2009). In most cases that have been studied, including work on bowhead, gray and beluga whales, the actual radius of effect is considerably smaller than the radius of detectability. Various studies have provided information about the sound levels and distances (e.g., Richardson and Malme 1993; Richardson *et al.*, 1995; Miller *et al.* 1998) in relation to potential disturbance. In addition, bowhead whales are not expected to occur within the barrier islands. As described in SLR 2017, only the behavioral threshold for noise produced during vibratory sheet pile driving in the open water season would reach out to, but not significantly beyond the barrier islands (see SLR report ; Appendix A). Behavioral thresholds for all other noise producing work both during ice-covered and open water seasons are reached within the barrier islands and in some cases within the immediate vicinity of the island or pipeline route.

Inupiat whalers believe that some migrating bowheads are diverted by noises at greater distances than have been demonstrated by scientific studies (as reported in BPXA 2009). The whalers have also

mentioned that bowheads sometimes seem more "skittish" and more difficult to approach when industrial activities are underway in the area (Galginaitis 2006, 2007 reported in BPXA 2009; public comments at NMFS, Open Water Meeting, April 2010, Anchorage, Alaska). Recently, there has been concern among Inupiat hunters that barges and other vessels operating within or near the bowhead migration corridor may deflect whales for an extended period (a concern expressed multiple times in discussions at the Open Water Meetings, Anchorage, Alaska, 2009-2010). It has been suggested that if the headings of migrating bowheads are altered through avoidance of vessels, the whales may subsequently maintain the "affected" heading well past the direct zone of influence of the vessel. This might result in progressively increasing deflection as the whale progresses west. However, crew boats and coastal barges supporting LDPI will remain well inshore of the main bowhead migration corridor. Therefore, effects of this type are unlikely to occur in response to LDPI Project-related vessel traffic.

8.1. Subsistence-Harvest Areas in Waters Adjacent to Foggy Island Bay

The subsistence pursuit of bowhead whales has major sociocultural importance to the communities of Barrow, Nuiqsut, and Kaktovi While subsistence resource harvests differ from community to community, the bowhead whale is the preferred food and is of primary importance because it provides a unique and powerful cultural basis for sharing and community cooperation (Courtnage, and Braund 1984).

Whaling traditions include kinship-based crews, use of skin boats (only in Barrow for their spring whale-hunting season) and fiberglass skiffs with outboard motors, exploding harpoons, distribution of the meat, and total community participation and sharing. Bowhead whale hunting strengthens family and community ties and the sense of a common Inupiaq heritage, culture, and way of life. In this way, whale hunting activities provide strength, purpose, and unity. Historically, Barrow's subsistence harvest areas do not extend as far east as Foggy Island Bay, ending for the most part at the Colville River Delta. Therefore, Barrow whaling crews would not be impacted by any activities at the LDPI Project site and the subsistence harvests at Barrow are not discussed further.

Bowhead whales are harvested in Nuiqsut and Kaktovik only during the fall whaling season during which time in-water construction activities would be curtailed in accordance with measures agreed upon in the CAA. During the harvest, generally, three to four whales were harvested per year in Kaktovik and Nuiqsuit, 1994-2003 (Bacon *et al.* 2009). This trend has continued since then (BPXA 2009). While hunters may pass through the bay in transit, and have observed whales in the area on occasion, Foggy Island Bay has not been reported as a traditional whaling location in recent years. Beluga whales are taken opportunistically during the bowhead harvest and throughout ice-free months. Generally, work is not stopped for beluga hunts in this area as they are sporadic and incidental to other subsistence related activities such as fishing. This is different than the beluga whale harvest in the Chukchi where beluga whale occurrence is predictable due to foraging at mouths of rivers on fish moving into area and there is often a targeted hunt.

Most of the Beaufort Sea population migrate from the Bering Sea into the Beaufort Sea in April or May. The spring migration routes through ice leads are similar to those of the bowhead whale. A major portion of the Beaufort Sea population concentrates in the Mackenzie River estuary (Canada) during July and August. Fall migration through the western Beaufort Sea is in September or October. Small numbers of whales have been observed migrating inside of Foggy Island Bay (Smultea *et al*. 2014) but their

occurrence during summer (July-August) open water season is sporadic and not timed specifically to an event such as migrating salmon or fish moving into a river. Surveys of the fall distribution strongly indicate that most belugas migrate offshore along the pack ice front (Frost *et al.* 1988) beyond the reach of subsistence harvesters. The proposed activities at the LDPI Project site should not affect beluga whale subsistence harvests.

Nuiqsut and Kaktovik residents hunt seals in ice-free months primarily July-August in rivers outside of Foggy Island Bay. The most important seal hunting area for Nuiqsut hunters is off the Colville Delta, extending as far west as Fish Creek and as far east as Pingok Island (149º40'W). Pingok Island, the closest edge of the main sealing area, is east of Foggy Island Bay. Sealing occurs in this area by snow machine before break-up and by boat during the summer. Cross Island is a productive area for seals, but is too far from Nuiqsut to be used on a regular basis. During the whaling season, the hunters at Cross Island concentrate on bowhead whales, not seals.

While seal meat is eaten, the dietary significance of seals in both communities primarily comes from seal oil, served with almost every meal that includes subsistence foods. Seal oil also is used as a preservative for meats, greens, and berries. Seal skins are important in the manufacture of clothing and spotted seal skins often are preferred for making boots, slippers, mitts, and parka trim. In practice, however, ringed seal skins are used more often in the making of clothing because the harvest of this species is more abundant.

Bearded seals are harvested primarily in the spring during breakup of the sea ice. While they are harvested opportunistically, hunting would not be affected because bearded seals are in very low density in the action area. Generally they are largely absent throughout most of the year therefore hunting would be minimally impacted, if at all. When harvested, bearded seals are harvested for meat and for their skins. Between 1994 -2003, 29 bearded seals were taken in Kaktovik. All of these seals were taken during two years throughout that period. In Nuiqsut, 17 seals were taken during the same time period (Bacon *et al.* 2009).

8.1.1. Kaktovik Subsistence Area

Kaktovik is the easternmost village in the North Slope Borough. Kaktovik is located on the north shore of Barter Island, situated between the Okpilak and Jago rivers on the Beaufort Sea coast. Barter Island is one of the largest of a series of barrier islands along the north coast and is about 300 mi (48 km) east of Barrow. Kaktovik's subsistence-harvest areas are well to the east of the LDPI area. Generally marine mammal species migrating eastward during spring-summer occur seaward of the Project Area. The bowhead harvests occur during the fall migration before whales get to Foggy Island Bay. Therefore activities at the LDPI will have no impact on subsistence hunting out of Kaktovik. Current Kaktovik subsistence activity does not take place as far west as the LDPI site for any of the preferred species. However, some of the preferred species—bearded seal (ugruk) and, to a lesser extent, beluga whale—pass through the area. Three to four bowhead whales have been taken each year during the fall migration from Kaktovik whaling crews (Bacon *et al.* 2009, BPXA 2009).

8.1.2. Nuiqsut Subsistence Area

Nuiqsut is located on the west bank of the Nechelik Channel of the Colville River Delta, about 25 mi (40 km) from the Arctic Ocean and approximately 150 mi (242 km) southeast of Barrow. The Inupiat community of Nuiqsut has subsistence-harvest areas adjacent to the LDPI Project Area. However, most sources indicate that the Project Area is not visited regularly by Nuiqsut subsistence hunters primarily because of its distance from the community. Nuiqsut's important bowhead whale hunting area is at Cross Island, a barrier island approximately 20 mi (31 km) northwest of the proposed LDPI Project. Even though Nuiqsut is located inland, bowhead whales are considered a vital resource for the community, and residents participate in hunts from the bowhead camp at Cross Island (SRBA 2010). Inupiat believe that whales follow the ocean currents carrying food organisms. If the currents go close to Cross Island, whales migrate near there (NMFS 2001). Three to four bowhead whales have been killed by subsistence hunters each year by Nuiqsut whaling crews operating from Cross Island (Bacon *et al.* 2009). For the most part, whaling continues to be a group activity requiring cooperative efforts (SRBA 2010). Whaling crews comprised of people pursuing whales on the water and their support teams on shore or ice is an important aspect of local culture (BOEM 2012).

8.2. Impacts of the LDPI Project on Subsistence Species and the Availability of Such Species or Stock for Subsistence Uses

Aerial surveys of bowhead whales in the Alaskan Beaufort Sea have been conducted since 1979 (MMS 2002a). Aerial surveys near the proposed LDPI in 1997 (BPXA 1998) showed that the primary fall migration route was offshore of the barrier islands outside the development area. However, a few bowheads were observed in lagoon entrances between the barrier islands and in the lagoons immediately inside the barrier islands (BPXA1998). Because survey coverage in the nearshore areas was more intensive than in offshore areas the importance of nearshore areas relative to offshore areas to bowhead whales was overestimated. Only a small number of bowheads, if any, came within 6 mi (10 km) of the LDPI area.

Most of the ASAMM surveys were flown outside of the barrier islands. However, during July and August 2016, the surveys extended inside of the barrier islands into Foggy Island Bay (pers. comm. J. Clarke, December 18, 2017). While over 522 sightings of bowhead whales (1,226 adults and 44 calves) were observed throughout the surveys, many occurred in near-shelf waters and none of them occurred inside of the barrier islands. This supports the statement that bowhead whales generally do not use Foggy Island Bay. While ASAMM surveys were outside of these islands, the lack of sightings inside the islands and along the nearshore transect points (during most years) strongly support the findings of others that the fall migration occurs outside the islands.

There is no indication that the activities at LDPI Project will have greater than a temporary impact on marine mammal behavioral in the Action Area. Serious injury or mortality is not anticipated from the proposed activities and there is no indication that the activities will have any impacts on reproductive or survival rates of any of the species. Also, the isolation of the LDPI Project in Foggy Island Bay inside the Barrier Islands, suggests there would be no impact on the ability or availability of whaling crews or subsistence hunters to obtain those species used for subsistence purposes. While Cross Island is closer to LDPI, it is still considerably outside the Action Area. Further, the activities would have no impact on the

behavior of subsistence species such that it would impact the ability of subsistence hunters to harvest the species outside the Action Area.

Hilcorp will take measures to avoid impacts from vessel traffic (marine and aircraft) to the Cross Island bowhead whale hunt as described in the CAA (see Section 12). Hilcorp would also allow subsistence hunters to use Liberty Island for safe harbor if necessary during severe storms. Hilcorp has consulted with subsistence users each year of the project activities in recent years including meeting with potentially affected whaling captains' associations and the AEWC to obtain input about how to carry out proposed activities in a manner to avoid impacts to the hunt.

Project-specific subsistence mitigation measures will be developed during consultations with the NSB, AEWC, and the community of Nuiqsut. These may include:

- Consulting on supporting marine traffic (routes, frequency, schedule) with Nuiqsut Whaling Captains' Association;
- Employ local subsistence representatives during appropriate project phases;
- Execute and implement a CAA, which may include supporting communications centers during the whaling season and operational procedures, among other mitigation measures;
- Employ personnel skilled at protected species identification on support vessels when warranted to prevent vessel-marine mammal interaction during the open water season;
- Establish preferred marine routes for transport of facilities and supplies to LDPI;
- Establish minimum aircraft altitudes and routes for helicopters and other support aircraft to avoid disturbing bowhead whales and other subsistence resources, consistent with safety requirements and weather considerations;
- Train Hilcorp and contract personnel on the importance of subsistence and measures to avoid conflict. Identify Hilcorp's point of contact for subsistence-related issues and provide contact information to potentially affected subsistence communities; and
- Continue to convene open meetings in Nuiqsut to discuss the Project and ongoing issues related to development of LDPI.

As described in Section 13, Hilcorp is also proposing to explore opportunities to employ Native observers to collect traditional knowledge on the presence and behavior of marine mammals within the vicinity of the barrier islands near Foggy Island Bay (or another location to be determined through consultation with whaling captains and the North Slope Borough Wildlife Department). Traditional knowledge data could be integrated with other datasets to provide improved understanding of the presence and behavior of marine mammals in the project vicinity. Specific details of the Native observer monitoring protocol would be determined in consultation with NSB and whaling captains prior to Project start.

In summary, bowhead whales migrate north of the barrier islands during late summer and autumn, outside the barrier islands and are generally absent within Foggy Island Bay throughout the year. The ringed seal is the only relevant species present during winter months (November through March). Winter use of the development areas by subsistence hunters is likely quite limited or does not occur. While seals are also present near the proposed LDPI throughout the open water season, there is no evidence subsistence hunting occurs in the Project Area to any significant extent. For these reasons, the proposed activities at

the LDPI will have no more than a negligible or minimal impact on subsistence species and will not have an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses.

9. ANTICIPATED IMPACT ON HABITAT

9.1. Seal and Whale Prey

The ringed seal, the most common seal near LDPI, feeds on fish and a variety of benthic species, including crabs and shrimp. Bearded seals feed mainly on benthic organisms, primarily crabs, shrimp, and clams. Spotted seals feed on pelagic and demersal fish, as well as shrimp and cephalopods. Spotted seals are also known to feed on a variety of fish including herring, capelin, sand lance, Arctic cod, saffron cod, and sculpins.

Bowhead whales feed in the eastern Beaufort Sea during summer and early autumn but continue feeding to varying degrees while on their migration through the central and western Beaufort Sea in the late summer and fall (Richardson and Thomson 2002). When feeding in relatively shallow areas such as those where oil development may occur, bowheads feed throughout the water column. However, feeding is concentrated at depths where zooplankton is concentrated (Würsig *et al.* 1984, 1989; Richardson 1987; Griffiths *et al.* 2002). Lowry and Sheffield (2002) found that copepods and euphausiids were the most common prey found in stomach samples from bowhead whales harvested in the Kaktovik area from 1979 to 2000. Areas to the east of Barter Island appear to be used regularly for feeding as bowhead whales migrate slowly westward across the Beaufort Sea (Thomson and Richardson 1987; Richardson and Thomson 2002). In some years however, sizable groups of bowhead whales have been seen feeding as far west as the waters just east of Point Barrow near the Plover Islands (Braham *et al.* 1984; Ljungblad *et al.* 1985; Landino *et al.* 1994).

Beluga whales feed on a variety of fish, shrimp, squid and octopus (Burns and Seaman 1985). Very few beluga whales occur near LDPI; their main migration route is further offshore although incidental sightings do occur.

Gray whales are primarily bottom feeders, and benthic amphipods and isopods form the majority of their summer diet, at least in the main summering areas west of Alaska (Oliver *et al.* 1983; Oliver and Slattery 1985). Farther south, gray whales have also been observed feeding around kelp beds, presumably on mysid crustaceans, and on pelagic prey such as small schooling fish and crab larvae (Hatler and Darling 1974).There is no indication that activities at the LDPI Project site will have any effect on the type, amount, or availability of food (as forage) to seals and whales.

9.2. Noise Effects on Seal and Whale Prey

Two kinds of fish inhabit marine waters in the Project area: (1) true marine fish that spend all of their lives in salt water, and (2) anadromous species that reproduce in fresh water and spend parts of their life cycles in salt water (BPXA 2009). Most arctic marine fish species are small, benthic forms that do not feed high in the water column. The majority of these species are circumpolar and are found in habitats ranging from deep. The most important pelagic species, and the only abundant pelagic species, is the Arctic cod. The Arctic cod is a vector for the transfer of energy from lower to higher trophic levels and in summer can form very large schools in both nearshore and offshore waters (Craig *et al*. 1982). Locations and areas frequented by large schools of Arctic cod cannot be predicted, but can be almost anywhere. The Arctic cod is a major food source for beluga whales and ringed seals (Frost and Lowry 1984).

The proposed activities may result in an increased level of noise around the LDPI. Construction activities produce both impulsive sounds (e.g., pile driving) and longer-duration sounds. Short, sharp sounds can cause overt or subtle changes in fish behavior. Pearson *et al.* (1992) conducted a controlled experiment to determine effects of strong noise pulses on several species of rockfish off the California coast. Pearson et al. used an airgun with a source level of 223 dB re 1 µPa. They noted:

- Startle responses at received levels of 200–205 dB re 1 µPa and above for two species of rockfish, but not for two other species exposed to levels up to 207 dB;
- Alarm responses at 177–180 dB for the two rockfish species and at 186 to 199 dB for other species;
- An overall threshold for the above behavioral response at about 180 dB;
- An extrapolated threshold of about 161 dB for subtle changes in the behavior of rockfish; and
- A return to pre-exposure behaviors within the 20- to 60-minute exposure period.

In summary, fish often react to sounds, especially strong or intermittent sounds of low frequency, but return to pre-exposure conditions thereafter, and catch rates could be increased or decreased depending upon location of predator (Streever *et al.* 2016). Sound pulses at received levels of 160 dB re 1 µPa may cause subtle changes in behavior. Pulses at levels of 180 dB may cause noticeable changes in behavior (Pearson *et al.* 1992). It also appears that fish often habituate to repeated strong sounds rather rapidly, on time scales of minutes to an hour. However, the habituation does not endure, and resumption of the strong sound source may again elicit disturbance responses from the same fish. Underwater sound levels from LDPI Project site should be lower than the response threshold reported by Pearson *et al*. (1992), and are not likely to result in significant effects to fish in Foggy Island Bay. Construction and melting of ice roads is not expected to impact marine fish (MMS 2002b).

The reactions of fish to research vessel sounds have been measured in the field with forward-looking echosounders. Sounds produced by a ship varies with aspect and is lowest directly ahead of the ship and highest within butterfly-shaped lobes to the side of the ship (Misund *et al.* 1996). Avoidance reactions are quite variable and depend on species, life history stage, behavior, time of day, whether the fish have fed, and sound propagation characteristics of the water (Misund 1997).

The behavior of zooplankters is not expected to be affected by construction operations at LDPI. These animals have exoskeletons and no air bladders. Therefore, their ability to move significant distances is limited depending on the type of plankton. Impacts on zooplankton behavior are predicted to be negligible and this would translate into negligible impacts on feeding bowheads.

9.3. Habitat Disruption

Construction of the ice road for Northstar (BPXA 2009) was an activity that was difficult to separate into its individual components, as one or more bulldozers and other machinery were normally working concurrently. Of the construction activities reported, those related to ice road construction (bulldozers, auguring and pumping) produced the least amount of sound (BPXA 2009). Overall impacts to habitat at Northstar were minimal. As bottom disturbance is a natural phenomenon in this region due to ice scour and ice gouging of the seafloor, seafloor surface disruption associated with island construction and pipeline trenching resulted in only temporary disturbance to benthic communities within the island and pipeline footprint (BPXA 2009). These communities have a naturally patchy distribution. In nearshore

areas, these communities are subject to natural seasonal disruption by ice scour and ice gouging of the sea floor and transport of significant amounts of suspended sediments due to river outflow and coastal erosion (BPXA 2009). This suggests that recovery of disturbed areas at Liberty will occur in a manner similar to that occurring after natural disturbance, except for those areas buried by island construction. Effects of pipeline trenching on total suspended sediments in the water column are expected to be localized and effects are likely indistinguishable from naturally occurring disturbances to the benthos by sea ice, river outflow, and coastal erosion (BPXA 2009). In addition, the island slope protection system will introduce hard bottom structures for possible colonization by arctic kelp species, some invertebrates or fish.

9.4. Summary

Overall, the construction and development activities at the LDPI, and other activities associated with the development of the Project are not expected to cause significant impacts on habitat used by marine mammals or on the food sources that marine mammals use. This is consistent with a similar determination during the construction phases of Northstar Island (BPXA 2009)

10. ANTICIPATED EFFECTS OF HABITAT IMPACTS ON MARINE MAMMALS

The relatively small area covered by the footprint of the LDPI and excavated and ice roads is not believed to have any influence on marine mammal use. Ice habitat for ringed seal breathing holes and lairs (especially for mothers and pups) is normally associated with pressure ridges or cracks (Smith and Stirling 1975). While these occur near LDPI, they are more abundant offshore of the LDPI location where seals are also more abundant. The amount of habitat altered by LDPI ice-road construction is minimal compared to the overall habitat available in the region. Densities of ringed seals on the ice near LDPI during late spring are considered similar to those elsewhere in the region (Miller *et al.* 1998; Moulton *et al.* 2002c, 2005). Ringed seals use multiple breathing holes (Smith and Stirling 1975; Kelly and Quakenbush 1990). The loss of 1 to 2 breathing holes during Northstar construction, within the thickened ice road, did not adversely impact ringed seal densities in that region (Williams *et al*. 2006c). Similarly, ringed seals near LDPI have the ability to open new holes and create new structures throughout the winter, and ringed seal use of landfast ice near LDPI does not appear to be much different than that observed at Northstar (Williams *et al.* 2001b). Active seal structures were found within several meters of thickened ice (Williams *et al.* 2006b, 2006c). These studies noted that a few ringed seals occurred within areas of artificially thickened ice as a result of ice road construction if cracks that can be exploited by seals form in that thickened ice.

Bowheads are not present near LDPI during the winter and are not normally found in the development area during mid-summer (July through mid-August) when the whales are further east in the Canadian Beaufort. Therefore there are no impacts on foraging habitat for whales during mid-summer. Starting in late August and continuing until late October, bowheads may be exposed to sounds from the proposed activities at LDPI or may encounter vessel traffic to and from the island. It is unlikely that any whales would be displaced from sounds generated by activities at the LDPI due to their distance from the offshore migrating whales, and the effects of buffering from the barrier islands. Any displacement would be subtle and involve no more than a small proportion of the passing bowheads, likely less than that found at Northstar (Richardson 2008; Mcdonald *et al.* 2012). This is due to the baffling-effect of the barrier island between the construction activity and the main migratory pathway of bowhead whales. Feeding does not appear to be an important activity by bowheads migrating through the central part of the Alaskan Beaufort Sea in most years. In the absence of important feeding areas within the LDPI Action Area, marine mammals (including bowheads whales) are not likely to experience more than a temporary behavioral effect. Therefore in summary, some habitat will be displaced by the LDPI. However, this habitat is minimally used by marine mammals, is small in comparison to that available in areas of higher marine mammal densities, and no species will be excluded from any habitat required for their livelihood.

11. MITIGATION MEASURES

To minimize the likelihood that impacts will occur to the species, stocks and subsistence use of marine mammals, all activities associated with the construction at the LDPI Project development site will be conducted in accordance with all Federal, state and local regulations. Hilcorp will coordinate important activities with the relevant Federal and state agencies including NMFS, USFWS, BOEM Alaska Region, and Alaska Department of Fish and Game (ADFG). Hilcorp has and will continue to coordinate important activities with local authorities (North Slope Borough), representatives of communities (Barrow, Nuiqsut, and Kaktovik), and representatives of whaling captains (AEWC, and the Barrow [BWCA], Nuiqsut [NWCA], and Kaktovik [KWCA] Whaling Captains Associations). A Plan of Cooperation was developed between Hilcorp and the subsistence users in the region (see Section 12). The POC will continue to be renewed for the life of the Project. This will ensure efforts have been made by Hilcorp to minimize the possibility that operations, maintenance, or training activities interfere with the fall hunt for bowheads, and that all activities are conducted safely.

Mitigation measures are proposed by Hilcorp to reduce exposure to potential harassment takes to the lowest level practicable. Hilcorp's mitigation and monitoring program is a combination of active monitoring of the area of operations and implementation of mitigation measures designed to minimize project impacts to marine resources. The mitigation measures described below are organized by: 1) general measures that would apply to construction and operations activities during both ice-covered conditions and open water, including industry Best Management Practices (BMPs); 2) specific measures for ice-covered conditions; and 3) specific measures during broken ice or open water conditions.

The overall construction strategy for the LDPI Project is to use the winter season to its maximum advantage for island and pipeline construction, allowing for the use of conventional or adapted land-based construction techniques. This minimizes the use of marine vessels to move material and equipment. Additional but minimal island construction may take place in the summer months including gravel farming, sheet pile installation, and island armament installation.

11.1. General Mitigation Measures and BMPs

Hilcorp performs construction in accordance with the best guidance available to avoid and minimize (to the greatest extent possible) impacts on the environment, ESA species, designated critical habitats and species protected under the MMPA. Appendix D of the LDPI DPP provides specific details on the Safety and Environmental Management System (SEMS) that will be implemented by Hilcorp. The Hilcorp environmental program addresses water quality, air quality, waste management, wildlife, spill response, archeological resources and other related environmental media.

Some general BMPs include:

- Toxic or hazardous material specifications, inventories, separation, confinement, and handling will be determined, documented, and communicated to appropriate personnel;
- Properly sized equipment would be used to drive piles and sheet pile; and

- Hilcorp's SEMS program will ensure emergency response and control plans are in place and ready for immediate implementation. The plans will be validated by drills and exercises carried out in accordance with a schedule defined by the SEMS training program (30 CFR 250.1915).

Regarding vessel management, Hilcorp will use the following BMPS to minimize interaction with mammals:

- Manage all vessels to and from LDPI ensuring that vessel captains will watch for and avoid all marine mammals, will reduce speeds if a marine mammal is seen, and will report sightings to other vessels operating in the area;
- All vessels shall reduce speed to less than 5 kn (9.26 km/hr) prior to coming within 900 ft (274 m) of whales. The reduction in speed will vary based on the situation but must be sufficient to avoid interfering with the whales. Those vessels capable of steering around such groups should do so. Vessels may not be operated in such a way as to separate members of a group of whales from other members of the group. A group is defined as being three or more whales observed within a 1,641ft (500 m) area and displaying behaviors of directed or coordinated activity (e.g., group feeding). It should be re-emphasized that bowhead whale occurrence in the proposed Action Area is considered very limited. Therefore, the need to steer around whales in the Action Area should be minimal;
- All vessels shall avoid multiple changes in direction and speed when within 274 m (300 yards) of whales and also operate the vessel(s) to avoid causing a whale to make multiple changes in direction;
- Check the waters immediately adjacent to the vessel(s) to ensure that no whales will be injured when the vessel's propellers are engaged;
- When visibility is reduced, such as during inclement weather (rain, fog) or darkness, adjust vessel speed accordingly to avoid the likelihood of injury to whales; and
- Vessels and barges will not allow tow lines to remain in the water and no trash or other debris will be thrown overboard, thereby reducing the potential for marine mammal entanglement.

In regards to North Pacific right whales and Steller sea lions (applicable for the sea going barge):

- The vessel operator will not approach within 2,624 ft (800 m) of a North Pacific right whale;
- The vessel shall avoid transiting within designated North Pacific right whale critical habitat. If transit within North Pacific right whale critical habitat cannot be avoided, vessel operators are requested to exercise extreme caution and observe the 10 kn (18.52 km/h) vessel speed restriction while within North Pacific right whale critical habitat. If transiting through North Pacific right whale critical habitat, ocean going barges will be actively engaged in sighting marine mammals; and
- The vessel shall not approach within 3 nm (5.5 km) of a Steller sea lion rookeries or major haulouts.

11.1.1. Aerial Traffic

Hilcorp will minimize potential disturbance to mammals from helicopter flights to support LDPI construction by limiting the flights to an established corridor from the LPDI to the mainland, and, except when limited by weather and during landing and takeoff, will maintain a minimum altitude of 1,500 ft (457 m). If a marine mammal is observed, then a horizontal radii of 1,000 ft (305 m) would be maintained. These minimums are established for aircraft not conducting marine mammal monitoring. Hilcorp intends to establish the shortest route from mainland to island that safety and weather conditions

will allow (see Section 1.3.6). By restricting, as practicable, aerial flights within this established flight corridor, potential behavioral disturbance to marine mammals is minimized.

Also, traffic has been and will continue to be closely coordinated with the NSB and AEWC to avoid disrupting subsistence activities, including the alteration of aerial routes if that will help prevent interruption of specific subsistence activities.

11.2. Construction During Ice-Covered Conditions

Island construction will include cutting of ice blocks and placement of gravel, island profiling and armoring, and installation of a vertical sheet pile wall (see Section 1.3.3). The wall protects the work surface of the island from ice and wave impacts. It also prevents most marine mammals from entering the work area. This design is similar to the Northstar Production Island constructed by BPXA in 2000. Construction, with the exception of sheet pile driving, conductor pipe drilling, and slope shaping, is planned to occur from January through mid-April. For the purposes of this request for authorization, it is assumed ice-covered conditions will be present until July 1, a total of approximately 4 months. During winter and spring activities on the sea ice, the ringed seal is the only marine mammal species under the jurisdiction of NMFS that is likely to be encountered near LDPI. Winter activities are planned to commence on the sea ice as early as practical, and prior to March 1 of each year before female ringed seals have established their birth lairs. The following sections provide specific mitigations to be implemented during ice-covered conditions.

11.2.1. Ice Road and Island Construction

Hilcorp will begin winter construction activities in December or as soon as ice conditions allow safe access which helps to minimize potential impacts on marine mammals. Early winter initiation of on ice activities (ice road construction, ice pad development, island construction) allows ringed seals to avoid disturbed areas as they establish breathing holes and birthing lairs. All activities will be conducted at least 500 ft (~150 m) from any observed ringed seal lair. Female ringed seals establish their birth lairs before pupping in late March to April. If for some unforeseen reason ice road construction activities cannot be initiated prior to March 1, any ice road or other on ice activities initiated after March 1 in undisturbed areas will be surveyed for ringed seals lairs by a subsistence advisor before activity begins. To determine the number of structures in the vicinity of winter construction, the subsistence advisor will survey a buffer zone along the ice road corridor to identify breathing holes. Surveys will occur in areas where water depth is greater than 9.8 ft (3 m). Identified ringed seal structures will be avoided by a minimum of 500 ft (~150 m), minimizing any disturbance to located seal structures. When practicable, vehicles will avoid pressure ridges, ice ridges, and ice deformation areas where seal structures are likely to be present. In addition, prior to initiation of work, as part of the orientation program Hilcorp will include wildlife interaction avoidance training. This training will include avoidance measures for ringed seals as described above. Hilcorp will develop a detailed survey plan in coordination with the subsistence advisor before initiation of on ice activities in the event this mitigation measure is needed. Hilcorp wishes to re-emphasize that it is their intent to complete these activities before the March deadline to minimize potential interaction with ringed seals.

11.3. Construction During Broken Ice and Open Water Conditions

11.3.1. Island Construction During Open Water Conditions

Hilcorp anticipates completing island construction prior to the beginning of open water season in July. For the purposes of this request, it is assumed open water conditions will be present beginning approximately July 1. Therefore, if necessary, island construction may be completed during approximately two weeks of open water conditions (July 1 – July 15). Sheet pile driving is expected to be completed prior to whales (i.e., bowheads and belugas) being present in the region. Slope shaping may occur between July 15 and August 31 but would not likely occur every day, if at all.

Notably, the construction of Northstar Island was completed during ice-covered conditions, requiring no construction of the island in open water. All work will be consistent with the existing CAA for open water season in the Beaufort Sea.

11.3.1.1. Project Scheduling

Project scheduling indicates that impact hammering will not occur during the whaling period for Cross Island bowhead whale subsistence hunting which usually occurs from the last week in August thru mid-September. This will ensure that disturbance to marine mammals and subsistence hunts is avoided to all practical extent. Any non-essential boat, hovercraft, barge, or aircraft will be scheduled to avoid approaching the harvest area around Cross island during this period, and possibly conflicting with the timing of the Cross island bowhead hunt consistent with the CAA.

11.3.1.2. Soft Start

Hilcorp will use the soft-start technique at the beginning of impact pile driving each day, or if pile driving has ceased for more than thirty minutes. Soft-start procedures would be used prior to pile (or sheet pile) installation to allow marine mammals to leave the area prior to exposure to maximum noise levels. For vibratory hammers, the soft start technique would initiate noise from the hammer for short periods at a reduced energy level, followed by a brief waiting period. This cycle will repeat two additional times. For impact driving, an initial set of three strikes would be made by the hammer at 40 percent energy, followed by a one-minute waiting period. As with vibratory hammers this cycle is repeated two additional times.

11.4. Mitigation Summary

Hilcorp has developed mitigation measures to ensure the least practicable impact on marine mammal species and stocks, and their habitat. Potential measures include consideration of the following factors: 1) the degree to which the successful implementation of the measure is expected to minimize adverse impacts to marine mammals; 2) the proven efficacy of the specific measure to minimize adverse impacts as planned based on monitoring plans from previous, similar MMPA authorizations applications incorporating pile driving; and 3) the practicability of the measure for implementation. Based on these factors, Hilcorp believes the mitigation measures being considered accomplish the following required objectives:

- Avoidance or minimization of injury or death of marine mammals;
- Avoidance of construction activities at times when animals are observed in or approaching those areas that may be exposed to noise levels exceeding the thresholds for Level A take to reduce the total number of marine mammals exposed to received levels of pile driving, or other activities expected to result in the take of marine mammals;
- Avoidance of those traditional areas and times when subsistence hunting for bowhead whales might be occurring consistent with terms in the CAA;
- A reduction in the number of times (total number or number at biologically important time or location) individuals would be exposed to stimuli expected to result in incidental take of marine mammals;
- The use of PSOs for monitoring in order to mitigate any potential for Level A or B takes in the second year of the construction activities (i.e., if pile driving occurs during open water);
- The use of PSOs and UASs to monitor potential Level B takes thereby reducing the likelihood that an animal might approach an area with noise levels that exceed Level A thresholds during potential pile driving.

Based on results of previous programs similar to the LDPI Project, the proposed mitigation measures provided would result in the least practicable impact on marine mammal species or stocks, and their habitat. Additional information on monitoring is provided in Section 13.

12. PLAN OF COOPERATION

In April 2018, Hilcorp submitted a POC to NMFS in accordance with 50 CFR 216.104(a)(12) for development of the Liberty Oil Field. The POC documents Hilcorp's stakeholder engagement activities with subsistence communities within the North Slope Region including Nuiqsut, Barrow and Kaktovik, the closest villages to the Project Area. The POC includes a description of the project, how access to the Project Area will occur, pipeline and island construction techniques, and drilling operations. The plan also describes the ongoing community outreach cooperation and coordination and measures that will be implemented by Hilcorp to minimize adverse effects on marine mammal subsistence. The POC is a living document and will be updated throughout the LDPI review and permitting process. As such, Hilcorp intends to maintain open communication with all stakeholders throughout the Liberty permitting and development process.

12.1. Stakeholder Engagement

In late 2014, Hilcorp began the community outreach process with a series of meetings with North Slope stakeholders. These meetings have continued into 2018. Several stakeholder engagement meetings have been held in support of the Liberty Development project to date including community visit in Barrow, Nuiqsut, and Kaktovik. In addition, attendance at AEWC meetings, discussions with the North Slope Borough Planning and Wildlife Department, and coordination with Native Allotment owners proximity to the Project have occurred. The POC also documents coordination with federal, state, and local agencies.

The LDPI Project Area does not contain any presently occupied human settlements but is recognized as an area that is sometimes used as a subsistence use area for residents of Nuiqsut, Kaktovik and Barrow. Hilcorp understands the importance of subsistence to these communities. Hilcorp follows the established CAA to mitigate noise and traffic impacts of offshore oil and gas production related activities on subsistence whaling. Hilcorp will meet annually with the communities of Nuiqsut and Kaktovik, and likely in Barrow during appropriate meetings of the NSB or whaling captains, to discuss the LDPI Project.

12.2. Conflict Avoidance Agreement

In addition to the POC, Hilcorp has signed a CAA in coordination with the AEWC and North Slope communities' Whaling Captains' Associations, which outlines activities that will help minimize disturbances to marine mammals with respect to subsistence hunting.

In coordination with AEWC, Hilcorp currently adheres to the existing CAA for North Slope oil and gas activities to minimize potential interference with bowhead subsistence hunting. Hilcorp will attend and participate in the CAA meetings scheduled in 2017 and 2018. The CAA describes measures to minimize any adverse effects on the availability of bowhead whales for subsistence uses and addresses the following:

A. Operational agreement and communications procedures
B. Where/when agreement becomes effective
C. General communications scheme, by season

D. Liberty Island operations, by season
E. Conflict avoidance
F. Seasonally sensitive areas
G. Vessel navigation
H. Air navigation
I. Marine mammal and acoustic monitoring activities
J. Measures to avoid impacts to marine mammals
K. Measures to avoid conflicts in areas of active whaling
L. Emergency assistance

Hilcorp will continue to convene meetings in the communities of Nuiqsut, Barrow, and Kaktovik as the proposed project develops to address questions and concerns from community members, and continue to provide them with contact information of project management to which they can direct concerns during construction and operations. Hilcorp is committed to adhering to the CAA for the duration of North Slope operations, as necessary.

12.3. Measures to Reduce Impacts

The POC describes the following measures that Hilcorp will implement to reduce impacts to the subsistence community including:

- Initiating ice road construction prior to March 1st to minimize potential impacts to ringed seals establishing birthing lairs;
- Scheduling the majority of island construction during the ice covered season when cetaceans will not be present;
- Using PSOs to monitor marine mammal presence and shut down operations if necessary to avoid impacts;
- Using unmanned aerial systems for marine mammal monitoring during Year 2;
- Using soft-start techniques;
- Adhering to the existing CAA;
- Scheduling all non-essential boat, hovercraft, barge, and air traffic to avoid conflicting with the timing of the Cross Island bowhead hunt;
- Ceasing impact pile driving to avoid the period of Cross Island bowhead whale subsistence hunting, if this activity occurs in open water conditions when the hunt is occurring; and
- Conducting acoustic monitoring as outlined in the 4MP.

12.4. Future Plan of Cooperation Consultations

Projected outreach activities for 2018 include:

- Attendance at AEWC Quarterly Meetings;
- Nuiqsut Community Meeting and meeting with Nuiqsut Whaling Captains Association;

- Liberty Project Coordination meetings with the North Slope Borough Planning Department and Wildlife Department; and
- Participation in the NSB-lead Camden Bay/Central Alaska Beaufort Sea Study Meeting

13. MONITORING AND REPORTING

In order to issue an LOA for an activity, Section 101(a)(5) of the MMPA states that NMFS must set forth "requirements pertaining to the monitoring and reporting of such taking." The MMPA implementing regulations at 50 CFR 216.104 (a)(13) indicate that requests for incidental take authorizations must include the suggested means of accomplishing the necessary monitoring and reporting that would result in increased knowledge of the species and the level of taking or impacts on populations of marine mammals that are expected to be present in the Action Area.

Hilcorp recognizes that monitoring requirements should be designed that improve the understanding of one or more of the following:

- Occurrence of marine mammal species in the Action Area (e.g., presence, abundance, distribution, density);
- Nature, scope, or context of likely marine mammal exposure to potential stressors/impacts (individual or cumulative, acute or chronic), through better understanding of: 1) action or environment (e.g., source characterization, propagation, ambient noise); 2) affected species (e.g., life history, dive patterns); 3) co-occurrence of marine mammal species with the action; or 4) biological or behavioral context of exposure (e.g., age, calving or feeding areas);
- Individual responses to acute stressors, or impacts of chronic exposures (behavioral or physiological);
- How anticipated responses to stressors impact either: 1) long-term fitness and survival of an individual; or 2) population, species, or stock;
- Effects on marine mammal habitat and resultant impacts to marine mammals; and
- Mitigation and monitoring effectiveness.

In keeping with guidance provided by NMFS, Hilcorp has considered a number of monitoring and reporting opportunities that could contribute to the collective knowledge of marine mammals, marine mammal prey, and marine mammal habitat. However, the potential to conduct meaningful research on impacts of LDPI Project sounds on marine mammals during the LDPI Project is limited due to the small number of animals anticipated to be in the region and other factors.

Concurrent with this petition, a Marine Mammal Monitoring and Mitigation Plan (4MP) has been developed that provides additional detail on Hilcorp's marine mammal monitoring program associated with this Project. The 4MP undergoes peer review by outside experts to ensure the plan is sound and enables Hilcorp to achieve the identified objectives for monitoring. The following sections provide an overview of the monitoring program while additional detail is provided in the Draft 4MP attached as Appendix C. Certain aspects of the 4MP may be modified based on peer review prior to NMFS issuance of an LOA.

In addition to PSO and UAS data, Hilcorp proposes to explore opportunities to employ Native observers to collect traditional knowledge on observations on the presence and behavior of marine mammals within the vicinity of the barrier islands near Foggy Island Bay (or another location to be determined through consultation with whaling captains and the North Slope Borough Wildlife Department). Data collected by

Native observers could be integrated with data collected by Hilcorp as well as ASAMM survey data to improve our understanding of the presence and behavior of marine mammals in the project vicinity. Specific details of the Native observer monitoring protocol would be determined in consultation with NSB and whaling captains prior to Project start.

13.1. Marine Mammal Monitoring

Marine mammal monitoring will be employed during all pile-driving and slope shaping activities during open water conditions if these activities must continue in open water to complete construction. Monitoring is also proposed during other noise-producing activities for specific periods in Years 3-5 to monitor for the presence and behavior of marine mammals as described in more detail below and in the 4MP. No observer monitoring for NMFS species is being considered during ice-covered season (except for observers looking for polar bears).

Current NMFS guidelines recommend that noise-producing activities be shut down prior to reaching the PTS threshold (NMFS 2016). This would occur at a noise level lower than that which would result in injury (Level A). Hilcorp proposes to monitor prescribed Level A shutdown zones using PSOs to ensure that no marine mammals are exposed to noise levels that may cause PTS. The distances from the noise source and exposure time required to reach Level A (PTS) thresholds during Year 2 construction are presented in Table 13-1.

Hilcorp will implement the following marine mammal monitoring procedures:

- All PSOs will be trained in marine mammal identification and behaviors and will be required to have no other construction-related tasks while conducting monitoring.
- Sheet pile and impact driving activities will only begin and generally be conducted when it is possible to visually monitor marine mammals unless the operation began prior to poor visibility, with the assumption that no marine mammals would enter the Level A zone once the noise was active.
- If poor environmental conditions restrict the ability for PSOs to see within the marine mammal shutdown zone (e.g. excessive wind or fog, high Beaufort state), pile installation will cease unless the operation began prior to bad weather.
- During pile/pipe-driving or slope shaping activities (anticipated in Year 2), two on-island PSOs will be stationed at locations providing an unobstructed view of the predicted Level A zone. The on-island PSOs monitoring the Level A zone will be placed at vantage points to monitor from the island out to 6,365 ft (1.94 km) when conditions allow. The PSOs will be located on a platform or platforms to maximize the potential for viewing marine mammals in the Level A zone. For example, assuming the average height of an observer is 5 ft 5 inches (1.8 meters), height of the island is 15 ft (4.6 meters), and Reticle Binoculars (5 mils) are used, Hilcorp will build a platform ~16.5 ft (5 m) high to view a distance of 1.42 miles (2.28 km). This would be sufficient to see beyond the Level A zone for any marine mammals approaching.
- PSOs monitoring the Level A zone will be placed on either side of the island where pile/pipe-driving or slope shaping activities are occurring. For example, one PSO would be placed on the side where construction activities are taking place and the other placed on the opposite side to provide complete observer coverage around the island. PSO stations will be moved around the island as needed during

construction activities to provide full coverage. PSOs will be switched out such that they will observe for no more than 4 hours at a time and no more than 12 hours in a 24-hour period.

- The waters will be scanned by PSOs (both land-based and using UAS) 30 minutes prior to commencing pile driving at the beginning of each day, and prior to commencing pile driving after any stoppage of 30 minutes or greater. If marine mammals enter or were observed within the designated marine mammal shutdown zone 30 minutes prior to pile driving, the monitors will notify the on-site construction manager to not begin until the animal has moved outside the designated radius. Sheet pile installation will not commence if any marine mammals are observed within or immediately approaching the Level A harassment zone.
- The waters will continue to be scanned for at least 30 minutes after sheet and pipe driving has completed each day, and after each stoppage of 30 minutes or greater.
- PSOs monitoring the Level A zone will scan the waters using binoculars, spotting scopes, and unaided visual observation. The PSO will also use a hand-held range-finder device to verify that no marine mammals were in the areas ensonified as a result of all activities at the Project site.
- In the unlikely event a low frequency cetacean (i.e., bowhead whale) enters their Level A zone, pile driving would be shut down. If a mid-frequency cetacean (beluga) or pinniped (seal) enters the Level A zone, Hilcorp proposes to complete setting that pile (estimated to require less than 10 or 15 minutes[20]) but not initiate additional pile driving of new piles until the mid-frequency cetacean or pinniped has left the Level A zone. During this time, PSOs will monitor the animal and record behavior. If after 20 minutes the marine mammal is still within the Level A zone and Hilcorp has not completed setting the pile, shut down procedures will be initiated and no new pile driving will begin until the marine mammal has left the Level A zone. This practical and precautionary measure will minimize the potential for PTS given that an animal must remain in the Level A zone for a total of 40 minutes to experience PTS (as shown in Table 6-13). This is a precautionary measure considering that the criteria for Level A harassment are SEL based and animals would need to remain in the Level A zone for approximately 40 minutes before PTS would occur (see Section 13.1.2). This approach minimizes the potential for harm to marine mammals. The observation would be reported and recorded as a Level A take.
- If for any unforeseen reason, pile or pipe-driving activities extend beyond the 15-day period or into Year 3, PSOs will be used to monitor the Level A zone.
- During pile/pipe-driving or sloping shaping that may occur during open water in Year 2, a third PSO will work closely with an aviation specialist to monitor the Level B zone using an unmanned aircraft system (UAS). This third PSO and the UAS pilot will be located on the island. The PSO and UAS pilot will monitor footage from the UAS in real time, to check for the occurrence of marine mammals in the Level B zone. Additional details regarding the use of the UAS are provided in Section 13.1.1 and the 4MP. Three additional PSOs and a second UAS pilot will rotate through these positions to allow sufficient breaks as specified in the 4MP. UAS will not be used after Year 2. If deployment of a UAS program is not possible, a third PSO could conduct marine mammal monitoring from a vessel located at the edge of the Level A zone (1.94 km) between July 1 and August 31st of Year 2.

[20] During sheet pile driving at Northstar Island, it was observed that "a typical vibrahammer operation lasted for 1 minute or less" (Shepard et al, 2001).

- Any marine mammal documented within the Level B harassment zone during sheet pile/pipe driving and slope shaping will constitute a Level B take (harassment) and be recorded.
- During the open water season of Years 2-5 Hilcorp is also proposing to conduct underwater acoustic monitoring (see Section 13.2).
- During Years 3 - 4, a PSO (and an alternate) will be placed on the island for approximately 4 weeks during the month of August to monitor for the presence of marine mammals around the island. The Level B zone is expected to be approximately 55 meters (180 feet) around the island during this time. The PSO will scan waters around the island using reticle binoculars and other protocols as described in the 4MP for Year 2. ASAMM surveys are typically scheduled for August, therefore, data collected by PSOs could be compared to sighting data collected during ASAMM surveys.
- Based on the results of PSO monitoring, underwater acoustic data, and in consultation with NMFS, Hilcorp would determine whether a PSO is needed during Year 5 to monitor for presence and behavior of marine mammals that may occur within the island vicinity. If, for example, exposure of marine mammals to noise levels that exceed regulatory thresholds is not anticipated based on the lack of mammals in the area or the results of acoustic monitoring indicating that propagation of underwater sound (that exceeds thresholds) during production is exceedingly small, a PSO during Year 5 may not be needed.

Table 13-1. Distance from Noise Source to NMFS Level A (PTS) Thresholds During Year 2 Construction (Open Water)[1]

Marine Mammal Hearing Group and Species	Distance From Source To PTS Threshold		
	Vibratory Sheet Piling (2.5 hrs)	Impact Sheet Piling (40 mins)	Impact Pipe Driving (2 hrs)
Low frequency cetaceans (bowhead, gray whales)	0.05 km 164 ft	1.94 km 6,365 ft	0.87 km 2,854 ft
Mid frequency cetaceans (belugas)	<0.01 km 33 ft	0.06 km 197 ft	0.03 km 98 ft
Phocid Pinnipeds (bearded, ringed, spotted seals)	0.02 km 66 ft	0.53 km 1,706 ft	0.24 km 787 ft

Source: SMRU 2017
[1]If island construction takes two winter seasons, these distances would apply in Year 3 rather than Year 2.

13.1.1. Unmanned Aircraft System (UAS) During Construction Year 2

Recent developments in the technical capacity and civilian use of UAS (defined as vehicles flying without a human pilot on board) have led to some investigations into the potential use of these systems for monitoring and conducting aerial surveys of marine mammals (Koski *et al.* 2009; Hodgson *et al*. 2013; Duke 2015). UASs, operating under autopilot and mounted with GPS and imaging systems, have been used and evaluated in the Arctic (Koski *et al*. 2009) and have the potential to replace traditional manned aerial surveys to provide an improved method for monitoring marine mammal populations.

The objectives of the Liberty UAS monitoring program are to: provide information on the numbers of marine mammals potentially affected by the LDPI construction operations and facilitate real-time mitigation to prevent potential injury of marine mammals by industrial sounds or activities; and document marine mammal presence, distribution, and (to the extent practicable) behavior in the vicinity of the LDPI area. A discussion of the types of UAS that could be used in the monitoring program are provided in the 4MP.

The UAS to be used by Hilcorp will be a fixed wing aircraft, mounted with a live-stream digital SLR camera for monitoring marine mammals. The UAS will fly at an altitude of 500 ft (or other altitude determined appropriate based on the platform) and a transect width to be determined through discussions with NMFS. Hodgson *et al.* (2013) conducted marine mammal surveys using a ScanEagle UAS flown at 500 ft. The survey consisted of 10 transects spaced at 235 ft (72 m) intervals (the width of view of the water surface within the images). The width of view at each altitude was the effective transect strip width. The image capture rate was set to achieve 10 percent overlap in images. The overlap in images was useful in detecting animals masked by reflection on the sea surface or animals at awkward body angles. A similar approach is suggested for Liberty but specific details can be determined based on the specifications of the UAS to be used and through discussions with NMFS.

Transects over the Action Area would likely be divided into sections that are 30 minutes of longitude across, as done by ASAMM. End points for the survey transects may be selected at random but would specifically cover the Action Area and allow for a continuous flight path within the survey area. If small boats are observed, the UAS pilot will truncate the transect to avoid interference with subsistence activities. The UAS will not be used to circle marine mammals. If it is too windy, or other weather condition prevent use of a UAS, activities would be adjusted accordingly and a backup plan of using a PSO based on land or, if necessary on a vessel, would be implemented. During the fall subsistence hunt of bowhead whales, a minimum altitude will be used near Cross Island. If that altitude cannot be maintained, transects will be truncated to avoid a specific radius around each whaling area (following similar ASAMM protocol for aerial surveys). These details will be further refined as the 4MP becomes finalized after the peer review process. Sightings recorded by video will be considered “off effort” following ASAMM protocol for recorded data (i.e., processed at a later point in time by a trained PSO).

To maintain consistency of data acquisition with previous years, PSOs responsible for processing recorded video will be trained according to NMFS protocols. UAS surveys are tentatively planned during periods when ASAMM would not be conducting surveys in order to maximize data collection on marine mammal presence in the area. Additional details on survey schedule and duration (i.e., number of days per survey), survey speed, altitude, and other methods will be further refined in the final 4MP prior to issuing the LOA (see Appendix C for the Draft 4MP).

These monitoring measures should result in an effective program that will supplement data collected by PSOs on marine mammal presence and behavior. These data will also be effective in reducing takes to a minimum by expanding the area being monitored beyond that which could be done visually by PSOs.

If necessary, Hilcorp will seek a waiver from the Federal Aviation Administration (FAA) to operate the UAS above 400 ft and beyond the line of sight of the pilot. Ground control for the UAS will be located on Liberty Island, Endicott or other shore-based facility close to Liberty.

13.1.2. Shutdown and Disturbance Zones

During open water conditions, Hilcorp will monitor a safety range for marine mammals around the island to ensure that the area is clear of any marine mammals. Observations will continue during all open-water activities that may exceed the Level A noise threshold (sheet pile driving and pipe driving) to prevent onset of PTS due to cumulative noise exposure (i.e., maximum duration impact sheet piling in each 24-hour period). While slope shaping activities may exceed the Level A threshold, the distance to that threshold is less than 10 m (33 ft). Animals are not expected to occur within 10 m of the island during construction, particularly for any given amount of time that could cause PTS. Therefore, monitoring the Level A during slope shaping (July 15 – August 31) is not needed. Active impact sheet pile driving is likely to occur for 10 to 20 minutes total per day however, to be precautionary, the maximum duration of 40 minutes has been used to estimate the ensonified area. Impact pipe driving is likely to occur only 2 hours total per day.

The Level A shutdown zone (6,365 ft or 1.94 km) would be scanned 30 minutes prior to commencing work at the beginning of each day, and prior to re-starting work after any stoppage of 30 minutes or greater. If marine mammals enter or were observed within the designated Level A shutdown zone 30 minutes prior to work, the PSOs would notify the on-site construction manager to not begin until the animal has moved outside the Level A zone.

The Level A zones as shown in Table 13-1 (based on marine mammal hearing group) will be monitored during all pile driving activities that occur during open water conditions. Pile driving activities will not begin if a marine mammal is observed in, or closely approaching, the Level A zone. As described above, In the unlikely event that pile driving activities are ongoing when a low-frequency cetacean is observed inside the Level A zone, PSOs will notify Hilcorp and shutdown procedures will be initiated. If a mid-frequency cetacean (beluga) or pinniped (seal) enters the Level A zone, Hilcorp proposes to complete setting that pile (estimated to require less than 10 or 15 minutes[21]) but not initiate additional pile driving of new piles until the mid-frequency cetacean or pinniped has left the Level A zone. During this time, PSOs will monitor the animal and record behavior. If after 20 minutes the marine mammal is still within the Level A zone and Hilcorp has not completed setting the pile, shut down procedures will be initiated and no new pile driving will begin until the marine mammal has left the Level A zone. Pile driving activities will not begin again until the animal is clear of the area. It is important to note that for an animal to experience PTS, it would need to spend between 40 minutes to 9.6 hours within the Level A zone as reported in the top row of Table 13-1. Additional details on the distances to cumulative PTS onset and the durations for which an animal must remain at that distance for PTS to occur are provided in Table 6-13 of this application as well as Tables 16 – 18 of Appendix A (Noise Report). Generally, any marine mammal observed approaching the Level A zone will have already been exposed to Level B thresholds and recorded as a potential take. If this occurs, observed animal behaviors will be documented.

The PSOs monitoring the Level A zone will be placed at a vantage point that allows monitoring from the island out to 6,365 ft (1.94 km) when conditions allow (please also see Section 13.1 above for details on PSO observation platforms and distances). The area potentially ensonified above Level A thresholds during pile driving will be truncated on the southwest by the proximity of island to mainland, and by the island itself (i.e., shadow effect) as described in Section 6.3. The area of water ensonified at or above

Level A threshold zones for all pinnipeds and cetaceans should be able to be visually monitored effectively by two PSOs.

13.1.3. Poor Visibility Conditions

Hilcorp plans to conduct 24-hr operations. PSOs and the UAS will not be on duty during darkness however, there will be no periods of darkness in the Project area until late August and current scheduling should prevent this condition from occurring. If poor environmental conditions restrict the PSOs from observing the marine mammal Level A shutdown zone (e.g. excessive wind or fog, high Beaufort state), sheet pile and pile installation will cease.

13.2. Acoustic Monitoring During Years 2-5[21]

This section briefly describes the acoustic monitoring planned to occur during Years 2-5 (see Appendix D). Please note that the 4MP provides detailed descriptions of these efforts once finalized after the peer review process prior to issuance of an ITA. The current draft 4MP is attached here as Appendix C. During Years 2-5 in open water conditions (i.e., approximately July – the beginning of October), Hilcorp proposes to conduct underwater acoustic monitoring for the purposes of conducting sound source verification. Acoustic monitoring will be conducted to document ambient noise conditions and to characterize the long-range propagation of sounds produced during the LDPI construction activities (i.e., sound source verification). These data will be used to help verify distances from the noise sources at which marine mammal impact thresholds may be reached. Data can also be used to compare the estimated distances to ambient sound levels and impact thresholds collected at Northstar. For example, based on available data collected, this could include:

- Comparison of monitoring effort (i.e., total hours of effort, total distances monitored, and marine mammal distribution through the study period);
- accounting for sea state and other factors;
- analysis of the potential effects of factors that could alter detectability of marine mammals (weather, fog, sea state, one vs. two observers);
- species composition between the two regions, occurrence and distribution by date and location, group sizes, etc.; and
- data for periods when pile driving is occurring vs. not, or comparing animal responses (if possible) at the two different locations.

The reporting of this information should improve our understanding of the effectiveness of the mitigation and monitoring plan, and provide a mechanism for adaptive mitigation if considered necessary, at LDPI and expand our understanding of marine mammal distributions and occurrences in an area that have been only minimally monitored in past years.

13.3. Data Collection

Hilcorp will require that PSOs use approved data forms developed for this Project. Among other pieces of information, the PSOs will record detailed information about any implementation of shutdowns, including

[21] Years 2-5 acoustic monitoring would be conducted. Years 3-5 UAS would be used to collect data on marine mammal presence.

the distance of animals to the construction activity, description of specific actions that ensued and resulting behavior of the animal, if any. At a minimum, the following information will be collected on the observer forms:

- Date and time that monitored activity begins or ends;
- Construction activities occurring during each observation period;
- Weather parameters (e.g., percent cover, visibility);
- Water conditions (e.g., sea state, tide state);
- Species, numbers, and, if possible, sex and age class of marine mammals;
- Description of any marine mammal behavior patterns, including bearing and direction of travel and distance from construction activity;
- Distance from construction activities to marine mammals and distance from the marine mammals to the observation point;
- Description of implementation of mitigation measures (e.g., shutdown or delay);
- Locations of all marine mammal observations; and
- Other human activity in the area.

Hilcorp also proposes to use a UAS to monitor Level B ensonified zones. This monitoring effort would provide information on responses of animals at a greater distance from the LDPI during noise producing activities that could exceed thresholds. These responses will be recorded as part of the monitoring program.

13.4. Reporting

The results of the Liberty marine mammal monitoring program including estimates of "take by harassment", will be presented in 90-day and annual technical reports. Reporting will address the requirements established by NMFS. Hilcorp would provide records of all activities to NMFS and other responsible agencies to ensure compliance with the incidental take authorization and all other environmental statutes and requirements.

The technical report(s) will include:

- Summaries of monitoring effort: total hours, total distances, and distribution of marine mammals through the observation period accounting for sea state and other factors affecting visibility and detectability of marine mammals;
- Summaries of sound-producing activity start and end dates and duration, type of equipment, and sound source verification of sound producing activities;
- Analyses of the effects of various factors influencing detectability of marine mammals including sea state, number of observers, and fog/glare;
- Species composition, occurrence, and distribution of marine mammal sightings including date, water depth, numbers, age/size/gender categories (for example, coloration in beluga whales may indicate a difference between adult whales and subadults or calves), group sizes, and ice cover;
- Analyses of the effects of construction operations;

- Sighting rates of marine mammals during periods with and without construction activities (and other variables that could affect detectability);
- Initial sighting distances versus construction activity (impulse or vibratory driving or slope shaping);
- Observed behaviors and types of movements versus construction activity;
- Numbers of sightings/individuals seen construction activity;
- Distribution around the island versus construction activity;
- Complete descriptions of any work shutdowns, total number of animals exposed to noise levels that may exceed take thresholds;
- Estimates of "take by harassment"; and
- If applicable, a summary of any injured or dead marine mammals discovered.

Results and a complete description of methods used to survey for ringed seals will be submitted as part of the annual report. The annual monitoring report will summarize the type of activities conducted and completed, all findings and observations and compare those findings to other similar reports (i.e., from Northstar and other Beaufort Sea offshore and nearshore developments). This information will add to the overall data and knowledge of marine mammals in the Project Area and to a larger extent marine mammal use of coastal waters inside the barrier islands.

In the unanticipated event that the specified activity at LDPI clearly causes the take of a marine mammal in a manner prohibited by the LOA, such as an unforeseen injury or mortality to a pinniped, the observer will report the incident to Hilcorp, who will report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS and NMFS Alaska Region Office. This communication will occur as soon as practicable. In the event of a ship strike, operations would not cease, but the PSO would report the incident to NMFS and Hilcorp, and Hilcorp would work with NMFS to determine appropriate follow on actions. A report documenting the incident will include:

- Time, date, and location (latitude/longitude) of the incident;
- Description of event;
- Name and type of vessel involved (if applicable);
- Vessel's speed during and leading up to the incident (if applicable);
- Description of the incident;
- Status of all sound source use in the 24 hours preceding the incident;
- Water depth;
- Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
- Description of all marine mammal observations in the 24 hours preceding the incident;
- Species identification or description of the animal(s) involved;
- Fate of the animal(s); and
- Photographs or video footage of the animal(s) (if equipment is available).

In the event that an observer discovers an injured or dead marine mammal, the cause of the injury or death is unknown, and the death is relatively recent (i.e., in less than a moderate state of decomposition), Hilcorp will report the incident to the NMFS Chief of the Permits and Conservation Division, Office of Protected Resources in Silver Spring, Maryland and the Alaska Stranding Coordinator in Juneau, Alaska, as soon as practicably possible. The report will include the same information identified in the paragraph above. Activities would be allowed to continue while NMFS reviews the circumstances of the incident. NMFS will work with Hilcorp to determine whether modifications in the activities are appropriate.

Under such circumstances that the injury or death is not associated with or related to the activities authorized in the LOA (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), Hilcorp will report the incident to the NMFS Chief of the Permits and Conservation Division, Office of Protected Resources or by email to the Alaska Stranding Coordinator within 48 hours of the discovery. Hilcorp will provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network.

14.CORDINATING RESEARCH TO REDUCE AND EVALUATE POTENTIAL INCIDENTAL TAKE

Hilcorp has benefitted from the results of past marine mammal monitoring programs for the open-water and ice-covered seasons during operation of Northstar. These programs were coordinated by BPXA with BOEM (MMS), NMFS, ADFG, University of Alaska, NSB and other groups conducting related work.

Hilcorp will continue to work with various external entities, possibly including other energy companies, agencies, universities, the AEWC, and NGOs, in its efforts to manage, understand, and fully communicate information about environmental impacts related to LDPI activities.

Hilcorp plans to involve Inupiat personnel as well as biologists from the NSB, and elsewhere as appropriate, in the monitoring and research programs proposed here. This will provide more opportunities for exchange of traditional and western scientific knowledge.

Hilcorp will provide copies of draft monitoring reports to the NSB, the AEWC, and BOEM for their review. Comments received as a result of the review processes will provide additional opportunities for input from and coordination with other groups with interests and experience in the area.

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APPENDIX A

LDPI Project

Underwater Noise Assessment

March 2017

global environmental solutions

Hilcorp Liberty Project
Alaska

Underwater and Airborne Noise Modelling

SLR International Corporation Ref. 105.00874.16017

March 2017
SLR Consulting (Canada) Ltd Project No.: 201.04399.00000

HILCORP LIBERTY PROJECT

UNDERWATER AND AIRBORNE NOISE MODELLING

SLR International Corporation Project No.: 105.00874.16017

SLR Consulting (Canada) Project No.: 201.04399.00000

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EXECUTIVE SUMMARY

This report describes an assessment of the potential underwater and airborne noise generated by construction and operation of the Liberty Project in Alaska. The proposed development centers on the Liberty Drilling and Production Island, which will be constructed of thaw stable gravel in 19 feet of water about 5 miles offshore in Foggy Island Bay in the Beaufort Sea.

The Liberty Project has many similarities to previous projects constructed in the area, which include Endicott, Northstar and Oooguruk. These projects have not resulted in documented changes in marine mammal populations or in observations of meaningful behavioral responses. This precautionary investigation is intended to identify the potential extent of noise generated by the project, to inform a Letter of Authorization (LoA) application for the Liberty Project.

A series of construction and operational activities, equipment and scenarios with the potential for noise generation have been identified and quantitatively assessed. The assessment process involves the identification of major noise sources and emission characteristics; the application of guideline marine mammal noise thresholds (underwater and in air); prediction of underwater and airborne noise propagation and noise levels across the Project area; and identification of the areas with potential for noise levels above the various guidance thresholds.

Interim guidance from the National Marine Fisheries Service (NMFS) on noise thresholds for behavioral effects has been applied. The assessment indicates that for most construction scenarios (with the exception of vibratory pile driving), marine mammal behavioral responses are not expected away from the immediate vicinity of the Project. Vibratory pile driving may generate noise at a level with potential for short term marine mammal behavioral responses within the barrier islands, at maximum distances of up to 17.5 km (11 miles) from Liberty Island in the open water season. The predicted distances of noise propagation to the NMFS interim underwater behavioral effects thresholds for each scenario are summarized in Table 1.

Table 1 Distances to NMFS interim marine mammal behavioral effects thresholds (1)

Scenario	Underwater Noise (Ice-Covered)	Underwater Noise (Open Water) (3)			Airborne Noise
		Min	Median	Max	
Ice road construction and maintenance	170 m	n/a	n/a	n/a	< 15 m
Pipeline construction	210 m	n/a	n/a	n/a	< 15 m
Island construction	210 m	n/a	n/a	n/a	< 15 m
Vibratory sheet pile driving	390 m	12000 m	14800 m	17500 m	15 m
Impact sheet pile driving	90 m	1700 m	2050 m	2250 m	100 m
Slope shaping, armament installation	n/a	880 m	1160 m	1260 m	< 15 m
Conductor pipe impact driving	11 m (2)	300 m	315 m	400 m	100 m
Emergency spill response training	170 m	165 m	225 m	280 m	< 15 m
Helicopter (take-off, landing)	n/a	n/a	n/a	n/a	67 m
Vessel transportation	n/a	1500 m	1850 m	2200 m	< 15 m
Hovercraft transportation	n/a	~10 m (2)	70 m	95 m	15 m
Drilling & Production	230 m	~20 m (2)	55 m	85 m	30 m
Production only	40 m	~15 m (2)	45 m	75 m	30 m

Note 1: NMFS interim guidance behavioral thresholds are RMS 120 dB re 1µPa (continuous underwater noise); 160 dB re 1µPa (impulsive underwater noise); and 100 dB re 20µPa (airborne noise).
Note 2: For some scenarios the identified distances may be within the island, so no actual behavioral response is possible.
Note 3: Underwater noise varies with depth and range. Open water results are minimum, median and maximum distance to the noise threshold across all depths calculated in the direction of maximum noise propagation from the source (away from shore).

The interim behavioral effect thresholds used in this study are based on broadband unweighted sound levels, and do not account for differences between species in hearing ranges and sensitivity to noise at different frequencies. These thresholds are conservative – many natural and anthropogenic noise sources can cause noise levels above these thresholds, often with no adverse behavioral effects to marine mammals.

Underwater noise is expected to propagate further in open water conditions than under ice. At higher exposure levels, noise can induce a permanent or temporary reduction in marine mammal hearing sensitivity, ie Permanent Threshold Shift (PTS) or Temporary Threshold Shift (TTS). The potential for PTS as a result of open water activity scenarios has been assessed following guidance provided by the National Oceanic and Atmospheric Administration (NOAA), including consideration of species-specific hearing sensitivity through use of marine mammal frequency weighting functions (M-weighting). Impact pile driving and impact pipe driving are the only activities with theoretical potential to cause PTS, and then only if marine mammals remain in proximity to the noise source for extended periods of time as indicated in Table 2. Cetaceans are unlikely to be present within the identified distances. The potential for PTS in the ice-covered season is anticipated to be negligible.

In practice, the potential for PTS would depend on the likelihood of animals being present within the identified distances from the noise source, whether impact driving of sheet piles is required, and if so, whether this activity takes place in the open water season. The behaviour of individual animals in response to noise is also a factor. PTS would not occur if an animal moved away from the noise source during the work day, or if an animal did not remain underwater for the full duration of active noise generation.

Table 2 Indicative distances from source to NOAA marine mammal PTS thresholds

Marine Mammal Hearing Group and Species	Indicative Distance From Source to PTS Threshold	
	Impact Sheet Pile driving (10-20 mins in 24 hrs)	Impact Pipe Driving (2 hrs in 24 hrs)
Low frequency cetaceans (bowheads, gray whales)	770 to 1,220 m	870 m
Mid frequency cetaceans (belugas)	25 to 37 m	27 m
Phocid Pinnipeds (bearded, ringed, spotted seals)	210 to 330 m	240 m

Notes: Durations are assumed active noise generation time for each source in a 24 hour period. In the case of impact pipe driving, the noise source is located in the interior of the island, so PTS to belugas would not be theoretically possible due to the distance to the water. Low frequency cetaceans are unlikely to be present within the identified distances.

For the open water scenarios, this study includes a comparison of predicted underwater noise propagation characteristics with data measured at Northstar Island, and with a practical spreading loss model. These comparisons provide a “sanity check” on the Liberty noise model.

The interpretation of these results to inform a Letter of Authorization (LoA) application for the Liberty Project should acknowledge inherent uncertainties in prediction of both airborne and underwater noise levels. In particular, practical limitations introduce uncertainty in measurements of underwater noise; predictions of underwater noise; and in the interpretation of noise levels in terms of the resulting effects on marine mammals. While the noise thresholds used in this assessment follow guidance provided by the National Oceanic and Atmospheric Administration (NOAA), it is recognized that variation in the responses of different species and individual animals to noise will occur. Potential effects associated with the Liberty Project are likely to be comparable to or less than those associated with Northstar and other more recent developments.

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APPENDICES

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1.0 INTRODUCTION

1.1 Project description

Hilcorp Alaska, LLC (HAK) proposes to develop the Liberty Field, located in the Beaufort Sea about 5 miles offshore in Foggy Island Bay. The Liberty Development will be a self-contained offshore drilling and production facility located on an artificial gravel island with a pipeline to shore. Full details of the proposed Project are contained in the Liberty Development and Production Plan (DPP) (HAK, 2015).

Noise generated by construction and operation of the Liberty Project has the potential to affect marine mammals. The Liberty Project has many similarities to previous projects constructed in the area, which include Endicott, Northstar and Oooguruk. These previous projects have not resulted in documented changes in marine mammal populations or in observations of meaningful long term behavioral responses. This precautionary investigation is intended to identify the potential extent of airborne and underwater noise generated by the project, to inform a Letter of Authorization (LoA) application for the Liberty Project.

1.2 Noise assessment overview and objectives

In order to provide an objective and quantitative assessment of project related noise levels both underwater and in air, it is necessary to be able to estimate, measure or predict the following parameters:

- The source noise level and its temporal and spectral characteristics.
- The transmission or propagation loss, that is, the rate at which sound from the source is attenuated as it propagates underwater or through the air.
- The hearing bandwidth or sensitivity of the species in question.
- The noise threshold, that is, the level of sound at which a particular effect such as behavioural change, hearing damage or injury is experienced by a particular species.

The first two parameters define the sound level at all points in the air or water for the various construction and operational activities. The hearing bandwidth and noise threshold are used to indicate the potential effects of noise on marine mammals, and will differ for different species, different individuals within a species, and even for an individual at different times, but are generally considered to be conservative.

The potential effect of man-made noise on an animal depends on the level of noise exposure. At moderate exposure levels, noise may cause a change in animal behaviour. At higher exposure levels, noise can induce a temporary or permanent reduction in hearing sensitivity, i.e. temporary threshold shift (TTS) or permanent threshold shift (PTS). The effect of noise exposure generally depends on a number of factors relating to the physical and spectral characteristics of the sound (*e.g.*, the intensity, peak pressure, frequency, duration, duty cycle), and relating to the animal under consideration (*e.g.*, hearing sensitivity, age, gender, behavioural status, prior exposures). The type and level of the impact also depends on whether the noise consists of single-pulse, multiple-pulse or non-pulsed continuous sounds.

Definitions of acoustic terms utilized throughout this report are provided in Appendix A.

1.3 Noise assessment guidance

The Liberty Project has the potential to generate noise in areas occupied by marine mammals. The species of interest for this study bowhead whales, beluga whales, gray whales, bearded seals, ringed seals and spotted seals, which are within the jurisdiction of the National Marine Fisheries Service (NMFS). While polar bears and walrus may also be present in the area, the acoustic effects of the Project on these species are considered under the jurisdiction of the United States Fish and Wildlife Service (USFWS) and are not included in the scope of this study.

Guidance on acoustic thresholds for marine mammal injury and disturbance are provided by the National Oceanic and Atmospheric Administration (NOAA) NMFS. The assessment of noise effects on marine mammals can be separated into underwater and airborne scenarios.

1.3.1 Underwater noise assessment thresholds

NMFS released Technical Memorandum NMFS-OPR-55 *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts* in 2016. This Technical Guidance provides acoustic thresholds to help quantify potential for PTS and TTS, but does not represent the entirety of a comprehensive effects analysis. Other factors and thresholds such as behavioral impact thresholds and auditory masking effects should also be considered in attempting to understand the ultimate effects of any particular type of impact on individual animals and populations.

As it is a permanent auditory injury, the onset of PTS may be considered an example of ‘‘Level A harassment’’ as defined in the Marine Mammal Protection Act (MMPA). TTS is by definition recoverable rather than permanent, and has historically has been treated as ‘‘Level B harassment’’ under the MMPA. Behavioral effects may also constitute Level B harassment, and are expected to occur at even lower noise levels than would generate TTS. For this reason, predicted noise levels are not assessed against TTS thresholds in this study.

The recent Technical Guidance (NMFS, 2016) contains thresholds that may be applied to identify the potential for PTS. A dual metric approach is used for impulsive sounds, considering both cumulative sound exposure level and peak sound level. For non-impulsive sounds, only the cumulative sound exposure level is used (unless the impulsive peak level threshold is exceeded). Different thresholds and auditory weighting functions are provided for different marine mammal hearing groups, which are defined in the Technical Guidance (NMFS, 2016). The generalized hearing range of each hearing group is reproduced in Table 3. The PTS thresholds corresponding to each hearing group are shown in Table 4.

Table 3
Marine mammal hearing groups (from NMFS, 2016)

Hearing Group	Generalized Hearing Range
Low-frequency cetaceans	7 Hz to 35 kHz
Mid-frequency cetaceans	150 Hz to 160 kHz
High-frequency cetaceans	275 Hz to 160 kHz
Phocid pinnipeds	50 Hz to 86 kHz
Otariid pinnipeds	60 Hz to 39 kHz

In relation to hearing groups, the species of interest for this study are classified as follows:

- Bowhead, gray whales: low-frequency cetaceans
- beluga whale: mid-frequency cetaceans
- bearded, ringed, spotted seals: phocid pinnipeds

Table 4
Underwater acoustic thresholds for PTS onset

Hearing Group	PTS Onset Acoustic Thresholds (Received Level)		
	Impulsive (Peak, L_{pk}, flat)	Impulsive (cumulative weighted, $L_{E,\,24h}$)	Non-impulsive (cumulative weighted, $L_{E,\,24h}$)
Low-frequency cetaceans	219 dB	183 dB	199 dB
Mid-frequency cetaceans	230 dB	185 dB	198 dB
High-frequency cetaceans	202 dB	155 dB	173 dB
Phocid pinnipeds	218 dB	185 dB	201 dB
Otariid pinnipeds	232 dB	203 dB	219 dB

Notes: Peak sound pressure (Lpk) has a reference value of 1 µPa and is "flat" or unweighted.
Cumulative sound exposure level (LE) has a reference value of 1µPa^{2}s.
LE received levels should be appropriately weighted for the hearing group for assessment to the thresholds.

The recent Technical Guidance does not provide updated information on thresholds for the onset of behavioral effects. The NMFS interim underwater thresholds for behavioral effects[1] are shown in Table 5.

Table 5
Interim underwater acoustic thresholds for behavioral disruption

Criterion Definition	Threshold
Behavioral disruption for impulsive noise (e.g., impact pile driving)	160 dB_{rms}
Behavioral disruption for non-impulsive noise (e.g., vibratory pile driving, drilling)	120 dB_{rms}

Notes: dB referenced to 1 micro Pascal (re: 1µPa).
All thresholds are based off root mean square (rms) levels and are broadband (unweighted).
The 120 dB threshold may be slightly adjusted if background noise levels are at or above this level.

The objective of this quantitative noise modelling assessment is to identify the areas with noise potentially above the interim underwater thresholds for marine mammal behavioral disruption, and above the PTS onset thresholds where applicable.

1.3.2 Airborne noise assessment thresholds

NOAA is understood to be developing a guideline on sound characteristics likely to cause injury and behavioral disruption, which will provide airborne threshold levels corresponding to permitted levels of harassment to marine mammals. Until this guideline becomes available, the interim thresholds for behavioral disruption to pinnipeds in air are used, as shown in Table 6. Harbor seal range does not extend to the Beaufort Sea (NMFS, 2009); therefore, the airborne noise behavioral disruption threshold for all pinnipeds in the study area is 100 dB_{rms}.

[1] http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/threshold_guidance.html Accessed 30 November 2016.

Table 6
Interim in-air acoustic thresholds for behavioral disruption

Criterion Definition	Threshold	Source
Behavioral disruption for harbor seals	90 dB_{rms}	NMFS
Behavioral disruption for non-harbor seal pinnipeds	100 dB_{rms}	NMFS

Note: dB referenced to 20 micro Pascals
All thresholds are root mean square (rms) levels and are broadband (unweighted).

1.4 Structure of this report

This study includes the following components:

- An overview of the baseline noise environment is provided in Section 2.0.
- Identification of construction and operational activities and scenarios with the potential for generating noise, in Section 3.0.
- A literature review to identify underwater and airborne source noise levels and spectra for each scenario, in Section 3.0 and Appendix B.
- Empirical prediction of underwater noise propagation under ice-covered conditions, in Section 4.0.
- Detailed frequency-dependent open water underwater noise sound transmission loss modelling (STLM), i.e. prediction of the received sound levels over a range of up to 15 miles (25 km) from the proposed island, in Section 5.0.
- Comparison of open water noise propagation predicted by the detailed model with measured propagation at Northstar and with a practical spreading loss model.
- Frequency-dependent airborne noise modelling, in order to assess potential for noise disturbance to animals above the water or ice surface, in Section 6.0.

A summary of identified ranges to the identified noise level thresholds for all scenarios is provided in Section 7.0.

2.0 EXISTING NOISE ENVIRONMENT

2.1 Ambient underwater noise levels

Background or ambient noise in the ocean is variable, caused by a number of sources which fluctuate over time. These existing underwater noise sources include shipping noise or other anthropogenic noise sources, waves, weather and sea ice, and noise from biological sources.

The existing underwater noise environment in the Liberty project area is described in Appendix A of the Liberty DPP (HAK, 2015) with reference to a review of historical measurements including those in the region between Northstar and Liberty (Shepard et al, 2001). Additional ambient noise measurements collected during a passive acoustic monitoring study in Foggy Island Bay are reported in Frouin-Mouy et al, 2016.

The median open-water summer ambient noise level measured in 1997 (Greene, 1998) was 97 dB re 1µPa, in a frequency range from 20 Hz up to 5 kHz. The corresponding 5th and 95th percentile levels were 78 and 110 dB re 1µPa respectively. The more recent measurements summarized in the DPP (HAK, 2015) and in Frouin-Mouy et al (2016) have been found to be consistent with these ambient underwater noise levels, with 2016 median ambient noise levels in Foggy Island Bay of 96 and 98 dB re 1µPa, in a frequency range from 10 Hz up to 32 kHz.

The difference in frequency range between data sets is a function of the equipment used and the methods used to process data recordings.

Ambient noise levels in winter under ice are generally lower than summer levels in open water, particularly at frequencies where vessel noise normally dominates the overall level.

2.2 Ambient noise levels in air

Environmental sound in air also includes noise from multiple sources which constantly vary over time. Noise in coastal areas can be generated by animals, birds, weather and waves, in addition to anthropogenic sources including transportation and industry.

The descriptor commonly used for ambient noise measurements in air is the energy equivalent sound level (L_{eq}). The L_{eq} value is the sound energy average over a defined time period. When assessing noise effects on human receptors, the L_{eq} values are commonly A-weighted and expressed in units of dBA. However, the interim thresholds for assessing potential for behavioral disturbance to marine mammals (see Table 6) are unweighted. Unweighted L_{eq} values are representative of the average sound level, and are equivalent to the rms sound level parameter used to define behavioral disturbance thresholds in Table 6, for continuous or non-varying noise sources.

Measurements of noise in air in the Liberty project area or nearby have generally been undertaken in the presence of some human activity, so may not be truly indicative of the long-term background or ambient noise level. Greene et al (2008) report background unweighted in-air noise levels of 59 to 84 dB re 20µPa, measured in the vicinity of Northstar Island in Prudhoe Bay during the winter of 2000, and noted the background noise level was related to wind speed. Blackwell et al (2004a) indicate minimum background unweighted in-air noise levels of 44 to 52 dB re 20µPa, measured up to 10 km from Northstar Island in Prudhoe Bay during the winter of 2001 and 2002, in ice-covered conditions with low wind. Blackwell and Greene (2005) indicate background unweighted in-air noise levels of 74-80 dB re 20µPa, measured near Prudhoe Bay in the summer of 2003 again with low wind but in open water conditions. High winds can result in overall unweighted in-air noise levels that are similar to or greater than the NMFS interim in-air thresholds.

Reports of A-weighted airborne noise from the summer operation of the Northstar facility (Blackwell and Greene, 2006) also note that the lowest levels recorded in the far-field were more related to sea state and wind speed than the presence of boats, with levels of 37 to 40 dBA re 20µPa obtained under “ideal recording conditions” with low wind speeds and relatively calm seas.

The overall baseline noise environment in air is predominantly controlled by natural events, rather than by anthropogenic noise sources. During construction and operation of the Project, noise from human activity will take over as the dominant noise source in the vicinity of Liberty Island.

3.0 NOISE SOURCES AND ASSESSMENT SCENARIOS

A list of construction and operational activities, equipment and scenarios with the potential for noise disturbance to wildlife was developed in consultation with HAK, NMFS and the Bureau of Ocean Energy Management (BOEM). In developing this list, shown in Table 7, reference has been made to experience gained during construction and operation of the comparable Northstar production island in Prudhoe Bay.

Table 7
Noise assessment scenarios sources and locations

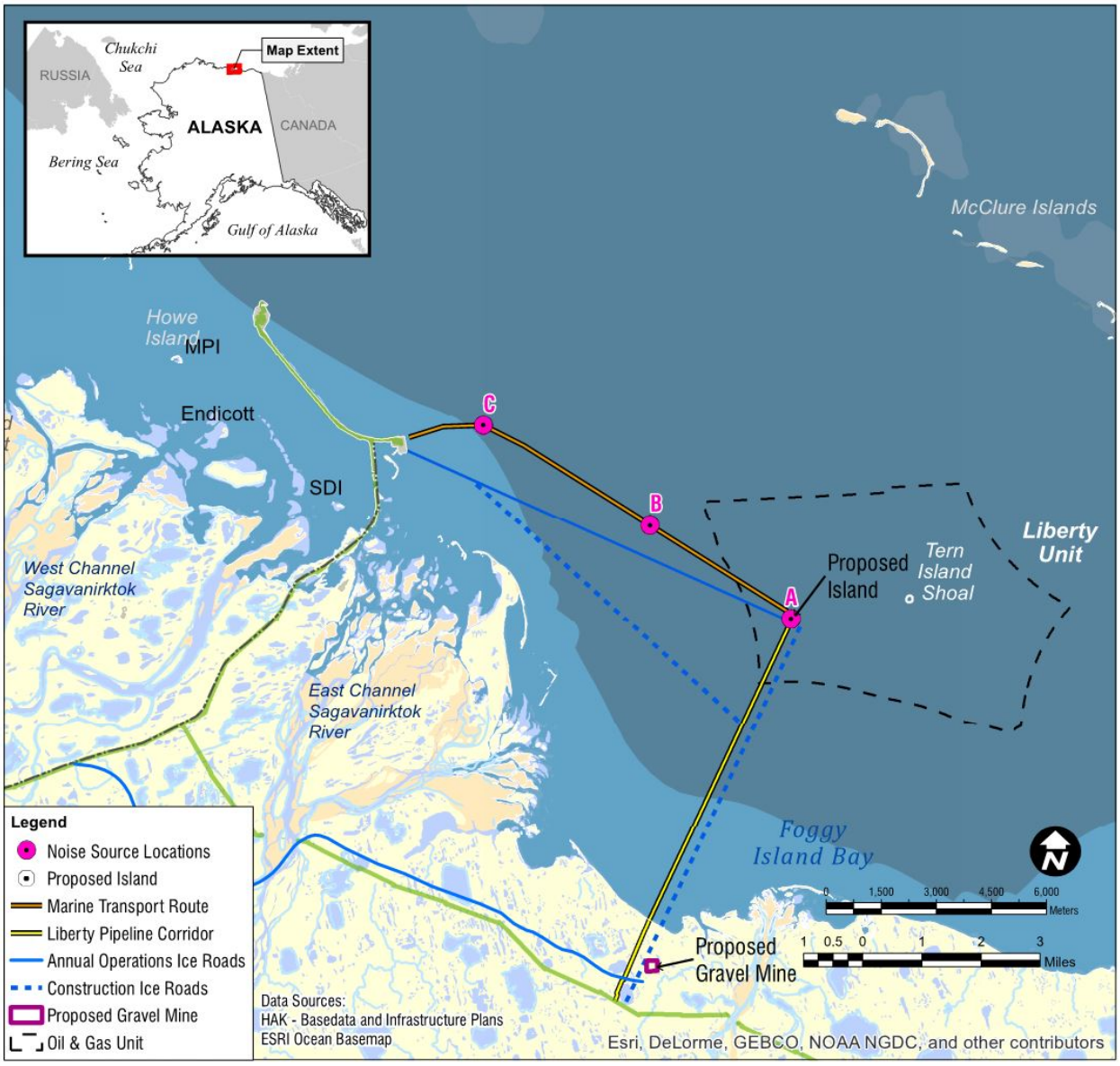
Season	Scenario	Noise Source	Source Location(s)
Ice-covered	Ice road construction and maintenance	Grader Ice auger Water pump trucks	Ice roads
	Pipeline construction	Trucks on ice road Backhoe digging Ditchwitch sawing ice	Ice roads along pipeline route
	Island construction	Trucks on ice road Backhoe digging Ditchwitch sawing ice	Ice roads Island & gravel mine Island
	Vibratory sheet pile driving	Vibratory pile driver	Island edge
	Impact sheet pile driving	Impact pile driver	Island edge
	Conductor pipe impact driving	Impact pile driver	Island interior
	Emergency and oil spill response training	Grader Bobcat loader Ice auger Generators / Light plants Snowmachine All-terrain vehicle ARKTOS	Island and vicinity
	Helicopter transportation	Helicopter	Island & vessel route
	Drilling & Production	Drilling & Production	Island interior
	Production only	Production	Island interior
Open water	Slope shaping, armament installation	Excavator	Island edge
	Vibratory sheet pile driving	Vibratory pile driver	Island edge
	Impact sheet pile driving	Impact pile driver	Island edge
	Conductor pipe impact driving	Impact pile driver	Island interior
	Emergency and oil spill response training	Vessels – eg Zodiacs, Kiwi Noreens, Bay-class boats (12-45 ft)	Island and vicinity
	Vessel transportation	Barge Tugs Small/crew boat	Island & vessel route
	Hovercraft transportation	Griffin 2000 TD	Vessel route
	Helicopter transportation	Helicopter	Island & vessel route
	Drilling & Production	Drilling & Production	Island interior
	Production only	Production	Island interior

Source levels and spectra (indicating the source noise contribution at each frequency) for each noise source and scenario were determined by a review of the literature. Full details of the

source noise levels, references and spectra used to model noise propagation in air, in water and under ice are provided in Appendix B. It is noted that this approach relies heavily on historical noise measurements from the Northstar development over ten years ago, with inherent limitations related to their use in estimating source levels. At Liberty, noise generated may be different depending on the details of equipment used, substrate conditions, and propagation factors.

The locations of the various noise sources described in Table 7 are shown in Figure 1.

Figure 1 Noise source locations



Notes: Noise source locations A, B and C represent points used to represent noise sources in the model. Location A is at or near Liberty Island, while Locations B and C are representative points along the vessel route between Liberty and SDI / Endicott.
Ice road routes shown as "construction" ice roads may also be required during operations eg for inspections.

The noise sources are approximated as either points or lines for modelling purposes. For example, sources located at the island are modelled as a single stationary point, whereas

sources associated with ice road construction are represented as a line along the route. The underwater noise generated by vessel movements has been modelled at several points along the linear route as shown in Figure 1, with the resulting predictions extrapolated along the line.

While activities such as emergency and oil spill response training may occur in various locations in the vicinity of the island, the noise generated by these activities would extend over a similar area regardless of the precise location of the activity. Therefore, the approximation of a single point source at the island for these types of scenarios is appropriate in determining the potential area within which disturbance of marine mammals may occur.

Several other potentially noise-generating activities were considered, in consultation with HAK, NMFS and BOEM, but have not been modelled. The additional activities considered and reasons for exclusion from the list of modelled activities are as follows:

- Underwater noise generated by helicopters – the broadband noise levels underwater due to helicopters flying at altitudes of 500 feet (150 m) or more are expected to be around 109 dB re 1µPa (Richardson et al, 1995), which is significantly below the interim underwater acoustic threshold of 120 dB re 1µPa for behavioral disruption due to a continuous noise source. Helicopter noise is therefore modelled to determine in-air noise effects only.
- Underwater noise generated by hovercraft operating on ice – while this scenario is possible, no empirical data on the resulting noise levels is available. It is assumed that underwater noise generated by a hovercraft on ice would be less than the noise from a hovercraft over open water.
- Bathymetry surveys – noise generated by bathymetry surveys has not been modelled, as these surveys take place independently of the Liberty project development and would not be included in HAK's application for a Letter of Authorization for the Liberty project.
- Noise from fixed wing aircraft or vessel movements associated with marine mammal monitoring efforts, such as deploying and retrieving noise monitoring equipment, or aircraft surveys of marine mammal density or polar bear dens – if required, these activities may occur only a few times each year, with behavioral effects expected to be negligible.
- Noise from vessels travelling to and from Liberty Island are assessed along the vessel route only as far as SDI/Endicott, although some vessels would continue to West Dock or transit through areas further west. In the Western Arctic, and between West Dock and SDI/Endicott, it is assumed that Liberty vessels would join other vessels and any noise effects in this area would be attributed to general vessel traffic, rather than solely to the Liberty project.
- Noise generated during installation of conductor pipes by methods other than impact driving. The location of conductor pipes in the interior of the island means underwater noise levels are inherently low. The need for impact driving would depend on local conditions. Alternatives to impact conductor pipe driving include vibratory driving, or drilling (auger). These alternatives would generate less noise than impact driving, and are therefore not modelled in this study.

4.0 UNDERWATER NOISE MODELLING – UNDER ICE SCENARIOS

4.1 Under-ice noise modelling methodology

As described in the Liberty DPP (HAK, 2015), sea ice covers Foggy Island Bay for around 9 months of each year, typically freezing up in October and breaking up in July. An empirical approach has been used to predict the extent of underwater noise propagation for ice-covered scenarios. There are two primary reasons for selection of an empirical approach:

- A comprehensive set of existing measured noise propagation data under ice at Northstar is available as a reference; and
- Theoretical modelling and prediction of noise propagation under ice remains an area of ongoing research rather than an established and validated process.

The literature documenting measurements at Northstar has been used to determine both overall broadband unweighted rms source levels, and propagation relationships with distance under ice as summarized in Appendix B. Received noise levels with distance for each scenario have been calculated directly from these relationships, for comparison with the underwater behavioral disturbance thresholds in Table 5.

4.2 Under-ice noise modelling results

Table 8 summarizes the predicted distances from the noise source to the behavioral disturbance thresholds for marine mammals in water underneath ice layers for each of the project scenarios considered. The affected areas are illustrated in Appendix C.

Table 8
Ice-covered underwater distance to behavioral disturbance thresholds

Scenario	Source Location(s)	Distance from Source to Behavioral Threshold
Ice road construction and maintenance	Ice roads	170 m
Pipeline construction	Pipeline & ice road	210 m
Island construction	Ice roads & island	210 m
Vibratory sheet pile driving	Island edge	390 m
Impact sheet pile driving	Island edge	90 m
Conductor pipe impact driving	Island interior	11 m
Emergency and oil spill response training	Island edge	170 m
Drilling & Production	Island	230 m
Production only	Island	40 m

Note 1: NMFS interim guidance behavioral thresholds are RMS 120 dB re 1µPa (continuous underwater noise); and 160 dB re 1µPa (impulsive underwater noise); and 100 dB re 20µPa (airborne noise).
Note 2: For some scenarios the identified distances may be within the island, so no actual behavioral response is possible.

Behavioral studies (Blackwell et al, 2004b) have indicated seals are highly tolerant to noise generated during ice-road construction, and indications are that the NMFS interim thresholds are conservative in this respect. As previously noted, this study applies the interim behavioral effect thresholds in the absence of other guidance.

Vibratory sheet pile driving is the scenario with the potential for underwater noise behavioral disturbance over the largest area, within around 1280 feet (390 m) from the noise source

around the boundary of the island in the event that this activity takes place during the ice-covered season.

Note that the background noise levels under ice are less than the interim behavioral impact thresholds. The distances provided in Table 8 indicate the anticipated distance to these thresholds, rather than the distance at which received noise levels are expected to be undetectable above the background noise level. For example, Greene et al (2008) indicate that noise from vibratory pile driving under ice-covered conditions typically reached median background noise levels at a distance of up to 4.6 miles (7.5 km) from the source.

With reference to the corresponding open water predictions in Section 5.4.1, underwater noise is expected to propagate further in open water conditions than under ice. For this reason, and because many species of interest will not be present during the ice-covered season, the potential for marine mammal PTS as a result of Liberty activities in the ice-covered season is anticipated to be negligible.

5.0 DETAILED UNDERWATER NOISE MODELLING – OPEN WATER SCENARIOS

Measured open water noise data from Northstar Island is available for the drilling and production scenario, and also for vessel noise (Blackwell et el, 2006). However, open water measured noise propagation data is not available for all activities and scenarios considered in this study. For example, sheet piling and noise monitoring was undertaken during construction of Northstar during the ice-covered season, but this activity did not occur or was not monitored after ice break-up. This study for Liberty aims to address the possibility that some activities proposed to occur with ice-cover may take place after ice break-up. Therefore, an alternative numerical modelling approach to underwater noise propagation prediction is required, that does not solely rely on reported broadband propagation relationships from Northstar.

In addition to the lack of comprehensive open water measurement data from Northstar, there are two additional reasons to undertake more detailed numerical noise modelling of the open water scenarios for Liberty:

- Liberty Island is located in around 19 feet of water, which is considerably shallower than Northstar Island at around 39 feet. For this reason there are expected to be differences in open water noise propagation and attenuation between the two sites. In particular, lower frequency underwater sound (below about 80 to 150 Hz) within the Liberty project area is expected to have higher attenuation than Northstar, due to the shallower water environment for Liberty.
- Liberty is located within the barrier islands, and whale migration routes predominantly lie to the north of the barrier islands. A more detailed numerical model is able to consider the “shielding” effect of the barrier islands on underwater noise.

Although numerical underwater noise modelling is a more established means of prediction for open water than for under-ice scenarios, model validation and verification by measurement remains difficult. Approximations and assumptions are required in developing a model (see also Section 5.4), and in addition underwater noise measurements to validate predictions are inherently difficult. Aerts and Streever (2016) compared modelled and measured noise levels from air guns operated in Alaska and found poor agreement. For this study, the available measured propagation relationships from Northstar and commonly used “practical spreading loss” propagation relationships described below are referenced to provide a check on the validity of the numerical model predictions.

5.1 Geometric spreading loss models and Northstar observations

Underwater noise propagation models predict the sound transmission loss between the noise source and the receiver. When the source level (SL) of the noise source is known, the predicted transmission loss (TL) is then used to predict the received level (RL) at the receiver location as:

$$\mathrm{RL} = \mathrm{SL} - \mathrm{TL}$$

The transmission loss between two distances D1 and D2 may be described by a logarithmic relationship with an attenuation factor F:

$$\mathrm{TL} = F \cdot \log(D_1/D_2)$$

If all losses due to factors other than geometric spreading are neglected, then the transmission loss would be wholly due to spherical spreading (in deep water) or cylindrical spreading (in shallow water, bounded above and below). Spherical spreading means underwater noise would attenuate by 6 dB with each doubling of distance, or F = 20. Cylindrical spreading means an attenuation of 3 dB with each doubling of distance, or F = 10.

Guidance provided by the California Department of Transportation (Caltrans, 2015) indicates that in practical cases the attenuation factor can range from 5 up to 30. A “practical spreading loss model” based on an attenuation factor of 15 for sound transmission in the near shore is commonly assumed (NMFS, 2012).

Blackwell et el (2006) report broadband propagation losses for noise from vessels associated with the Northstar production island. The calculated attenuation factors for vessel noise were 14.4 and 18.3 measured on two separate days, at distances ranging from 500 m to 27 km from the island.

Drilling and production noise from Northstar was also measured in open water. Being lower in level than vessel noise, drilling and production noise could only be detected above the background at distance out to about 2 km, giving fewer data points for calculation of the propagation loss. Two sets of measurements in different years resulted in highly variable measured attenuation factors of 32.6 and 6.3.

5.2 Detailed modelling methodology and procedure

In shallow water noise propagation is highly dependent on the properties of the bottom and the surface as well as the properties of the fluid. Parameters such as depth and the bottom properties can vary with distance from the source. There is a low-frequency cut-off related to the water depth, below which energy is transferred directly into the sea floor. Overall, the transmission loss in shallow water is a combination of cylindrical spreading effects, bottom interaction effects (absorption) at lower frequencies and scattering losses at high frequencies.

For this study, the fluid parabolic equation (PE) modelling algorithm RAMGeo (Collins, 1993) has been used to calculate the transmission loss between the source and the receiver. RAMGeo is an efficient and reliable PE algorithm for solving range-dependent acoustic problems with fluid seabed geo-acoustic properties. The noise sources were assumed to be omnidirectional and modelled as point sources. In practice many sources are directional, this assumption is conservative. Also, it is acknowledged that representing a non-point source in this way can overstate the near field sound levels.

With the noise source levels and spectra shown in Appendix B, the received noise levels are calculated following the procedure outlined below:

1. One-third octave source spectral levels are obtained via reference spectral curves with their subsequent corrections based on their corresponding overall source levels;
2. Transmission loss is calculated using RAMGeo at one-third octave band central frequencies from 50 Hz to 8 kHz, based on appropriate source depths corresponding to relevant source scenarios. Lower frequencies have not been modelled, as they will not propagate over long distances in shallow water;
3. Propagation paths for the TL calculation have a maximum range of 25 km and bearing angles with a 5-degree azimuth increment from 0 degrees to 355 degrees around the source locations. The bathymetry variation of the vertical plane along each modelling path is obtained via interpolation of the bathymetry dataset;
4. The one-third octave source levels and transmission loss are combined to obtain the received levels as a function of range, depth and frequency; and
5. The overall received levels are calculated for multiple depths in a 0.5-m depth resolution along each propagation path by summing all frequency band spectral levels.

To extend the modelling to consider the potential for PTS in addition to behavioral disturbance, constant conversion factors have been applied between rms sound pressure level (SPL), sound exposure level (SEL) per strike and peak SPL for the impact pile driving scenario. The conversion factors are based on measurements undertaken at the locations close to the pile driving rig, as described in the literature (Blackwell, 2005). This approach does not account for increasing distortion effects (including dispersion and interference) in the peak noise parameter that occur when an impulsive noise event propagates over distances. In principal, this approach will result in increasing over-prediction of peak noise at increasing distances from the sound source. Therefore, it is a conservative approach for the prediction of the potential for PTS effects.

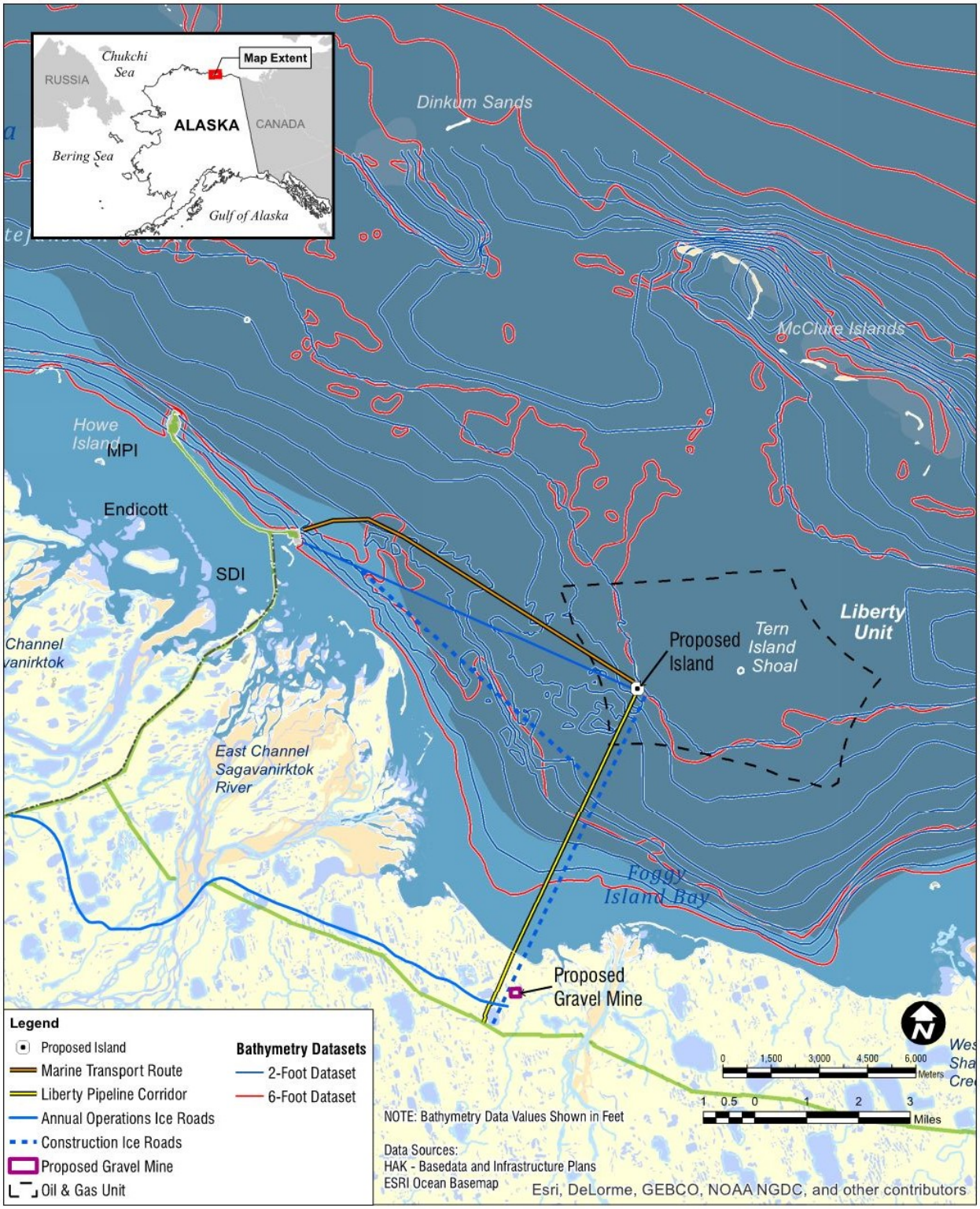
5.3 Modelling input parameters

5.3.1 Bathymetry

The bathymetry data used for the sound propagation modelling were obtained from the combination of the two GIS datasets provided by the HAK, as used in development of the Liberty DPP (HAK, 2015). The dataset with a vertical resolution of 2-foot covers the immediate project area and the dataset with a vertical resolution of 6-foot covers a wider region extending tens of kilometres in both nearshore and offshore directions. The bathymetric contour map in the area of interest is shown in Figure 2.

Studies have shown that the very small water level variations (< 0.2 m) in the Beaufort Sea shelves are dominated by mixed, mainly semidiurnal, low range tide coupled with strong meteorological effects (Huang et al, 2011). As such, no additional corrections have been applied to the bathymetric data to account for the tidal changes within the study area.

Figure 2 Bathymetry datasets used for noise modelling



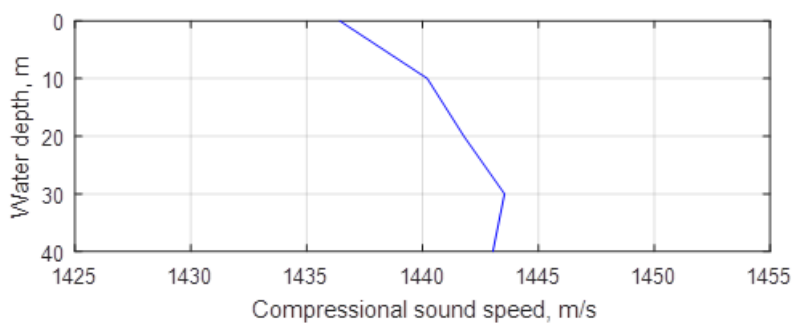
5.3.2 Sound speed profiles

Temperature and salinity data used to derive the sound speed profiles were obtained from the World Ocean Atlas 2009 (Locarnini et al., 2010; Antonov et al., 2010). The hydrostatic pressure used to calculate the sound speed based on depth and latitude of each particular modelling location was obtained using Saunders and Fofonoff's formula (Saunders and Fofonoff, 1976). The sound speed profiles were derived based on Del Grosso's equation (Del Grosso, 1974).

Figure 3 presents the typical average sound speed profile for the open water summer season from July to October near the Project area. The figure demonstrates that the assumed summer season sound speed profile comprises a weak upwardly refracting surface duct at the relatively shallow depths down to about 30 m within and beyond the barrier islands in the study area.

In practice, oceanographic conditions in the project area will vary considerably with seasons, and also with changes in wind direction and speed associated with upwellings. The modelled parameters are adopted as indicative of an anticipated worst case for the purpose of identifying the potential extent of underwater noise propagation.

Figure 3 Typical summer sound speed profiles, shallow Beaufort continental shelf



5.3.3 Seafloor geo-acoustic models

The Liberty DPP (HAK, 2015) has been used as a reference for information on the seafloor surficial sediments around the Foggy Island Bay. The seafloor is covered predominantly with fine sand and silts in layers of Holocene deposits. Some areas of coarser sand and gravel are found in higher wave-energy environments near the shoreline and barrier islands. Pleistocene deposits, comprised of stiff plastic silt and clay, are present under the Holocene layer but also outcrop on the seafloor in some areas. A deposit of cobbles and boulders known as the "Boulder Patch" is also found to the north and west of the proposed Liberty Island.

A summary of seafloor sediment types in and around Foggy Island Bay is provided in Table 9.

Table 9
Surficial sediment types within the project area

Region	Sediment Type
Foggy Island Bay shoreline and barrier islands	Coarse sand and gravel
Boulder patch (north and west of Liberty Island)	Cobbles and boulders
Outcropping Pleistocene deposits	Stiff plastic silt and clay
Holocene deposits elsewhere in Foggy Island Bay	Fine sand and silt

For the seabed stratification beneath the superficial sediment layer, the literature (e.g. Blasco et al, 2013) for the western region of the Canadian Beaufort Shelf indicates that the upper 100 m of sediment mainly consist of layers transitioning from unconsolidated top sand and silt sediment layer to more solid massive clay with exotic clasts of granitic and dolomitic composition. Based on a conservative consideration, a solid layer with material properties equivalent to weathered rock granite is assumed as the ground material beneath the unconsolidated top sediment layer (i.e. loose sand) and above the bedrock.

The overall seabed model parameters assumed over the entire study area are detailed in Table 10. This table includes the geo-acoustic properties and thickness for the top sandy sediment layer, the simplified layer of the weathered rock granite equivalent and the basalt substrate bedrock below. The geo-acoustic properties for each layer are based on relevant literature (e.g. Hamilton, 1980 and Jensen et al, 2011).

Table 10
Properties for the seafloor geo-acoustic model

Seafloor Materials	Thickness (m)	Density ρ, (kg.m^{-3})	Compressional Wave		Shear Wave	
			Speed c_p, (m.s^{-1})	Attenuation α_p, (dB/λ)	Speed c_s, (m.s^{-1})	Attenuation α_s, (dB/λ)
Loose sand (fluid)	10	1900	1650	0.8	-	-
Weathered rock granite	100	2200	2400	0.8	1400	0.5
Basalt	∞	2700	5250	0.1	2500	0.2

The modelling algorithm (i.e. RAMGeo) employed for this modelling study, as detailed in Section 5.2, utilizes a fluid model of the seabed. Therefore, the seabed model inputs only consider the compressional wave parameters for the substrate layer materials as listed in Table 10, with the shear wave parameter values set to zero. The effect of representing the seabed as a fluid substrate rather than as a solid elastic substrate layer in the model has been investigated, by examining the seafloor reflection coefficients for the two alternative (elastic and fluid) seabed approaches. This investigation was conducted using the plane-wave reflection coefficient program BOUNCE (Porter, 2010). It was found that for this study, the reflection coefficients are in general higher with the fluid seabed model than with the elastic seabed model. Therefore, using the fluid seabed model with parameters described in Table 10 is considered a conservative assumption for underwater noise modelling purposes.

5.4 Summary of conservative assumptions in approach to this study

As described throughout this report, underwater noise modelling inherently involves a simplified representation of a complex physical system. The model developed and described in this report is based on a series of assumptions. The interpretation of the effect of a particular noise level on a species also requires simplifications and assumptions. Since the objective of the study is a precautionary investigation into the potential effects of noise generated by the Project, the model assumptions tend to be conservative. Table 11 provides a summary of the main conservative assumptions incorporated in the approach applied to this study.

Table 11
Conservative assumptions in approach to this study

Component	Assumption	Discussion
Overall approach	Potential for marine mammal behavioral disturbance due to Liberty Project	Other similar projects in the area have not resulted in documented changes in marine mammal populations or in observations of meaningful behavioral responses. Undertaking the study is precautionary.
Behavioral noise effect thresholds	Broadband overall noise level thresholds	The NMFS interim thresholds are considered to be conservative. Natural noise sources can at times result in ambient noise levels above the thresholds. Species specific hearing sensitivity and masking effects are not considered. A noise level above the behavioral threshold indicates a potential for a behavioral response to noise – it does not necessarily equate to an adverse effect on an individual marine mammal or a population.
PTS noise effect thresholds	PTS onset thresholds	NMFS (2016) note that no direct measurements of marine mammal PTS have been published; the PTS onset acoustic thresholds recommended by NMFS have been extrapolated from marine mammal TTS measurements using a conservative assumed offset from TTS thresholds.
Model representation of noise sources	Omni-directional noise sources and propagation	The model assumes each source generates noise propagating in all directions. In practice many sources are directional. For example, vibratory sheet piling is modelled as generating noise simultaneously in all directions around the island. In practice, the island will act as a noise barrier and the noise from any individual pile being driven will propagate only over a partial segment of the overall area identified in the model. Therefore, on any single day the ensonified area due to vibratory piling would be considerably less than the overall area identified in this report.
	Point source representation	Representing noise sources as points results in an overestimation of noise levels in the near field. This is particularly relevant to the assessment of PTS, where effects identified as potentially occurring close to the source are likely to be based on overestimates of the actual noise level.
Oceanographic conditions	Constant, worst case propagation	Assumptions relating to sound speed profiles, temperature and salinity, and sea floor conditions are all made based on the worst case potential for noise propagation. In practice, these factors will vary and at times noise propagation may be less.
Noise duration for behavioral effects	Duration of noise has no influence on behavioral response	Many noise sources (including vessels and pile driving) are transitory or relatively short-term. The noise from these activities may only affect a particular area for a relatively short time in any 24 hour period. This study identifies areas with potential for behavioral effects without any adjustment for reduced disturbance due to short duration activities.

5.5 Underwater noise modelling results

5.5.1 Behavioral disturbance interim thresholds – open water

Figures showing the received noise levels across the study area and the location of the behavioral threshold isopleth for all scenarios are provided in Appendix D. The following figures are provided to illustrate and explain the predicted extent of noise impacts, using the vibratory sheet piling in open water scenario as an example.

Figure 4 shows a cross sectional example of the variation in noise level with depth and increasing distance from the source. This figure is plotted along a line directly to the north of Liberty Island. In this direction, the water depth increases only a small amount out to a distance of approximately 15 km, then deepens more rapidly. Overall broadband rms noise levels are highest near the source, and it can be seen that the highest noise levels are predicted in the middle of the water column, with lower noise levels predicted both near the bottom and near the surface. In this direction, the maximum distance predicted to the behavioral disturbance guidance threshold is approximately 15.2 km (mid-water column), and the minimum distance to the threshold is approximately 13.2 km (near surface or bottom).

Figure 4 Vibratory sheet piling noise level vs depth and distance from source, plotted along a line due north of Liberty Island

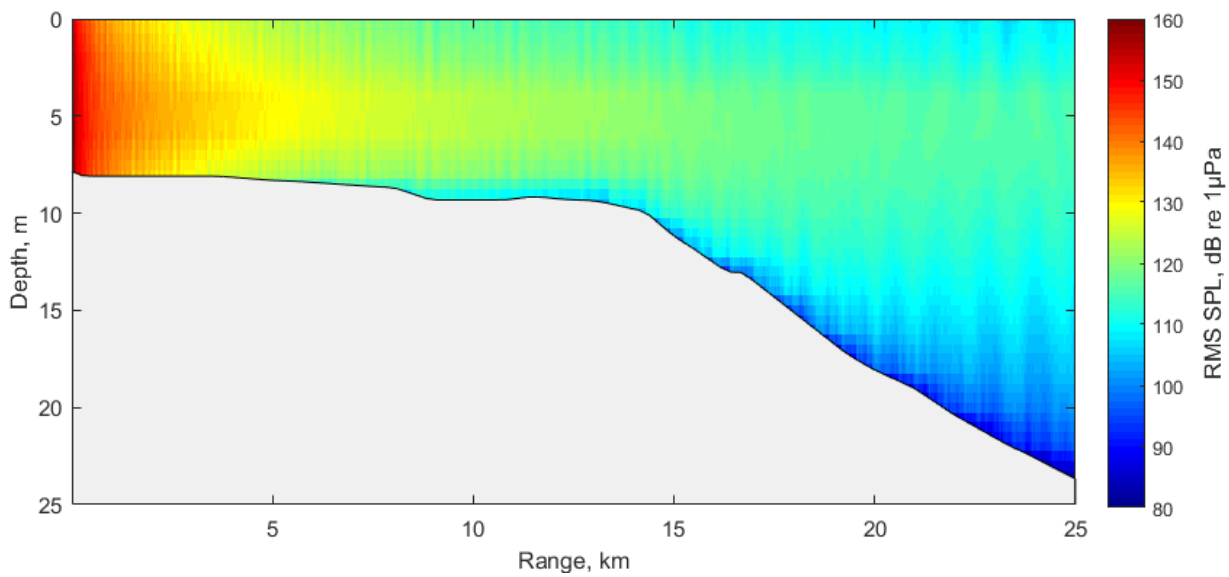


Figure 5 shows the plan view noise isopleths for the same scenario, indicating the maximum distance to the behavioral disturbance guidance threshold, along with the minimum distance and also the median distance. The median distance is recommended for use in estimating number of potential behavioral responses, since this distance best reflects that animals are mobile and may be present anywhere in the water column. Figure 5 also illustrates that noise propagates further in some directions than in others. In particular, noise propagates less in the shallower waters towards shore than in directions out to sea. Noise also propagates further in directions away from the McClure Islands. The shielding effect of Liberty Island itself has not been accounted for in this modelling. Using the vibratory sheet piling example, when piling occurs on the side of the island nearest the shore, the noise impacts to the north will be less than shown in Figure 5.

Figure 5 Vibratory sheet piling noise isopleth example

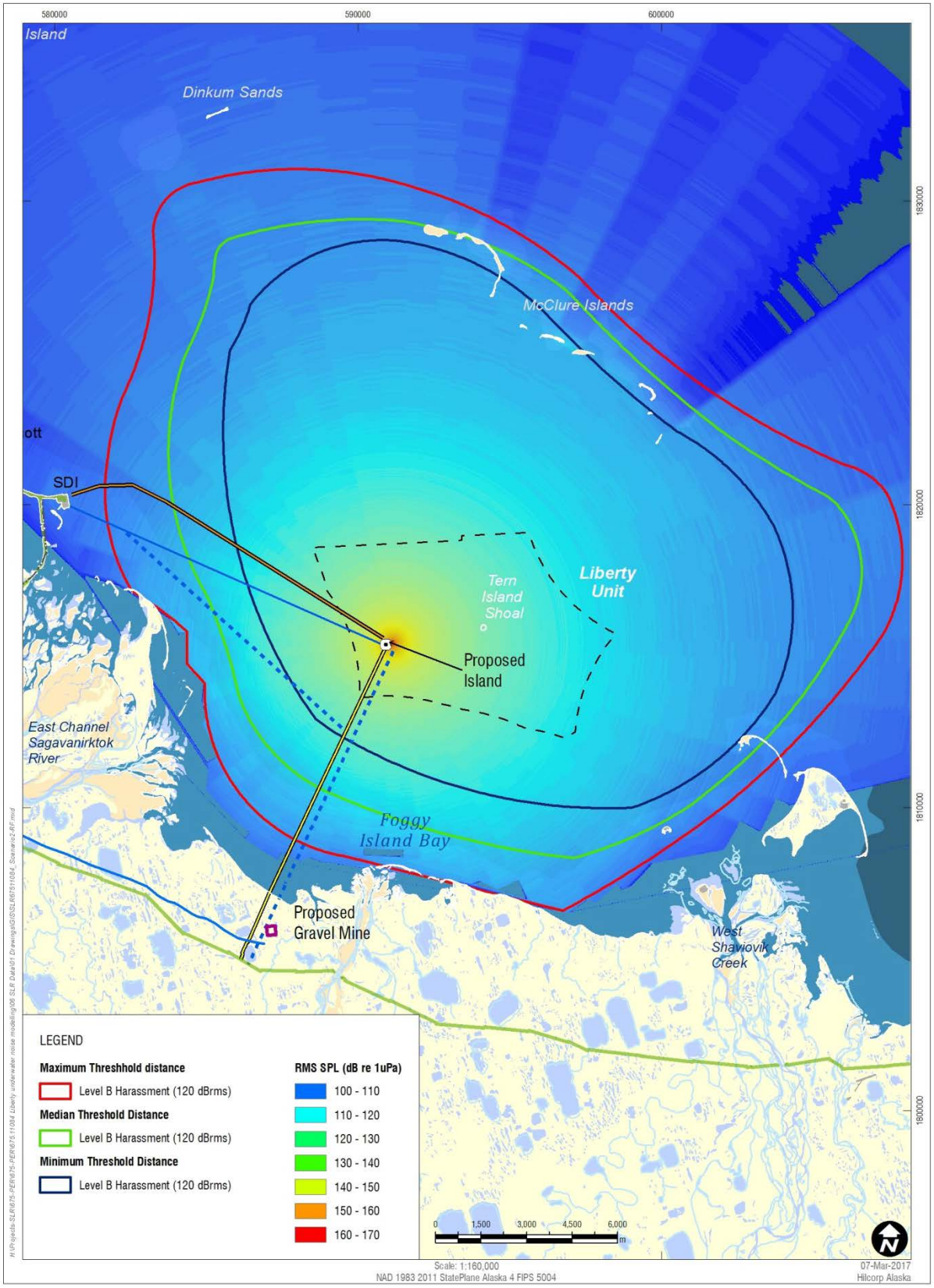


Table 12 summarizes the predicted distances from the noise source to the interim underwater behavioral impact thresholds for marine mammals for each of the project scenarios considered in the open water summer season, in the maximum propagation direction (ie, away from shore).

Vibratory sheet pile driving has potential for underwater noise above the interim behavioral effect threshold over the largest area, within up to 11 miles (17.5 km) from the island. With reference to Appendix D and Figure 5, the extent of noise levels above the behavioral threshold during vibratory sheet pile driving is out to but not significantly beyond the barrier islands. Noise generated by vibratory pile driving would propagate further in the summer open water season than under ice. It is noted that during construction of Northstar Island, pile driving was not required during the open water season. This report considers the possibility that pile driving may occur after ice-breakup, but disturbance to marine mammals would be minimized if the construction schedule mirrors that of Northstar with pile driving in the ice-covered season.

Vessel transportation is the scenario with the next greatest extent of potential behavioral disturbance, with broadband rms noise levels above the threshold occurring at distances of up to 1.4 miles (2.2 km) from larger barge-type vessels. Smaller vessels have lower noise emissions. Appendix D shows the location of the behavioral threshold isopleth for all scenarios.

Table 12
Open water distance to behavioral disturbance thresholds

Scenario – Open Water	Source Location(s)	Distance from Source to Interim Behavioral Threshold			Effective Range of Attenuation Factors
		Maximum	Median	Minimum	
Slope shaping, armament installation	Island	1,260 m	1,160 m	880 m	15.2 – 16.0
Vibratory sheet pile driving	Island	17,500 m	14,800 m	12,000 m	15.3 – 15.9
Impact sheet pile driving	Island	2,250 m	2,050 m	1,700 m	14.9 – 15.5
Impact pipe driving	Island	400 m	315 m	300 m	13.8 – 14.5
Emergency and oil spill response training	Island	280 m	225 m	165 m	14.7 – 16.2
Vessel transportation - barge	Transport route	2,200 m	1,850 m	1500 m	15.0 – 15.7
Vessel transportation - tug		1,020 m	880 m	760 m	14.6 – 15.3
Vessel transportation – small/crew Boat		320 m	260 m	200 m	14.4 – 15.6
Hovercraft Transportation	Transport route	95 m	70 m	~10 m	14.7
Drilling and production	Island	85 m	55 m	~20 m	17.1
Production only	Island	75 m	45 m	~15 m	16.5

Note 1: NMFS interim guidance behavioral thresholds are RMS 120 dB re 1µPa (continuous underwater noise); 160 dB re 1µPa (impulsive underwater noise); and 100 dB re 20µPa (airborne noise).
Note 2: For some scenarios the identified distances may be within the island, so no actual behavioral response is possible.
Note 3: Underwater noise varies with depth and range. Results are minimum, median and maximum distance to the noise threshold across all depths calculated in the direction of maximum noise propagation from the source (away from shore).

The right hand column in Table 12 provides the effective broadband attenuation factor based on the noise transmission loss between the source and the maximum behavioral threshold radius, in the direction of maximum propagation. These values range between about 14 and 17, with an average of 15 which corresponds to the practical spreading loss factor. Noise propagating towards the shore attenuates with a factor of up to 18.

Differences in the calculated effective attenuation factor for each scenario are related to the different frequency characteristics of each source, combined with frequency dependent propagation effects. Overall, the detailed model predicted attenuation factors are very similar to measured long distance attenuation factors from Northstar (14 to 18). This indicates that the overall broadband noise levels in the frequency range modelled are dominated by higher frequency components, and the shallower water at Liberty Island does not provide significantly more attenuation of the overall broadband noise levels in this range than is provided by the water surrounding Northstar Island.

5.5.2 PTS onset thresholds due to peak noise level – open water

Table 13 summarizes the predicted distances from the source to the peak noise thresholds corresponding to the onset of PTS, for all activities and marine mammal groups considered. Only impact sheet pile driving through gravel around the boundary of the island produces impulsive noise with the theoretical potential to exceed the peak noise PTS onset thresholds, with the highest threshold distance of 10 m from the source being identified for low-frequency cetaceans and phocid pinnipeds. The practical potential for PTS due to impulsive peak noise level exposure is even less, occurring only if an animal is underwater within about 10 m of the impact piling rig. This scenario could be readily avoided. Note that the source levels used for this activity were measured in a similar situation (piling through gravel) – sheet piling directly into the water column would be expected to produce higher noise levels. The attenuating effect of the gravel is incorporated in the source levels used.

Table 13
Distance to PTS onset thresholds for peak noise level

Scenario – Open Water	Source Location(s)	Maximum Distance from Source to PTS Onset Threshold (L_{pk}, flat)	
Impact sheet pile driving	Island	Low-frequency cetaceans	<10 m
		Mid-frequency cetaceans	0
		Phocid pinnipeds	<10 m

Note: For other scenarios the noise level at source is less than the peak noise threshold, so no exceedance is possible

5.5.3 PTS onset thresholds due to cumulative noise exposure – open water

In order to estimate the potential for PTS due to cumulative sound exposure following NMFS guidelines, an indication of the possible duration of noise generating activities in any 24 hour period is required. Table 14 indicates the potential activity durations that have been assumed for the purpose of this assessment, for non-impulsive noise generating activities on and around Liberty Island. Construction is expected to occur in 12 hour shifts, 24 hours a day. The active production of noise (or acoustic usage factor) would be less than the full work day duration. Activity durations in Table 14 have therefore been reduced from 24 hours to reflect the anticipated duration of active noise generation as follows:

- Slope shaping, armament installation – 40% usage factor from US Department of Transport guidelines for construction equipment acoustic usage factors (US DoT, 2006)
- Vibratory sheet pile driving – up to 20 piles per day may be driven to a depth of 25 feet. Pile penetration speed can vary depending on ground conditions, but a minimum sheet pile penetration speed is 20 inches per minute to avoid damage to pile or hammer (NASSPA, 2005). For this study, the anticipated duration is based on a preferred penetration speed greater than 40 inches or 1m per minute (Committee for Waterfront

Structures, 2012), resulting in 7.5 minutes to drive each pile. During sheet pile driving at Northstar Island, it was observed that "a typical vibrahammer operation lasted for 1 minute or less" (Shepard et al, 2001).

- Oil spill response training schedules for Northstar and other nearby facilities indicate one two-hour session per week.
- For other activities, indicative durations have been estimated in consultation with HAK.

In practice, the durations of each activity would vary on different days, and would frequently be less than indicated in Table 14.

Table 14
Non-impulsive activity durations for cumulative noise PTS assessment

Scenario – Open Water	Duration (per 24 h)	Comments
Slope shaping, armament installation	9.6 hours	40% usage factor
Vibratory sheet pile driving	2.5 hours	20 piles per day, 7.5 minutes per pile
Emergency oil spill response training	2 hours	One two hour session per week
Vessel transportation - barge	2 hours	Shipping noise around island up to 8 hours per day, with a range of vessels contributing
Vessel transportation - tugs	2 hours	
Vessel transportation – small / crew boat	4 hours	
Hovercraft Transportation	2 hours	One arrival and departure in 24 h
Drilling and production	24 hours	24 h production
Production only	24 hours	

The estimated durations and schedules for impulsive activities are detailed in Table 15. For these activities, durations have been estimated in consultation with HAK and with reference to monitoring undertaken during similar activities at Northstar.

Impact sheet pile driving – observations from Northstar by Greene et al (2008) indicate impact pile driving was required only to finish off each pile after vibratory driving into the frozen material of old Seal Island. Since Liberty will be a newly constructed gravel island, driving sheet piles should be easier than was the case at Northstar. Impact sheet pile driving therefore may not be required at Liberty and is included in this study as a precaution.

Impact pipe driving – a total of 16 conductor pipes would be set at Liberty, driven to 160 feet depth with impact hammers. Blackwell et al (2004a) observed impact pipe driving at Northstar. On most days, one conductor was driven in a day over a period of 5 to 8.5 hours. The longest day of observation was 10.5 hours in which time two pipes were driven. The observation period each day included all pipe driving time, but driving was never continuous during the entire observation period.

Table 15
Impulsive activity durations for cumulative noise PTS assessment

Scenario	Duration (per 24 h)	Comments
Impact sheet pile driving	Maximum 40 minutes per day, anticipated duration < 20 minutes per day.	Delmag D62-22 hammer, 35-50 strikes per minute (Greene et al, 2008). Approximately 2 minutes and 100 strikes per pile.
Impact pipe driving	2 hours 4400-6300 strikes per day	20% impact hammer usage factor from US Dot (2006) over a 10.5 hour period from Blackwell et al (2004a). Delmag D62-22 hammer, 35-50 strikes per minute.

As described in the recent Technical Guidance (NMFS, 2016), for PTS to occur due to cumulative noise exposure an individual animal would need to remain in proximity to the noise source for a sufficiently long time. The following tables provide a range of estimates for the distance of onset of PTS due to cumulative noise exposure, considering exposures of duration up to the estimated maximum activity duration in each 24 hour period. Results are provided for the various marine mammal hearing sensitivity groups of interest. A discussion of the overall potential for PTS due to cumulative noise exposure follows in Section 5.4.4.

Table 16
Distance to cumulative PTS onset thresholds low-frequency cetaceans

Scenario	Source Location	Indicative Distance from Source to PTS Onset Threshold (cumulative weighted, $L_{E, LF, 24h}$)	
Slope shaping, armament installation	Island	9.6 hours	<10 m
Vibratory sheet pile driving	Island	2.5 hours	50 m
Impact sheet pile driving	Island	10 min	770 m
		20 min	1,220 m
		30 min	1,600 m
		40 min	1,940 m
Impact pipe driving	Island	30 min	345 m
		1 hour	550 m
		1.5 hours	720 m
		2 hours	870 m
Emergency and oil spill response training	Island	n/a	
Vessel transportation – all vessels	Transport route	n/a	
Hovercraft Transportation	Transport route	n/a	
Drilling and production	Island	n/a	
Production only	Island	n/a	

Table 17
Distance to cumulative PTS onset thresholds mid-frequency cetaceans

Scenario – Open Water	Source Location	Indicative Distance from Source to PTS Onset Threshold (cumulative weighted, LE, MF, 24h)	
Slope shaping, armament installation	Island	9.6 hours	n/a
Vibratory sheet pile driving	Island	2.5 hrs	<10 m
Impact sheet pile driving	Island	10 min	25 m
		20 min	37 m
		30 min	50 m
		40 min	60 m
Impact pipe driving	Island	30 min	10 m
		1 hour	17 m
		1.5 hours	22 m
		2 hours	27 m
Emergency and oil spill response training	Island	n/a	
Vessel transportation – all vessels	Transport route	n/a	
Hovercraft Transportation	Transport route	n/a	
Drilling and production	Island	n/a	
Production only	Island	n/a	

Table 18
Distance to cumulative PTS onset thresholds phocid pinnipeds

Scenario – Open Water	Source Location	Indicative Distance from Source to PTS Onset Threshold (cumulative weighted, LE, PW, 24h)	
Slope shaping, armament installation	Island	9.6 hours	<10 m
Vibratory sheet pile driving	Island	2.5 hrs	20 m
Impact sheet pile driving	Island	10 min	210 m
		20 min	330 m
		30 min	435 m
		40 min	526 m
Impact pipe driving	Island	30 min	95 m
		1 hour	148 m
		1.5 hours	195 m
		2 hours	240 m
Emergency and oil spill response training	Island	n/a	
Vessel transportation – all vessels	Transport route	n/a	
Hovercraft Transportation	Transport route	n/a	
Drilling and production	Island	n/a	
Production only	Island	n/a	

5.5.4 Discussion of potential for PTS – open water scenarios

For the majority of the activities considered, the assessment confirms that there is no realistic potential for PTS in marine mammals due to either impulsive peak noise levels or cumulative noise exposure. A theoretical potential for PTS has been identified only for four construction scenarios, being slope shaping (armament installation), vibratory pile driving, impact pile driving and impact pipe driving. Of these scenarios, both vibratory pile driving and slope shaping would require an individual animal to remain underwater in close proximity to the source for extended periods of time for the theoretical potential of PTS to become actualized.

The potential for PTS due to impulsive peak noise levels is more limited than the potential for PTS due to cumulative noise exposure, even for impact pile driving. For the species of concern, the potential for PTS due to impulsive peak noise level exposure is predicted only within 10 m of impact sheet pile driving around the boundary of the island. This theoretical potential for PTS due to peak noise level applies to low frequency cetaceans (bowheads and gray whales) in addition to phocid pinnipeds (bearded, ringed, and spotted seals), but does not apply to belugas. In practice, elimination of any potential for PTS due to peak noise level would be readily achievable.

The only scenarios with theoretical residual potential for PTS are the cumulative noise effects of the impact pile driving and impact pipe driving scenarios. The residual potential for PTS for each of the marine mammal groups of interest is summarized as follows, for the underwater open water activities associated with the Liberty Project:

- Bowhead, gray whales (low-frequency cetaceans) – There is theoretical potential for PTS during impact sheet pile driving in the open water season, if animals remain within 770 to 1,220 m (2350 to 4000 ft) of the noise source throughout the work day, with active impact sheet pile driving occurring for 10 to 20 minutes in total. During impact driving of

conductor pipes, PTS may occur if animals remain within about 870 m (2850 ft) for the full work day with 2 hours of active impact driving. In practice, these species are extremely unlikely to be present this close to Liberty Island, in areas with water depths less than around 25 feet. Therefore, the theoretical potential for PTS in low frequency cetaceans is unlikely to be realized.

- Beluga whales (mid-frequency cetaceans) – There is potential for PTS during impact sheet pile driving in the open water season, but only if animals remain in very close proximity to the island (within 60 m or 200 ft) for the full work day. Again, this theoretical potential for PTS is unlikely to be realized.

- Bearded, ringed, and spotted seals (phocid pinnipeds) – There is potential for PTS during vibratory sheet pile driving in the open water season if animals remain within 210 to 330 m (690 to 1080 ft) of the noise source throughout the work day, with active impact sheet pile driving occurring for 10 to 20 minutes in total. During impact driving of conductor pipes, PTS may occur for animals remaining within about 240 m (790 ft) for the full work day with 2 hours of active impact driving.

The identified distances and durations corresponding to theoretical potential for PTS to the various marine mammals are provided in this assessment to inform the development (by others) of HAK's application for a Letter of Authorization for the Liberty Project. In practice, the potential for PTS would depend on the likelihood of particular species being present within the identified distances from the noise source, and on the behaviour of the individual animal in response to noise. In particular, PTS would not occur if an animal moved away from the noise source during the work day, or if an animal did not remain underwater for the full duration of active noise generation.

6.0 AIRBORNE NOISE MODELLING

6.1 Airborne noise modelling methodology

The following process has been used to assess Project-related airborne noise:

- Develop a 3-D computer model of the study area taking into account topography, ground surfaces and absorption effects;
- Incorporate the various Project noise sources in the model;
- Use the model to predict the maximum environmental noise contribution for each assessment scenario; and
- Identify scenarios that are predicted generate noise above the identified threshold, and the areas affected.

6.2 Airborne noise sources and assessment scenarios

Airborne noise impact has been assessed for the various identified scenarios, as shown in Table 7. For each scenario, the noise impact is assessed by comparing the maximum sound pressure level to the threshold. As only the maximum sound pressure level is being assessed (for example, the maximum noise level during a vehicle drive-by), the duration of exposure is not considered. Noise source locations are identified for each source, as shown in Figure 1.

The species of interest for the airborne noise component of this study are bearded seals, ringed seals and spotted seals.

6.3 Noise modelling method

Noise modeling software SoundPLAN Version 7.4 has been used to calculate noise emissions and propagation for this project. The ISO 9613-1 (ISO, 2015) and ISO 9613-2 (ISO, 2012) algorithms have been used to calculate propagation and attenuation including effects such as:

- Geometric spreading;
- Ground attenuation;
- Atmospheric absorption;
- Barrier attenuation (due to terrain); and
- Moderate downwind or inversion conditions.

6.4 Noise modelling inputs

Terrain elevation data and scenario layouts were provided by HAK. Full details of noise sources that have been included in the model for each scenario are attached in Appendix B. Details in Appendix B include source sound power level, height, and data source. Typical octave-band frequency spectrum shapes have been identified for each source type.

Equipment noise levels for stationary or quasi-stationary noise sources such as pile drivers, generators, and excavators are based on the energy average sound level (L_{eq}). Noise levels for mobile equipment such as trucks and transportation vessels are based on the maximum pass-by sound pressure level (L_{max}).

Ground attenuation over the sea was calculated using a reflective surface parameter (G=0) for both open water and ice-covered conditions. Ground attenuation over land for open water scenarios was calculated using a partially absorptive surface parameter (G=0.5), corresponding to arctic tundra with densely scattered bodies of water. Ground attenuation over land for ice-covered scenarios was also calculated using a partially absorptive surface parameter (G=0.5), corresponding to old snow cover.

Meteorological parameters typical of open water and ice-covered seasonal conditions were used in the computer model calculations. Predicted sound levels for open water scenarios were calculated for a temperature of 40°F (4.4^{o}C) and a relative humidity of 70%. Predicted sound levels for ice-covered scenarios were calculated for a temperature of -20°F (-29°C) and a relative humidity of 70%. Assumed downwind or inversion conditions produce downward refraction of air-borne sound, resulting in enhanced sound propagation between the source and receptor.

All calculations results correspond to un-weighted sound pressure levels at 5 feet (1.5 m) above ground level.

6.5 Airborne noise modelling results

Sound propagation predictions have been conducted for each of the identified scenarios. Prediction results are summarised in Table 19 in terms of the radius around the noise source with noise above the 100 dB_{rms} threshold. The noise model was designed to predict environmental noise levels, and was not designed to predict levels in very close proximity to the sources. As such, a specific radius is not provided for scenarios where the 100 dB_{rms} noise level contour lies within 15 m (50 ft) of the source.

All results presented in Table 19 correspond to propagation over ice or water, where the ground is modeled as “hard” (G=0). “Hard” ground reflects sound and therefore promotes sound propagation. Soft ground or snow is more absorptive and less reflective. The hard ground assumption is therefore a worst case scenario for airborne noise propagation.

The impact pile driving scenario has the largest 100 dB noise contour radius of 100 m (330 ft). The second largest 100 dB noise contour radius is 67 m (220 ft) for the helicopter during take-off and landing. The helicopter does not generate noise above 100 dB_{rms} on the ground while flying at an elevation of 300 m (1000 ft). The 100 dB noise contour radius is predicted to be 30 m (100 ft) for drilling and production, and 15 m (50 ft) or less for all other scenarios.

Table 19
Airborne noise assessment results summary

Scenario	Season	Location(s)	100 dB_{rms} Noise Contour Radius
Ice road construction and maintenance	Ice-covered	Construction ice roads	< 15 m
Pipeline construction	Ice-covered	Pipeline & ice roads	< 15 m
Island construction	Ice-covered	Construction ice roads	< 15 m
		Island	< 15 m
		Gravel mine	< 15 m
Vibratory sheet pile driving	Any	Island	15 m
Impact pile driving	Any	Island	100 m
Emergency and spill response training	Any	Island	< 15 m
Slope shaping, armament installation	Open water	Island	< 15 m
Vessel transportation	Open water	Vessel route	< 15 m
Hovercraft	Any	Vessel route	15 m
Helicopter	Any	Island (on ground)	67 m
		Vessel route (300 m elevation)	n/a
Drilling and production	Any	Island	30 m

Note 1: NMFS interim guidance behavioral thresholds are RMS 100 dB re 20µPa (airborne noise).
Note 2: For some scenarios the identified distances may be within the activity footprint, so no actual behavioral response is possible.

7.0 SUMMARY AND CONCLUSIONS

7.1 Summary of assessment approach

This report documents the potential underwater and airborne noise levels during construction and operation of the Liberty Project. It includes details of the source noise characteristics of various equipment types and noise-generating activities, and considers the generation and propagation of noise in both summer (open water) and in winter (ice-covered) conditions.

The assessment objectives and the various scenarios have prompted three different assessment approaches as follows:

- For **underwater noise in the ice-covered** season, an empirical approach has been used to determine noise propagation, based on measurements undertaken during comparable activities during construction of the Northstar Island in Prudhoe Bay. This approach is able to identify the extent of noise levels above interim marine mammal behavioral

disturbance thresholds based on overall unweighted noise levels. More severe PTS impacts have not been considered in the under-ice season, as these are anticipated to be negligible with reduced noise propagation under ice relative to in open water.

- For **underwater noise in the open-water summer season**, a detailed frequency dependent noise propagation model has been utilized. This approach enables prediction noise propagation over longer distances, accounting for site specific bathymetry and sea-floor characteristics. This frequency dependent approach also enables a review of the potential for PTS, by weighting the received noise level with consideration of the hearing sensitivity of the various species of interest. The detailed noise model predictions have been compared with empirical data from Northstar and also to a practical spreading loss model, as a check on the validity of the detailed model results.
- For **in-air noise**, commercial noise modelling software has been used to identify noise propagation and the extent of potential disturbance of marine mammals.

7.2 Summary of potential extent of marine mammal behavioral disturbance

The assessment indicates that for most construction scenarios (with the exception of pile driving), short-term behavioral disturbance to marine mammals is not expected away from the immediate vicinity of the project area. Vibratory sheet pile driving has the potential to generate noise above the marine mammal interim behavioral effect threshold within the barrier islands, at distances of up to 11 miles (17.5 km) from Liberty Island, if this activity occurs in the open water season. The potential extent of noise above the interim behavioral threshold for each scenario is summarized in Table 20.

Table 20
Extent of noise above interim behavioral effect threshold

Scenario	Underwater Noise (Ice-Covered)	Underwater Noise (Open Water)			Airborne Noise
		Min	Median	Max	
Ice road construction and maintenance	170 m	n/a	n/a	n/a	< 15 m
Pipeline construction	210 m	n/a	n/a	n/a	< 15 m
Island construction	210 m	n/a	n/a	n/a	< 15 m
Vibratory sheet pile driving	390 m	12000 m	14800 m	17500 m	15 m
Impact sheet pile driving	90 m	1700 m	2050 m	2250 m	100 m
Slope shaping, armament installation	n/a	880 m	1160 m	1260 m	< 15 m
Conductor pipe impact driving	11 m	300 m	315 m	400 m	100 m
Emergency spill response training	170 m	165 m	225 m	280 m	< 15 m
Helicopter (take-off, landing)	n/a	n/a	n/a	n/a	67 m
Vessel transportation	n/a	1500 m	1850 m	2200 m	< 15 m
Hovercraft transportation	n/a	~10 m	70 m	95 m	15 m
Drilling & Production	230 m	~20 m	55 m	85 m	30 m
Production only	40 m	~15 m	45 m	75 m	30 m

Note 1: NMFS interim guidance behavioral thresholds are RMS 120 dB re 1µPa (continuous underwater noise); 160 dB re 1µPa (impulsive underwater noise); and 100 dB re 20µPa (airborne noise).
Note 2: For some scenarios the identified distances may be within the island, so no actual behavioral response is possible.
Note 3: Underwater noise varies with depth and range. Open water results are minimum, median and maximum distance to the noise threshold across all depths calculated in the direction of maximum noise propagation from the source, away from shore.

The noise generated by vibratory pile driving would propagate further in the summer open water season than in the ice-covered scenario. During construction of Northstar Island, pile driving

was not required during the summer open water season. This report considers the possibility that pile driving may occur either in winter or after ice-breakup, but disturbance to marine mammals would be minimized if the construction schedule mirrors that of Northstar with pile driving undertaken in the ice-covered season.

Vessel transportation is the scenario with the next greatest extent of behavioral disturbance due to noise, with broadband levels above the threshold occurring at distances of up to 1.4 miles (2.2 km) from larger barge-type vessels. Smaller vessels have lower noise emissions.

7.3 Summary of theoretical potential extent of PTS

The only scenarios with theoretical potential for PTS onset are impact pile driving and impact pipe driving, if these activities occur in the open water season. The theoretical potential for PTS for each of the marine mammal groups of interest is summarized in Table 21. In practice, the potential for PTS would depend on the likelihood of particular species being present within the identified distances from the noise source, and on the behaviour of the individual animal in response to noise. In particular, PTS would not occur if an animal moved away from the noise source during the work day, or if an animal did not remain underwater for the full duration of active noise generation. Cetaceans are unlikely to be present within the identified distances.

Table 21
Theoretical possibility of PTS summary (open water season)

Marine Mammal Hearing Group and Species	Indicative Distance From Source to PTS Threshold	
	Impact Sheet Pile driving (10-20 mins)	Impact Pipe Driving (2 hrs)
Low frequency cetaceans (bowheads, gray whales)	770 to 1,220 m	870 m
Mid frequency cetaceans (belugas)	25 to 37 m	27 m
Phocid Pinnipeds (bearded, ringed, spotted seals)	210 to 330 m	240 m

Notes: Durations are assumed active noise generation time for each source in a 24 hour period. In the case of impact pipe driving, the noise source is located in the interior of the island, so PTS to some species would not be theoretically possible due to the distance to the water. Cetaceans are unlikely to be present within the identified distances of Liberty Island.

7.4 Closing Remarks

The Liberty Project has many similarities to previous projects constructed in the area, which include Endicott, Northstar and Oooguruk. These projects have not resulted in documented changes in marine mammal populations or in observations of meaningful behavioral responses. This precautionary investigation is intended to identify the potential extent of noise generated by the project, to inform a Letter of Authorization (LoA) application for the Liberty Project.

The interpretation of these results should acknowledge inherent uncertainties in prediction of both airborne and underwater noise levels, and in measurement of underwater noise levels. In particular, the measurement and prediction of underwater noise; and the interpretation of underwater noise levels in terms of the resulting effects on marine mammals is a developing field of research. While the noise thresholds used in this assessment follow guidance provided by the National Oceanic and Atmospheric Administration (NOAA), it is recognized that variation in the responses of different species and individual animals to noise are likely.

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9.0 STATEMENT OF LIMITATIONS

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APPENDIX A
Acoustic Terminology

Hilcorp Liberty Project, Alaska
Underwater and Airborne Noise Modelling

SLR Consulting (Canada) Ltd Project No.: 201.04399.00000

Appendix A

ACOUSTIC TERMINOLOGY (SEE ALSO NMFS, 2016)

Auditory weighting function	Auditory weighting functions take into account what is known about marine mammal hearing sensitivity and susceptibility to noise-induced hearing loss and can be applied to a sound-level measurement to account for frequency-dependent hearing (i.e. an expression of relative loudness as perceived by the ear).
Broadband	Broadband refers to a source that produces sound over a broad range of frequencies, while narrowband or tonal sources produce sounds over a more narrow frequency range, typically with a spectrum having a localized a peak in amplitude.
Cumulative sound exposure level (SELcum re 1 $\mu Pa^2 s$)	Level of acoustic energy accumulated over a given period of time or event. Specifically, ten times the logarithm to the base ten of the ratio of a given time integral of squared instantaneous frequency-weighted sound pressure over a stated time interval or event to the reference sound exposure.
Decibel (dB)	Unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power
Source Level (SL)	The acoustic source level (underwater) is the time-integrated squared signal sound pressure level, referenced to a distance of 1 m from a point.
Impulsive sound	Sound sources that produce sounds that are typically transient, brief (less than 1 second), broadband, and consist of high peak sound pressure with rapid rise time and rapid decay. They can occur in repetition or as a single event. Examples of impulsive sound sources include: explosives, seismic airguns, and impact pile drivers.
Isopleth	Line drawn through all points having the same numerical value. In the case of sound, the line has equal sound pressure or exposure levels.
Masking	Obscuring of sounds of interest by interfering sounds, generally with similar frequencies.
Non-impulsive sound	Sound sources that produce sounds that can be broadband, narrowband or tonal, brief or prolonged, continuous or intermittent, and typically do not have a high peak sound pressure with rapid rise time that impulsive sounds do. Examples of non-impulsive sound sources include: marine vessels, machinery operations/construction (e.g., drilling), certain active sonar (e.g. tactical), and vibratory pile drivers.
Octave	The interval between two sounds having a basic frequency ratio of two. For example, one octave above 400 Hz is 800 Hz. One octave below 400 Hz is 200 Hz.
1/3 Octave Band Levels	The energy of a sound split into a series of adjacent frequency bands, each being 1/3 of an octave wide.
Peak Sound Pressure Level (L_{pk})	The greatest absolute instantaneous sound pressure within a specified time interval and frequency band.

Appendix A

ACOUSTIC TERMINOLOGY (SEE ALSO NMFS, 2016)

Permanent Threshold Shift (PTS)	A permanent, irreversible increase in the threshold of audibility at a specified frequency or portion of an individual's hearing range above a previously established reference level.
Power Spectral Density (PSD)	PSD describes how the power of a signal is distributed with frequency.
Received level	The level of sound measured at the receiver.
Root-mean-square Sound Pressure Level (rms SPL)	The square root of the average of the square of the pressure of the sound signal over a given duration.
Sound Exposure Level (SEL or L_E)	A measure of sound level that takes into account the duration of the signal. Ten times the logarithm to the base 10 of the ratio of a given time integral of squared instantaneous frequency-weighted sound pressure over a stated time interval or event to the product of the squared reference sound pressure and reference duration of one second.
Sound Power Level (SWL, Lw)	The Sound Power Level of a source is the rate at which it emits acoustic energy. Sound power describes the source level characteristics of in-air noise sources As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units, but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.
Sound Pressure	A deviation from the ambient pressure caused by a sound wave
Sound Pressure Level (SPL)	The logarithmic ratio of sound pressure to a reference pressure. The reference pressure underwater is P_{ref} = 1 μPa. The reference pressure in air is P_{ref} = 20 μPa.
Sound Speed Profile	The speed of sound in the water column, derived from depth, temperature and salinity, and presented as a function of depth.
Source Level (SL)	The acoustic source level (underwater) is the level referenced to a distance of 1 m from a point source. The point representation is a simplification, in reality most sources are not points. Representation of a source as a point will give a reasonable noise level prediction in the far field, but will overstate predicted noise levels in close proximity to the source.
Spectral / spectrum	Of or relating to frequency component(s) of sound. The spectrum of a function of time is a description of its resolution into components (frequency, amplitude, etc.). The spectrum level of a signal at a particular frequency is the level of that part of the signal contained within a band of unit width and centered at a particular frequency
Temporary Threshold Shift (TTS)	A temporary, reversible increase in the threshold of audibility at a specified frequency or portion of an individual's hearing range above a previously established reference level

APPENDIX B
Noise Source Levels

Hilcorp Liberty Project, Alaska
Underwater and Airborne Noise Modelling

SLR Consulting (Canada) Ltd Project No.: 201.04399.00000

Scenario	Sources Included	Average Sound Pressure Level with Distance R (m) from Source: Received Level (RMS)	Units	Reference Level	Notes
Ice road construction	Graders	RL=189.1-31.3Log(R)	dB re 1µPa	Ref. 1	
	Ice Augers				
	Water pump trucks				
Pipeline construction	Trucks on ice road	RL=179.1-30.1 Log(R)	dB re 1µPa	Ref. 1	Different propagation coefficient for each source means a different source will dominate at different distances. Total noise for scenario is sum of each source, at each distance.
	Backhoe digging	RL=177.7-26.4 Log(R)	dB re 1µPa	Ref. 1	
	Ditchwitch sawing ice	RL=169.6-22.4 Log(R)	dB re 1µPa	Ref. 1	
Island construction	Trucks on ice road	RL=179.1-30.1 Log(R)	dB re 1µPa	Ref. 1	
	Backhoe digging	RL=177.7-26.4 Log(R)	dB re 1µPa	Ref. 1	
	Ditchwitch sawing ice	RL=169.6-22.4 Log(R)	dB re 1µPa	Ref. 1	
Vibratory sheet piling	Vibratory piling (island boundary)	RL=221.0-39.1 Log(R)	dB re 1µPa	Ref. 1	
Impact sheet piling	Impact piling (island boundary)	RL=235.7-39.1 Log(R)	dB re 1µPa	Ref. 1	Pulsed - RMS level is average per pulse
Impact pipe piling - disposal well conductor pipes	Impact pipe piling (interior of island)	RL= 171.7-11.3 Log(R)-0.014R	dB re 1µPa	Ref. 2	Pulsed - RMS level is average per pulse
Emergency and oil spill response training	Grader / bobcat loader	RL=189.1-31.3Log(R)	dB re 1µPa	Ref. 1	Assume underwater noise similar to ice road construction, since main underwater sources are similar (graders to clear snow, augers to cut holes in ice)
	generators / light plants			Ref. 3	
	Snow machines, all terrain vehicles and ARKTOS				
	Ice Augers				
Drilling and production	Drilling + production	RL=170.5-21.5Log(R)	dB re 1µPa	Ref. 4	Received levels during drilling were highly variable - fit of level vs distance based on maximum level
Production only	Production	RL=154.5-22.0Log(R)	dB re 1µPa	Ref. 4	

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Scenario	Sources Included	Source Sound Pressure Level			Source spectrum shape 1/3 octave band centre (dB, unweighted)								Reference	
		Parameter	Overall Level	Units	50 Hz	100 Hz	200 Hz	500 Hz	1000 Hz	2000 Hz	5000 Hz	10000 Hz	Level	Spectrum
Slope shaping, armament installation	Excavator (similar to grab or bucket dredger)	RMS	167	dB re 1µPa at 1m	125	130	140	136	132	126	120	110	Ref. 1	Ref. 2
Vibratory sheet piling	Vibratory piling	RMS	185	dB re 1µPa at 1m	146	145	152	162	167	163	155	151	Ref. 3	Ref. 4
		Peak	202	dB re 1µPa at 1m	146	145	152	162	167	163	155	151	Ref. 3	Ref. 4
		SEL	185	dB re 1µPa at 1m for 1s	146	145	152	162	167	163	155	151	Ref. 3	Ref. 4
Impact sheet piling	Impact sheet piling	RMS	210	dB re 1µPa at 1m	152	170	174	180	179	170	168	164	Ref. 3	Ref. 4
		Peak	225	dB re 1µPa at 1m	152	170	174	180	179	170	168	164	Ref. 3	Ref. 4
		SEL	200	dB re 1µPa at 1m per strike	152	170	174	180	179	170	168	164	Ref. 3	Ref. 4
Impact pipe driving	Impact pipe driving	RMS	196	dB re 1µPa at 1m	152	170	174	180	179	170	168	164	Ref. 5	Ref. 4
		Peak	200	dB re 1µPa at 1m	152	170	174	180	179	170	168	164	Ref. 5	Ref. 4
		SEL	190	dB re 1µPa at 1m per strike	152	170	174	180	179	170	168	164	Ref. 5	Ref. 4
Emergency and Oil Spill Response Training	Vessels - Zodiacs, Kiwi Noreens, Bay-class boats (12 to 45 ft)	RMS	156	dB re 1µPa at 1m	128	124	148	132	132	138	150	145	Ref. 1	Ref. 1
Vessel Transportation	Vessels -barge, tugs, small/crew boat	RMS	170	dB re 1µPa at 1m	143	157	157	161	156	157	157	150	Ref. 1	Ref. 1
Hovercraft Transportation	Hovercraft Griffin 2000 TD	RMS	149	dB re 1µPa at 1m	108	120	100	90	90	85	85	80	Ref. 6	Ref. 6
Drilling and production	Drilling + production	RMS	151	dB re 1µPa at 1m	80	72	68	58	57	50	45	40	Ref. 7	Ref. 7
Production only	Production	RMS	153	dB re 1µPa at 1m	83	71	60	58	55	48	45	40	Ref. 7	Ref. 7

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Source	Modeling height (m)	Source Sound Pressure Level			Source spectrum shape (dB, unweighted)								Reference	
		Overall Level at distance	Units	Distance (m)	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	Level	Spectrum
Graders	2	64.7	dB	100	82	84	76	75	78	76	70	62	Ref. 1	Ref. 2
Ice Augers	2	67.9	dB	100	81	81	78	76	74	72	68	63	Ref. 1	Ref. 2
Water pump trucks	2	72	dB	100	81	82	67	72	71	74	73	66	Ref. 1	Ref. 2
Trucks on ice road	2	74.8	dB	100	85	87	77	75	76	73	69	62	Ref. 1	Ref. 2
Backhoe digging	2	78	dBA	10	74	83	76	75	70	71	63	57	Ref. 2	Ref. 2
Ditchwitch sawing ice	2	76.3	dB	100	75	74	75	72	74	75	80	80	Ref. 1	Ref. 2
Vibratory piling	8	81	dB	100	83	82	79	82	84	82	77	67	Ref. 1	Ref. 2
Impact piling	8	93	dB	160	87	93	85	87	83	80	75	72	Ref. 3	Ref. 3
Grader / bobcat loader	2	64.7	dB	100	82	84	76	75	78	76	70	62	Ref. 1	Ref. 2
generators / light plants	2	65	dBA	10	78	71	66	62	59	55	56	49	Ref. 2	Ref. 2
Snow machines, all terrain vehicles and ARKTOS	1	79.1	dBA	15	58	64	70	70	68	66	60	50	Ref. 4	Ref. 4
Excavator	2	78	dBA	10	74	83	76	75	70	71	63	57	Ref. 2	Ref. 2
Vessels - Zodiacs, Kiwi Noreens, Bay-class boats (12 to 45 ft)	3	62	dBA	300	136	125	115	80	80	80	80	80	Ref. 5	Ref. 6
vessels -barge	3	62	dBA	300	136	125	115	80	80	80	80	80	Ref. 5	Ref. 6
vessels -tugs	3	62	dBA	300	136	125	115	80	80	80	80	80	Ref. 5	Ref. 6
vessels -small/crew boat	3	62	dBA	300	136	125	115	80	80	80	80	80	Ref. 5	Ref. 6
Hovercraft Griffin 2000 TD	3	104	dB	6.5	92	82	80	80	77	75	71	68	Ref. 7	Ref. 7
Helicopter 300m altitude	300	84	dB	300	78	68	77	70	65	60	55	50	Ref. 8	Ref. 8
Drilling + production	4	80	dB	220	50	40	35	32	20	10	10	10	Ref. 9	Ref. 9

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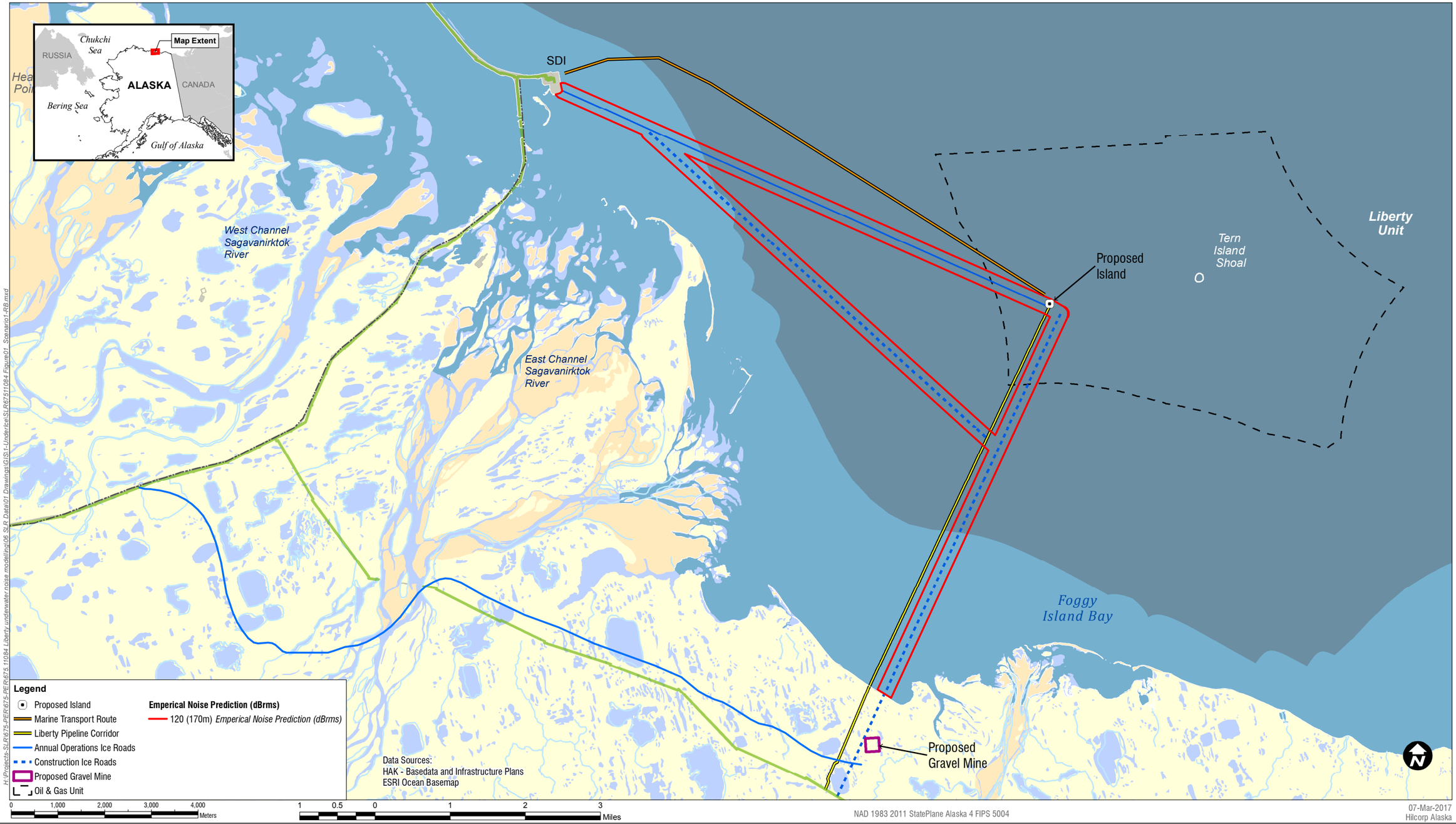
APPENDIX C
Results Figures – Underwater Ice Covered Scenarios

Hilcorp Liberty Project, Alaska
Underwater and Airborne Noise Modelling

SLR Consulting (Canada) Ltd Project No.: 201.04399.00000

This appendix contains figures indicating the areas potentially subject to underwater broadband rms noise levels above the guidance marine mammal behavioral disturbance thresholds during construction and operation of Liberty Island, for each of the activity scenarios considered in the ice-covered season.



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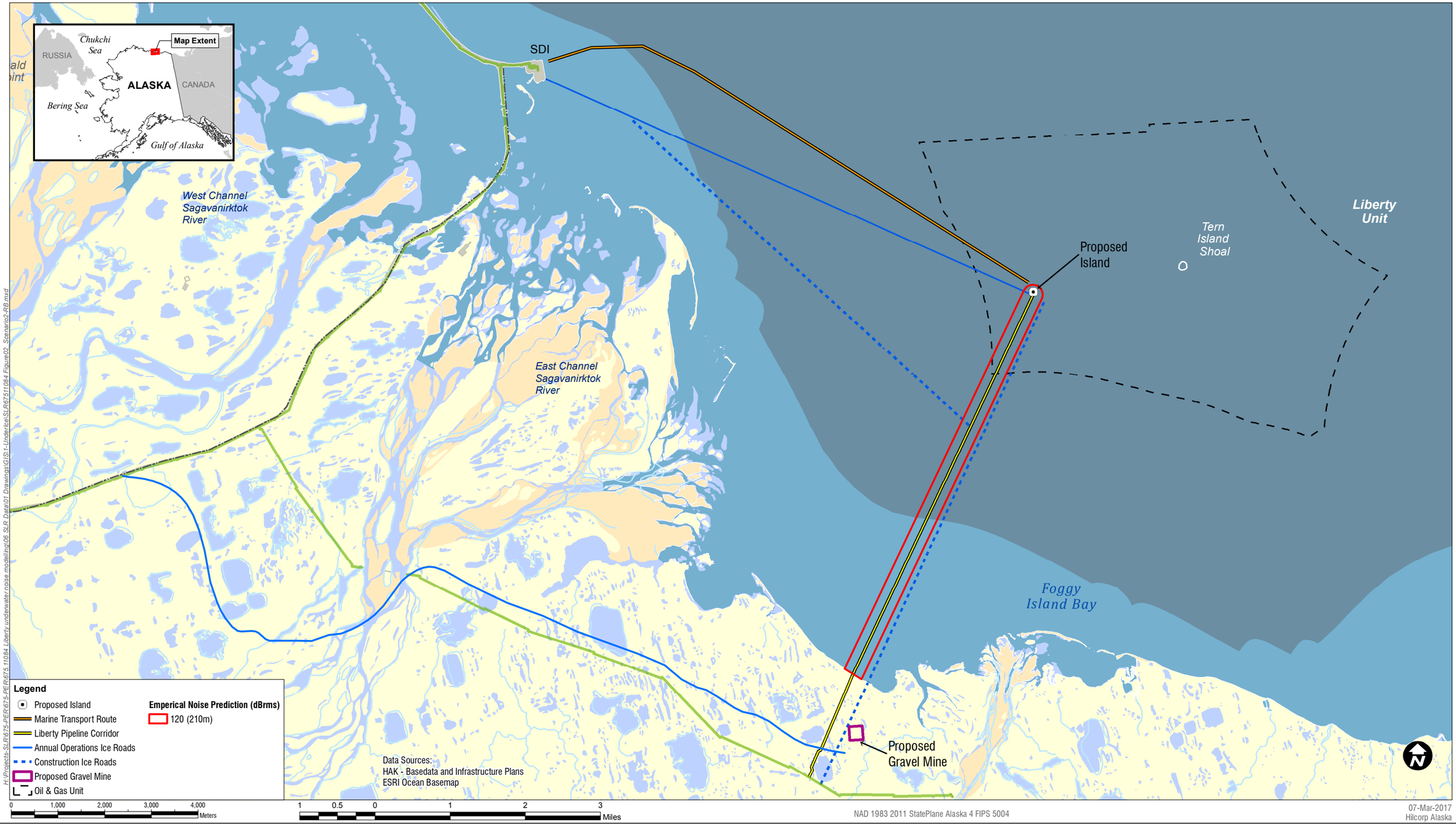
Hilcorp Alaska, Liberty Development
Construction Noise - Behavioural Threshold Lines
Scenario 1, Ice Road Construction & Maintenance

Figure 01



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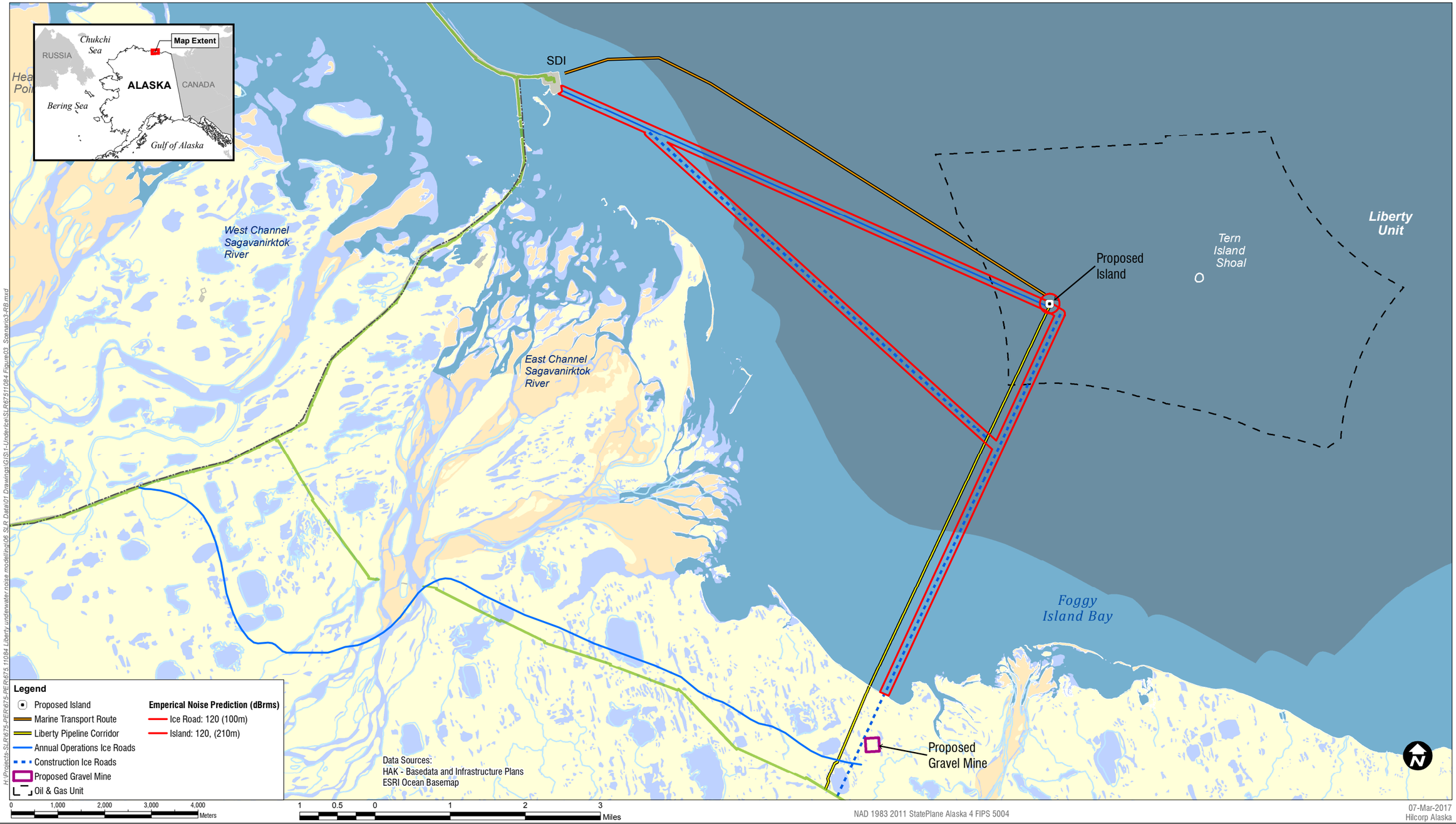
Hilcorp Alaska, Liberty Development
Construction Noise - Behavioural Threshold Lines
Scenario 2, Pipeline Construction

Figure 02



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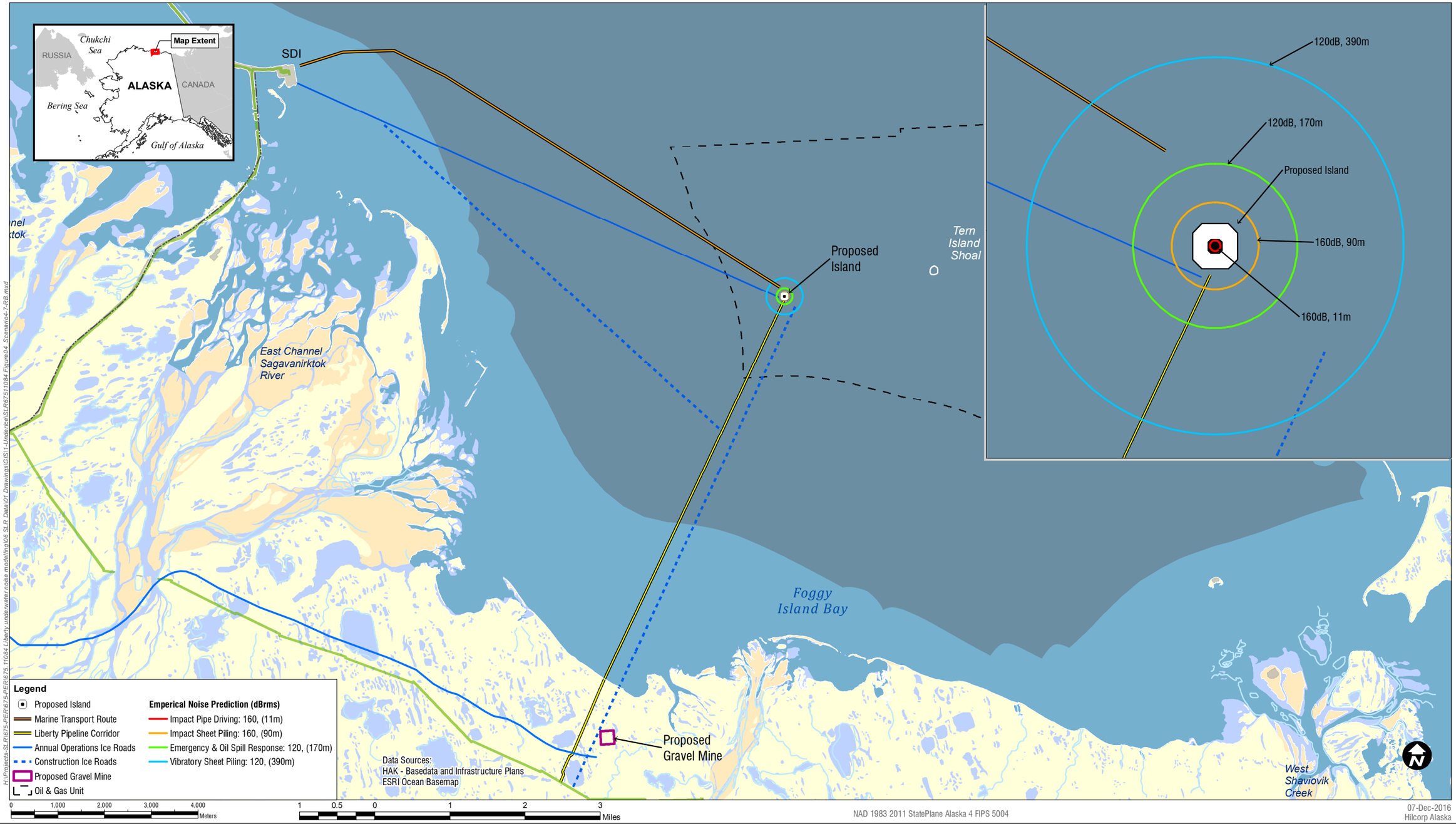
Hilcorp Alaska, Liberty Development
Construction Noise - Behavioural Threshold Lines
Scenario 3, Island Construction

Figure 03



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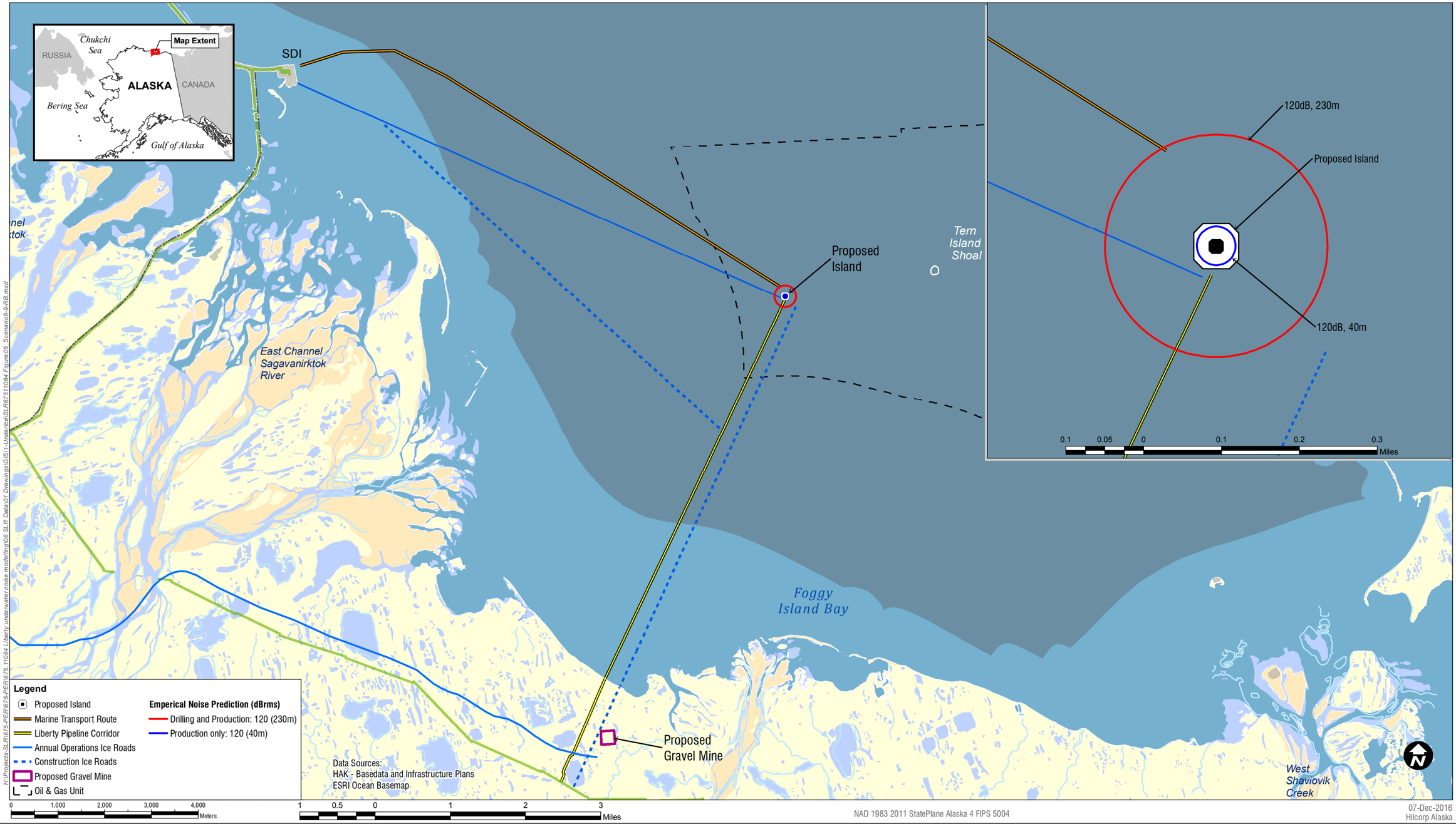
Hilcorp Alaska, Liberty Development - Construction Noise
Behavioural Threshold Lines Scenario 4 - 7
Piling, Pipe Driving, Emergency & Oil Spill Response Training

Figure 04



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Hilcorp Alaska, Liberty Development
Operational Noise - Behavioural Threshold Lines
Scenario 8 & 9, Drilling and Production Operation

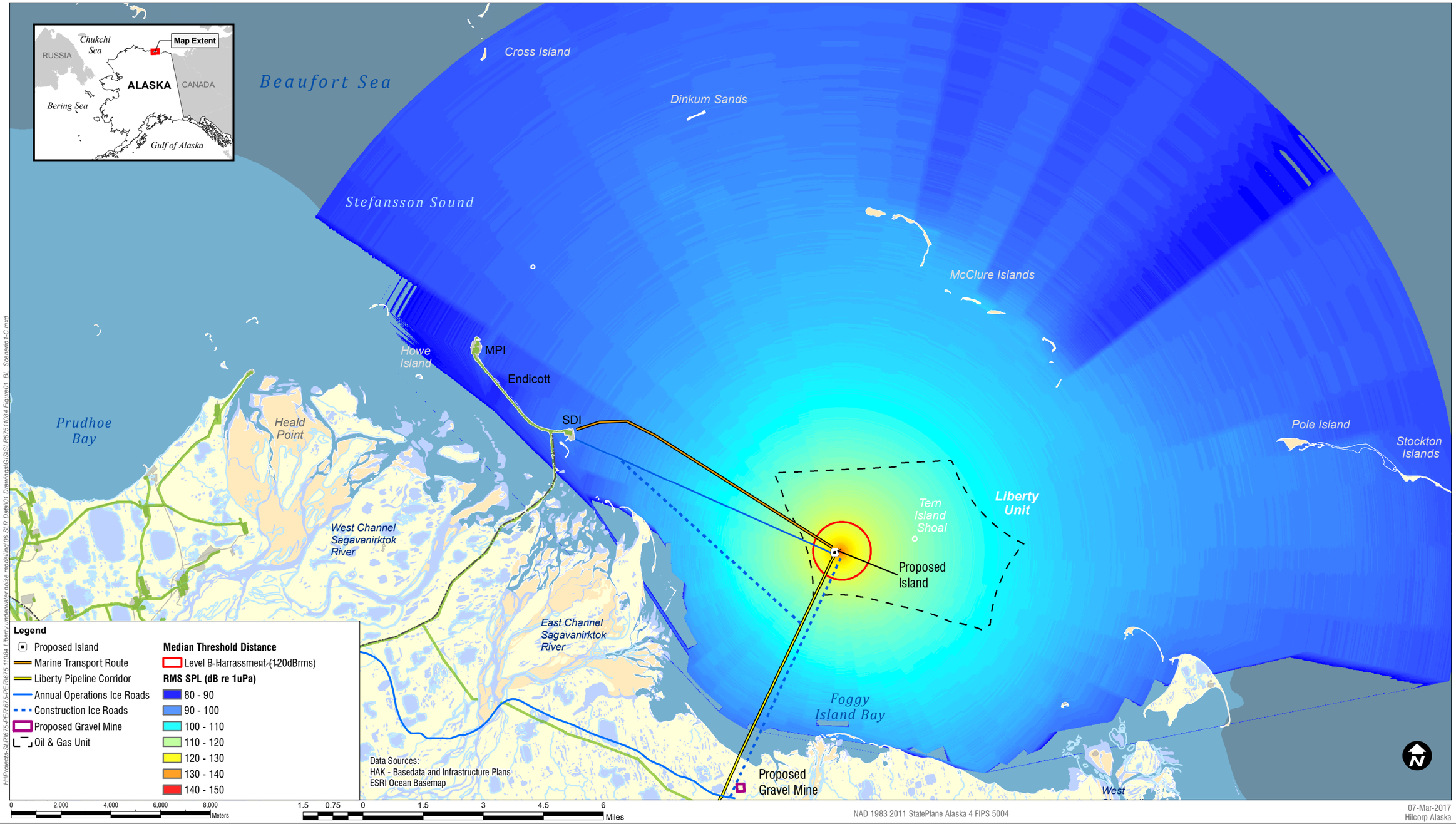
Figure 05

APPENDIX D
Results Figures – Underwater Open Water Scenarios

Hilcorp Liberty Project, Alaska
Underwater and Airborne Noise Modelling

SLR Consulting (Canada) Ltd Project No.: 201.04399.00000

This appendix contains figures indicating the areas potentially subject to underwater broadband rms noise levels above the guidance marine mammal behavioral disturbance thresholds during construction and operation of Liberty Island, for each of the activity scenarios considered in the open water season.



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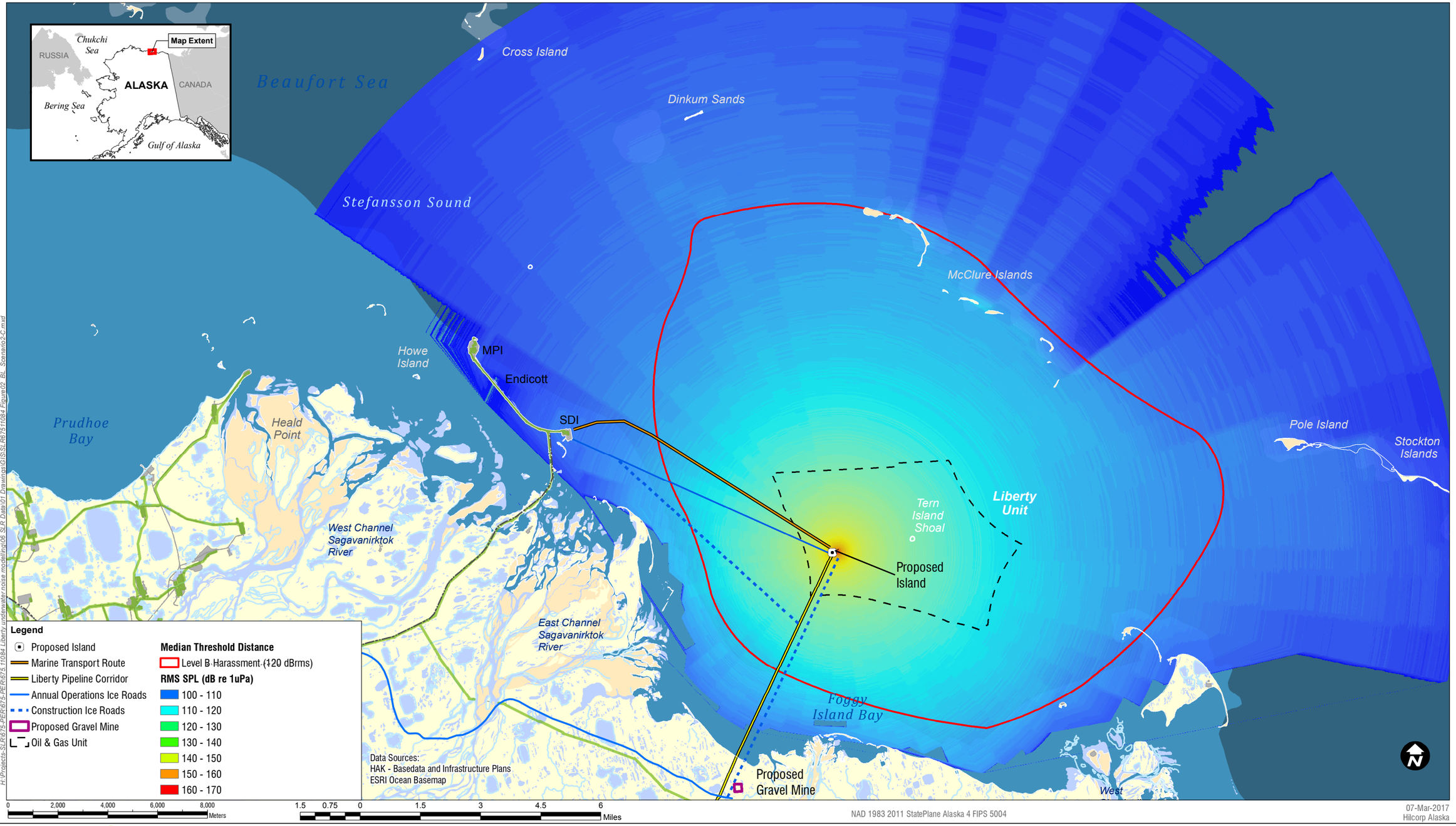
Hilcorp Alaska, Liberty Development, Scenario1 Construction Noise, RMS SPL (dB re 1uPa), Slope Shaping, Armament Installation, Open Water Season

Figure 01



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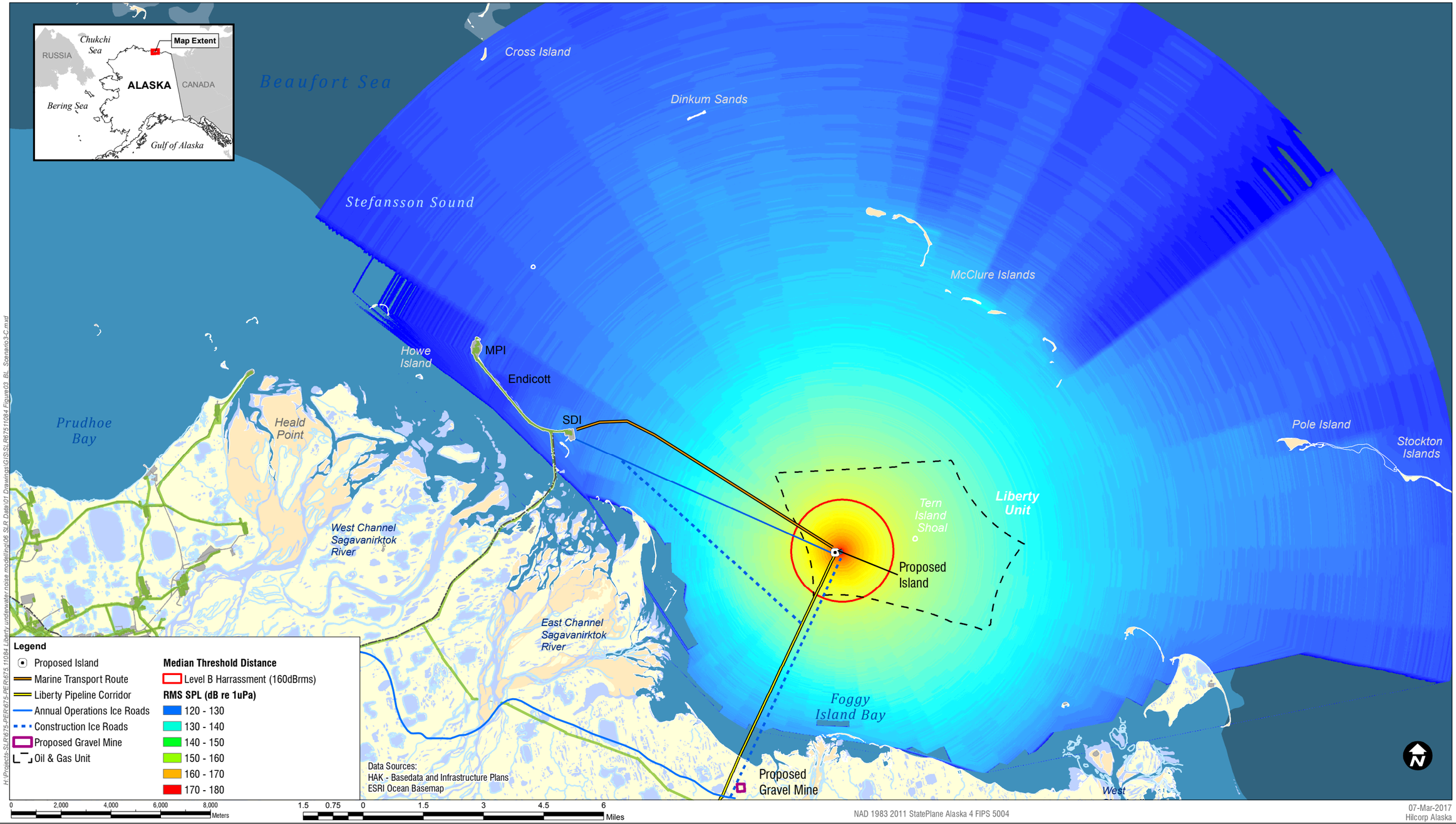
Hilcorp Alaska, Liberty Development, Scenario 2
Construction Noise, RMS SPL (dB re 1uPa)
Vibratory Sheet Piling, Open Water Season

Figure 02



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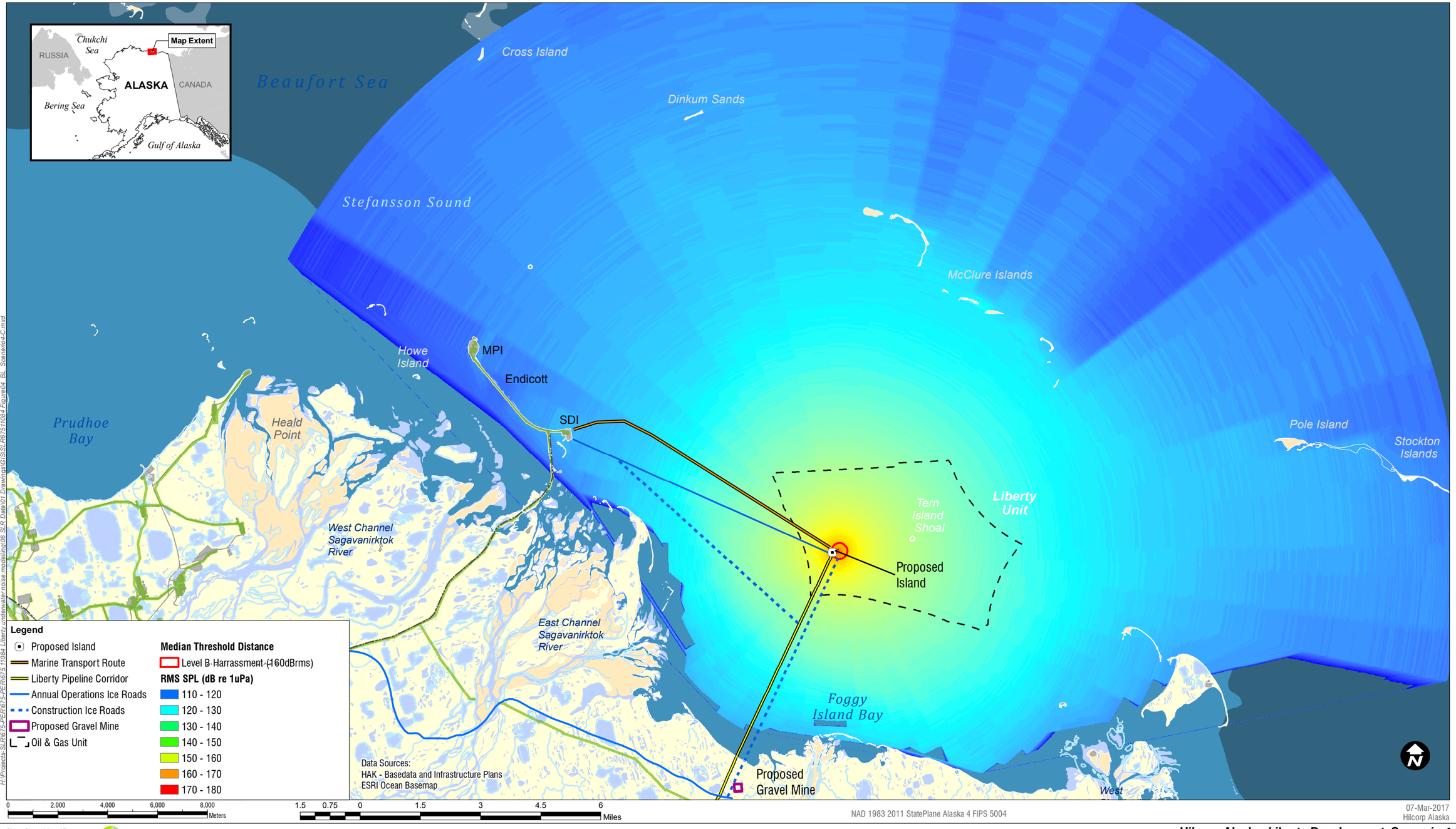
Hilcorp Alaska, Liberty Development, Scenario 3
Construction Noise, RMS SPL (dB re 1uPa)
Impact Sheet Piling, Open Water Season

Figure 03



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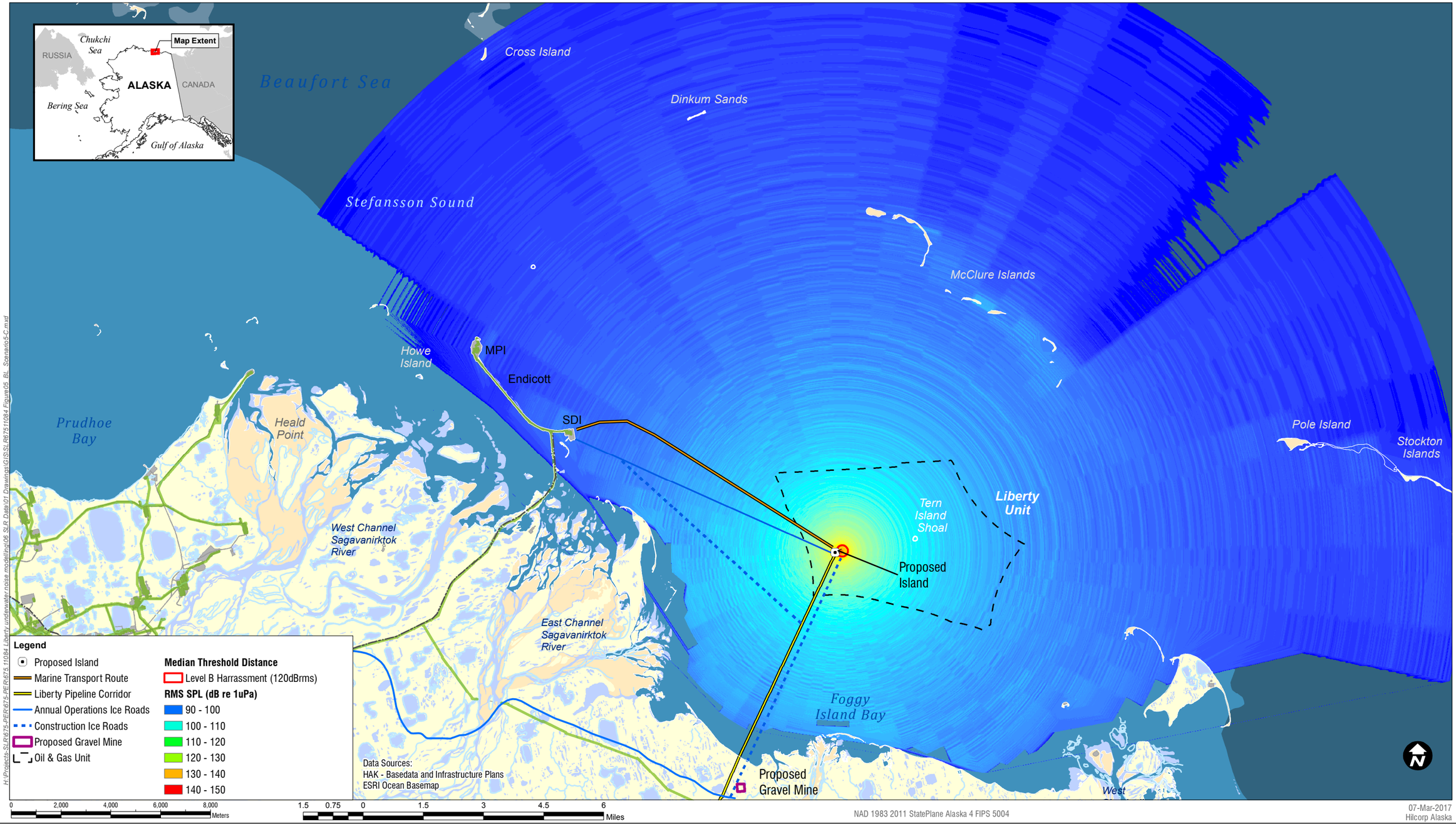
Hilcorp Alaska, Liberty Development, Scenario 4
Construction Noise, RMS SPL (dB re 1uPa)
Impact Pipe Driving, Open Water Season

Figure 04



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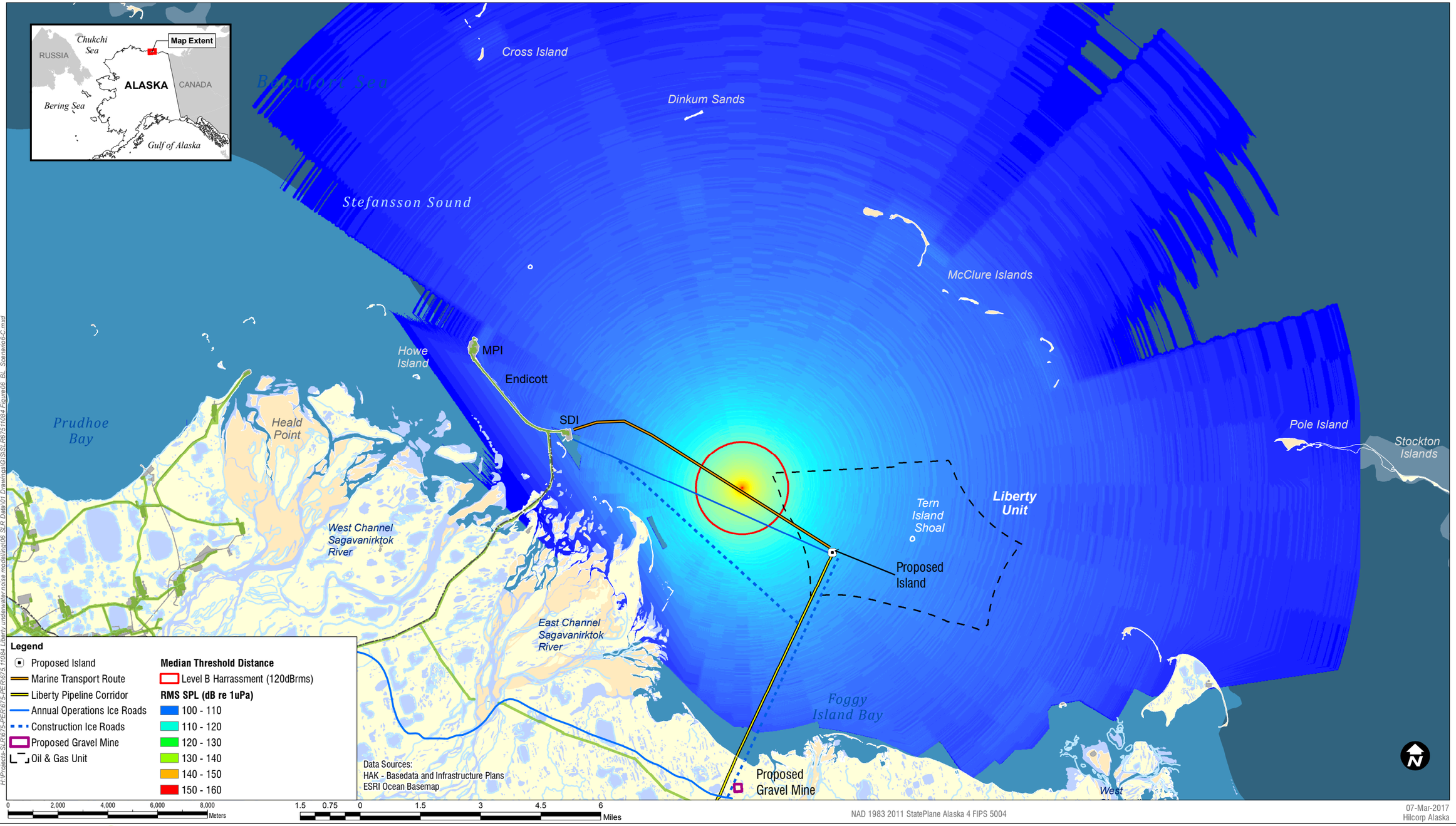
Hilcorp Alaska, Liberty Development, Scenario 5
Construction and Operation Noise, RMS SPL (dB re 1uPa)
Emergency and Oil Spill Response Training, Open Water Season

Figure 05



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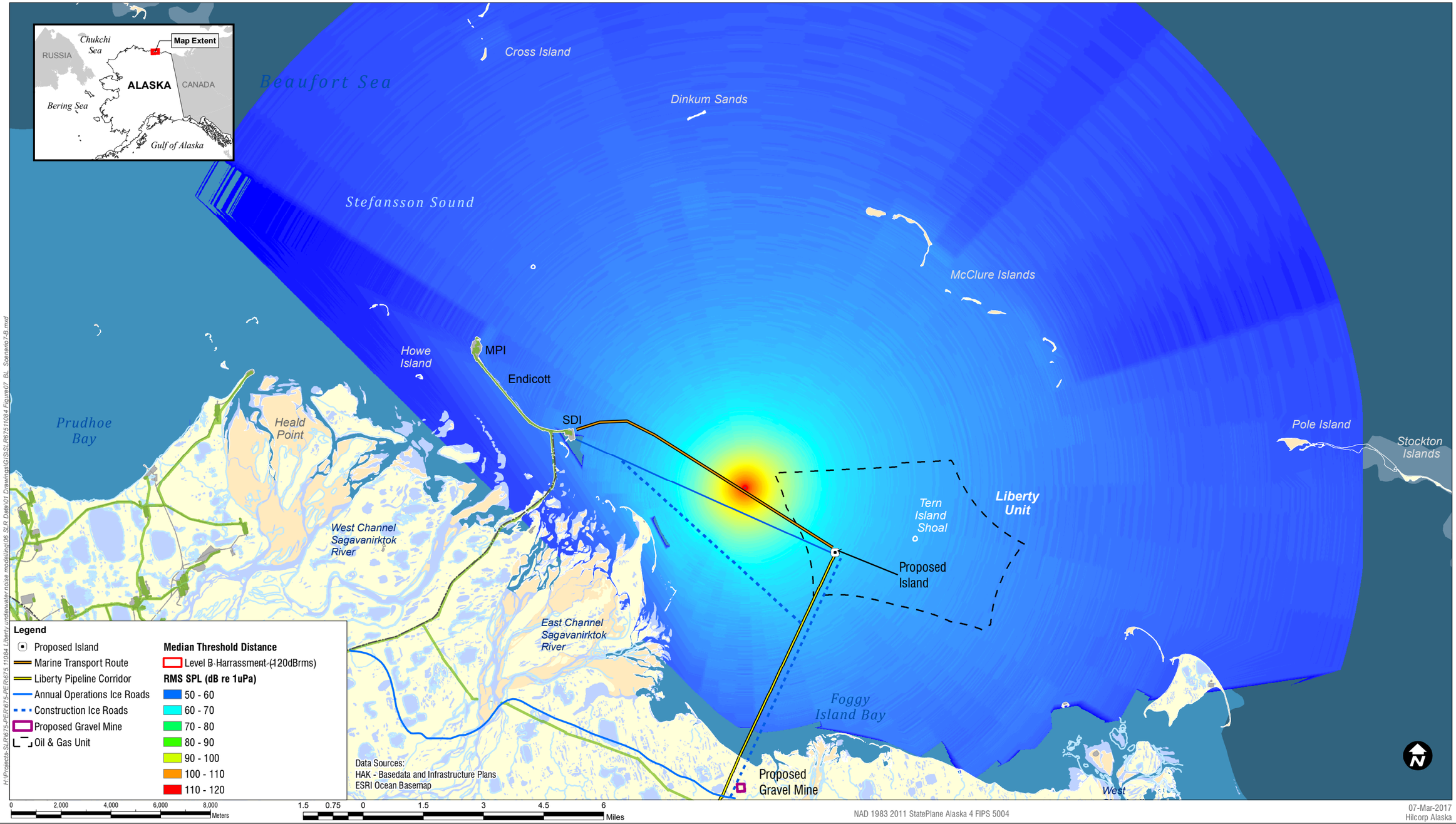
Hilcorp Alaska, Liberty Development, Scenario 6
Construction and Operation Noise, RMS SPL (dB re 1uPa)
Vessel Transportation - Barge, Open Water Season

Figure 06



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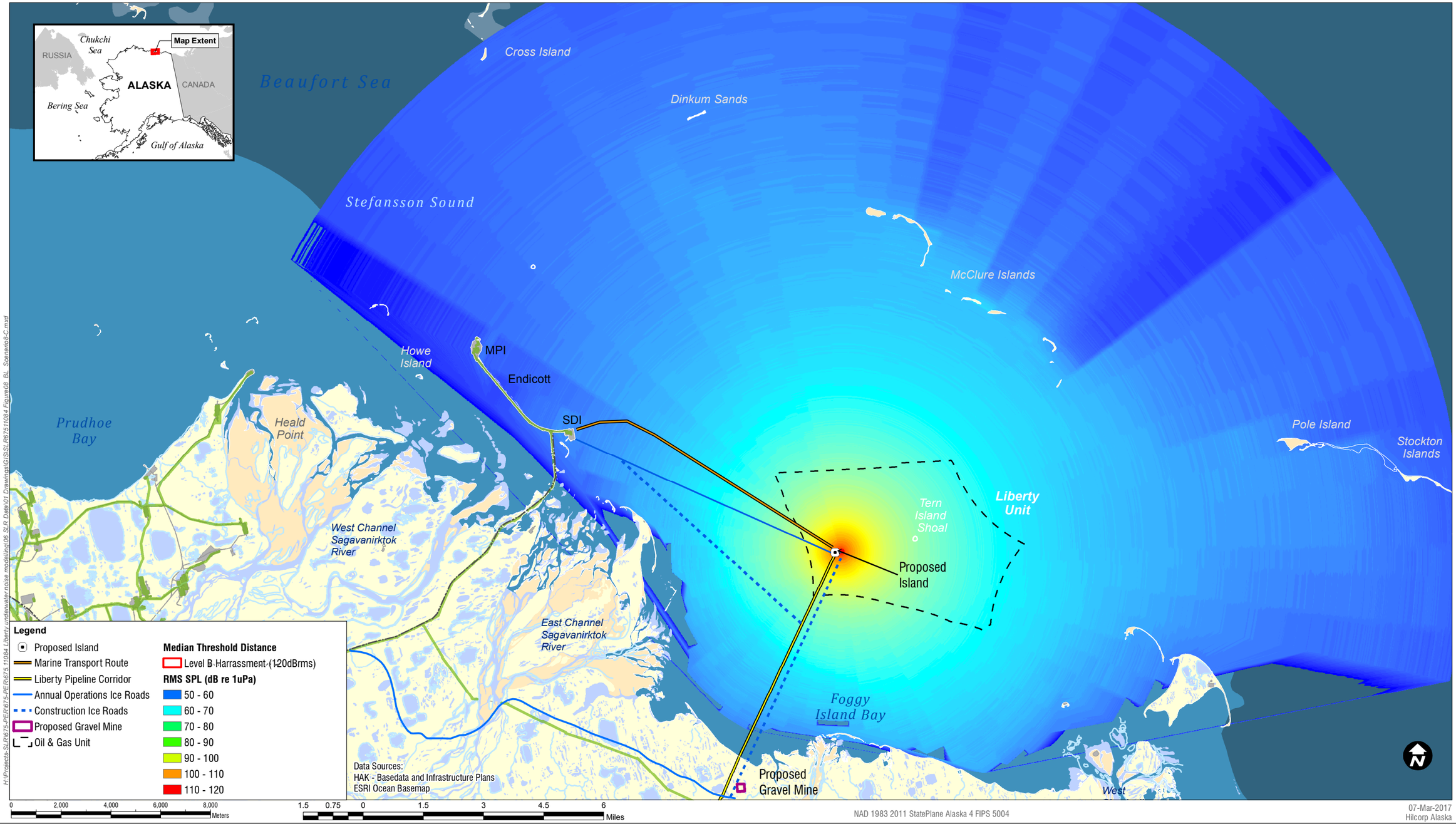
Hilcorp Alaska, Liberty Development, Scenario 7
Construction and Operation Noise, RMS SPL (dB re 1uPa)
Hovercraft Transportation, Open Water Season

Figure 07



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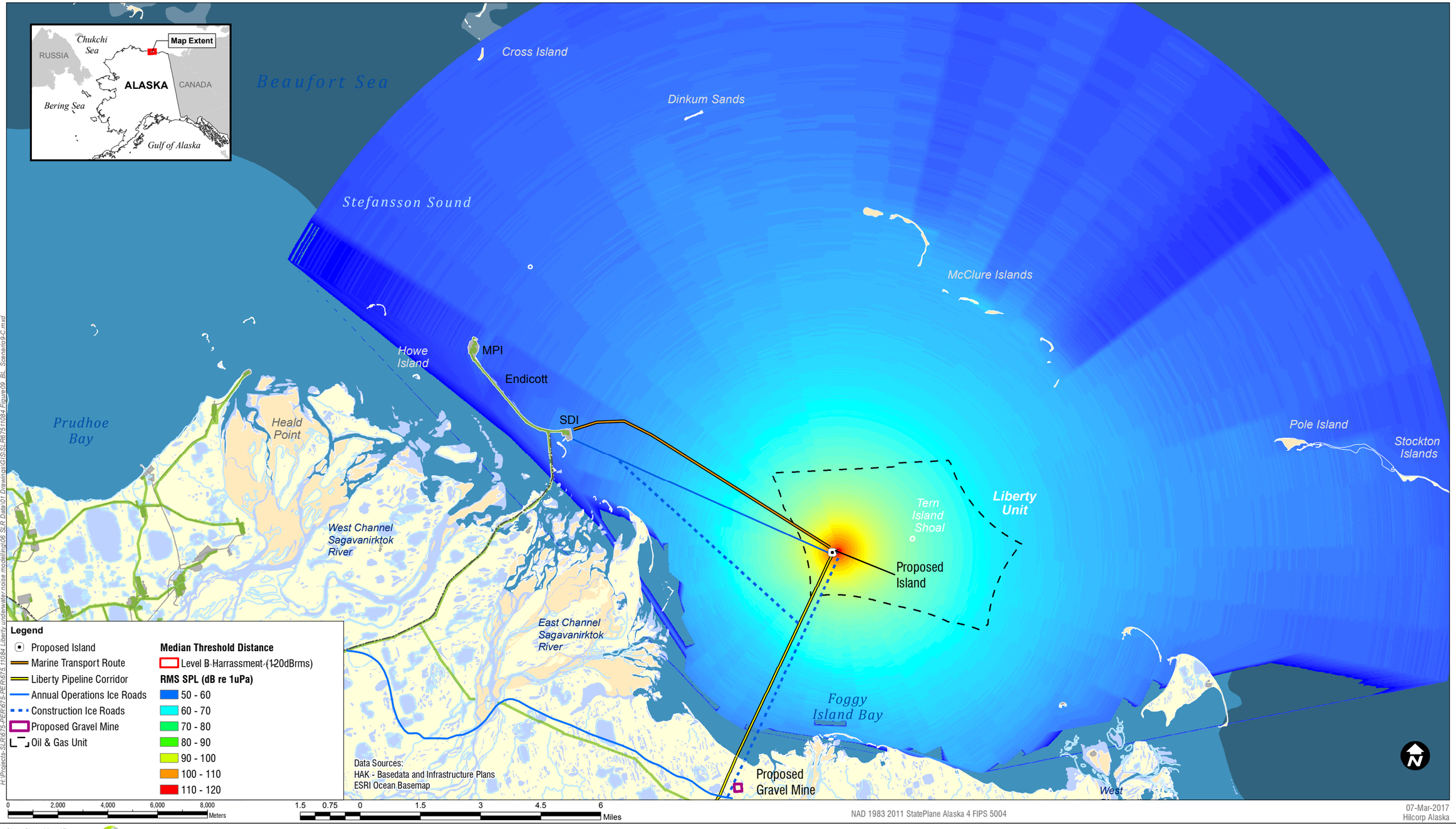
Hilcorp Alaska, Liberty Development, Scenario 8
Operation Noise, RMS SPL (dB re 1uPa)
Drilling and production, Open Water Season

Figure 08



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Hilcorp Alaska, Liberty Development, Scenario 9
Operation Noise, RMS SPL (dB re 1uPa)
Production only, Open Water Season

Figure 09

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APPENDIX B

LDPI Project

Construction and Production Marine Mammal Acoustic Exposure Estimates

5 May 2017

Liberty Project Construction and Production Marine Mammal Acoustic Exposure Estimates

Prepared for ECO49 and Hilcorp

[May, 2017]

SMRU Consulting North America

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Liberty Project Construction and Production Marine Mammal Acoustic Exposure Estimates

5 May 2017

Prepared by SMRU Consulting NA

Authors:

Jason Wood, PhD
Senior Research Scientist

Frances Robertson, PhD
Research Scientist

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Executive Summary

The Liberty Project will involve the creation of a gravel island in Foggy Island Bay (Beaufort Sea, Alaska) for drilling and extracting oil. In addition, a pipeline will be built to transport the oil ashore. Different construction and production activities associated with the Liberty Project will generate underwater and airborne noises that may exceed levels that the National Marine Fisheries Service (NMFS) has deemed to have the potential to cause harm to or may lead to behavior changes in marine mammals. However, the estimated sound levels of the Liberty project do not exceed levels associated with previous Beaufort Sea construction and production activities that, despite extensive studies, did not lead to documented harm to marine mammals or substantial changes in marine mammal behavior.

This report estimates the number of marine mammals that might be exposed to noise levels that, according to NMFS guidance, have the potential to cause harm or lead to possible behavioral changes in marine mammals during the construction and production in the first five years of the Liberty Project, in support of the LOA. To do so this report makes use of the following data inputs:

- Construction and production activities for the Liberty Project provided in the Liberty Development and Production Plan (HAK, 2015) and via correspondence with Hilcorp, Alaska.
- The results of conservative underwater and airborne acoustic sound level estimates of the planned Liberty construction and production activities provided in SLR (2017). This provided the range and exposure duration to the NMFS (2016) Permanent Threshold Shift (PTS) thresholds and the range to the interim NMFS (2017) behavioral response thresholds for the planned Liberty construction and production activities.
- The best available estimates of seasonal marine mammal density for the areas near Liberty. These were obtained from peer reviewed publications as well as government and industry reports. Where data were deficient or non-existent, conservative assumptions (which would lead to higher estimates of harm or disturbance) were made. Bowhead, beluga, and gray whales as well as ringed, bearded and spotted seals may occur in the Liberty area.

Based on SLR (2017) acoustic estimates, noise levels from impact sheet pile and impact pipe driving, during the open water season could, according to NMFS guidance, cause PTS in exposed marine mammals. PTS is considered a possibility when an animal is exposed to sound levels that exceed the NMFS Level A threshold under the Marine Mammal Protection Act (MMPA). The NMFS thresholds for PTS are based on Sound Exposure Level (SEL), which is a measure of both the amplitude of the sound and the duration of exposure. Based on the proposed Liberty noise sources, an animal would need to spend 40 minutes or much longer within proximity of the noise source to exceed PTS thresholds. With appropriate mitigation in place no noise sources are expected to lead to PTS, but because impact sheet piling an impact pipe driving may have the potential to exceed certain levels established in NMFS guidance (NMFS 2016), the number of animals potentially exposed to these levels under conservative assumptions and in the absence of mitigation were estimated for these two noise sources. For impact sheet piling we assumed a maximum 40-minute duration of activity per day (the anticipated duration is likely < 20 minutes per day, SLR 2017) and for impact pipe driving we assumed 2 hours of activity per

day (SLR, 2017). Based on the timing of impact sheet piling and impact pipe driving, the marine mammal density at those times, and the range within which a marine mammal would have to be to exceed the PTS threshold, we estimate the following numbers of animals could be potentially exposed to sound levels that NMFS guidance suggests could cause harm. Such sound levels would only occur during year 1 of the Project. All estimated Level A exposures were less than 0.02% of the species' populations.

A summary of expected Level A exposures (5-year total, all in year 1)

Species	Level A exposure
Bowhead whale	2
Beluga whale	2
Gray whale	0
Ringed seal	3
Spotted seal	2
Bearded seal	2

Based on the daily Project activity schedule, marine mammal densities and SLR (2017) modelled range to behavioral response threshold (or Level B exposure under the MMPA), we estimated the number of exposures that were likely to exceed Level B thresholds in all five years of the Project with the largest number of Level B exposures occurring in year 1. The interim NMFS (2017) guidance for Level B threshold is 120 dB and therefore results in a conservative estimate of the numbers of animals exposed to these sound levels. For cetaceans, estimated Level B exposures were less than 0.5% of the species' population, while estimated Level B exposures for pinnipeds were less than 1.2% of their population over all 5 years of the Project. Because exposures are calculated as the number of individuals potentially disturbed per day, some individuals may be exposed on different days.

A summary of expected Level B exposures by year

Year	Bowhead whale	Gray whale	Beluga whale	Ringed seal	Spotted seal	Bearded seal
1	29	1	35	1,622	126	229
2	24	1	28	1,057	103	180
3	7	1	6	361	29	51
4	5	1	5	251	19	33
5	5	1	5	251	19	33

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1. Introduction

1.1 Project Description

Hilcorp Alaska, LLC has proposed to develop the Liberty Oil Field approximately 5 miles offshore in Foggy Island Bay in the Beaufort Sea. This would entail the construction of an artificial gravel island and a pipeline to shore and would result in a self-contained oil drilling and production facility. Full details of the Project can be found in the Liberty Development and Production Plan (HAK, 2015).

During the construction and operation of the Liberty Project, marine mammals may be exposed to industrial sounds that may have the potential to affect marine mammals, including the potential to influence marine mammal behavior. SLR Consulting (Canada) Ltd. have modeled the propagation of sounds that will be associated with the construction and operation of the Liberty Project (SLR, 2017). This report uses the SLR sound estimates to estimate the number of marine mammals that could potentially be exposed to sound levels that exceed the Level A and Level B thresholds laid out by NMFS (NMFS 2016, 2017) during the first 5 years of this Project

1.2 Marine Mammal Exposure Estimates Overview and Objectives

Similar projects to the proposed Liberty Project have occurred in the past and some of these have been accompanied by significant marine mammal research and monitoring (e.g. Northstar, Williams et al. 2001). These studies suggested that only minor, short-term and localized disturbances may have occurred in response to the island construction and that none of the behavioral changes observed could be construed as takes (Moulton et al. 2003, 2005, Williams et al. 2006). However, the sound levels expected to be produced during the construction and operation of the Liberty Project have the potential to exceed those levels outlined in the NMFS Guidance for Level A (NMFS 2016) and Level B thresholds (NMFS 2017). Therefore, this report has been prepared as a precautionary measure to fulfill the obligation for an LOA application by Hilcorp for the proposed Liberty Project.

The objective of this report is to estimate the numbers of animals that may be exposed to sound levels that exceed the Level A and Level B thresholds laid out by NMFS (2016, 2017) due to sounds generated by the construction and operation of the Liberty Project during the first 5 years of the Project. In brief, this is achieved by

- Identifying the best available density estimates of marine mammals in the study area by season.
- Calculating the largest area expected to be ensonified to the NMFS Level A (NMFS, 2016) and the median area expected to be ensonified to the NMFS Level B thresholds (NMFS 2017)[*] as modeled by SLR (2017) from the construction and operation of the Liberty Project, on a day by day basis.
- Combining the above inputs to estimate the number of Level A and Level B exposures across the first 5 years of the Project.

[*] Level A thresholds follow NMFS, 2016 onset of Permanent Threshold Shift. Level B thresholds follow the interim NMFS thresholds of 160 dB_{rms} for impulsive noise and 120 dB_{rms} for non-impulsive noise as newer thresholds are not available. http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/threshold_guidance.html

2. Methods

The methods section explains the extent of the study area; how the best available marine mammal densities were determined; and how we combined these with the SLR (2017) sound estimates to evaluate the numbers of marine mammals that may be exposed. When assumptions were needed due to lack of data, we state those assumptions and endeavored to choose assumptions that are conservative (i.e. are more likely to result in an over estimate of the number of marine mammal exposures, rather than an under estimate).

2.1 Study Area

The proposed Liberty Project would be located in Foggy Island Bay, which is to the East of Prudhoe Bay on the Beaufort Sea. The main activities would center on the site of the artificial island, the pipeline to shore and a marine transit corridor to and from West Dock (Figure 1). Marine mammal density estimates were, as much as possible, based on data collected within the study area and from nearby areas.

For the purposes of this report, we consider summer to be July and August; fall to be September and October, winter to be November through March and spring to be April through June. The study area is considered to be ice-covered during winter and spring and open-water during summer and fall. However, the timing of freeze-up and thaw vary from year to year with freeze-up ranging from approximately mid-October to December and the thaw from mid-April to June.

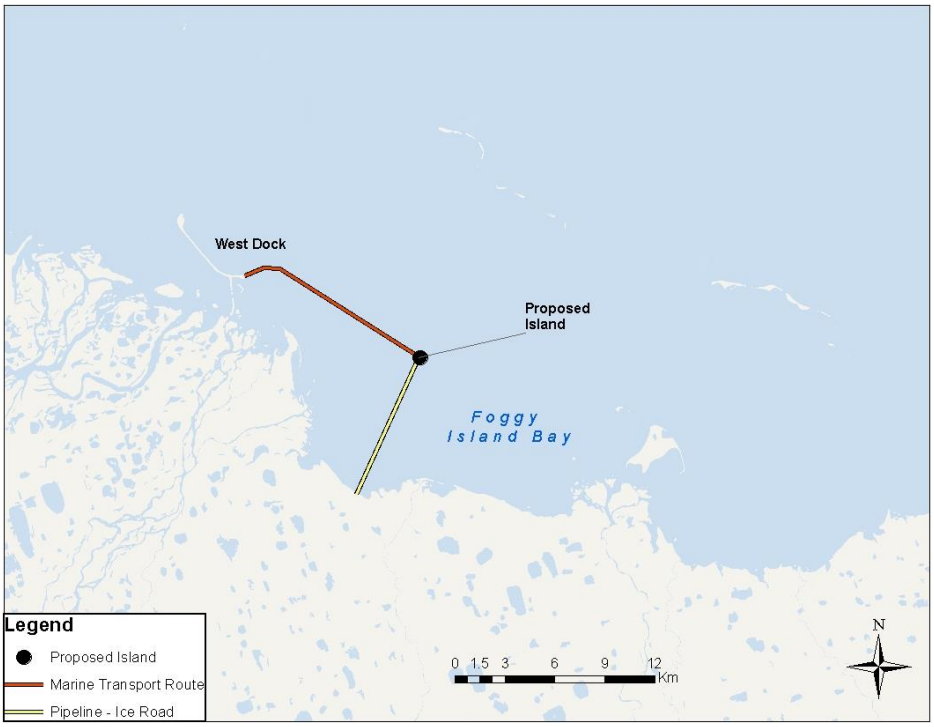

Figure 1. Map of study area. The map shows the location of the Liberty Island development, the main marine transport route for open water periods and the ice road route constructed for the ice-covered season. This latter route is also the planned pipeline route.

2.2. Marine Mammal Densities

Six species of marine mammal were considered for sound exposure estimates. These included three cetacean species: the bowhead whale (*Balaena mysticetus*), the gray whale (*Eschrichtius robustus*), and the beluga whale (*Delphinapterus leucas*). The three species of pinniped were: bearded seal (*Erignathus barbatus*), ringed seal (*Pusa hispida*), and spotted seal (*Phoca largha*). None of the marine mammal density estimates calculated have been corrected for either availability or detectability bias, therefore the densities presented in sections 2.2.1 and 2.2.2 may be considered underestimates. All marine mammals are protected under the Marine Mammal Protection Act (MMPA). In addition, the bowhead whale and bearded seal are listed as endangered and threatened, respectively, under the Endangered Species Act (ESA). The following sections outline the data sources available and how species densities were estimated.

2.2.1 Cetaceans

Extensive aerial surveys for Arctic marine mammals have been flown in the Beaufort Sea since the late 1970s. The Bowhead Whale Aerial Survey Program (BWASP) was conducted by the Bureau of Ocean Energy Management (BOEM; formerly the Minerals Management Service) during the fall months until 2010; since this time the Aerial Surveys for Artic Marine Mammals (ASAMM) survey program was developed to combine the BWASP surveys and Chukchi Offshore Monitoring and Drilling Area (COMIDA) surveys. ASAMM surveys are now flown during both summer and fall months. The ASAMM surveys are conducted within blocks that overlay the Beaufort and Chukchi Seas oil and gas lease sale areas offshore of Alaska (Figure 2), and provide sighting data for the cetacean species considered here during summer and fall months. Aerial survey data collected prior to 2011 focused on bowhead whales during the bowhead whale fall migration and thus, were only flown during September and October (the fall months). For bowhead and gray whales, we have considered those survey data that were collected during the ASAMM aerial surveys in 2011 - 2015 (Table 1). Data on beluga whales were available for 2012 - 2015. These data represent the best available systematically collected sightings data for the region.

All ASAMM surveys conducted 2011 - 2015 were flown in an Aero Commander twin turbo prop aircraft, equipped with bubble windows (Clarke et al. 2012, 2013, 2014, 2015, 2017). The surveys provided sightings and effort data by month and season (summer and fall), as well as each survey block and, in some cases by depth strata (Figure 2, Clarke et al. 2012, 2013, 2014, 2015, 2017). While none of the effort and sighting data reported in the aerial survey reports include the Liberty Project site within Foggy Island Bay due to its more inshore location within the barrier islands, we followed the approach used in previous Liberty IHA applications and selected only on-transect effort and sighting data from Survey Block 1 (Figure 2).

Species densities were calculated in a two-step approach; we first calculated a sighting rate of whales per km for each species, we then multiplied the transect length by the effective strip width (esw) using the modeled species-specific esw for an aero commander aircraft calculated by Ferguson and Clarke (2013). These modeled esw were specific to the aero commander airplane used in the 2011-2014 surveys and were estimated for bowhead, gray, and beluga whales based on the NMFS ASAMM surveys. Thus whale density was calculated as follows:

$$Whales/km^2 = \frac{sightings/km}{(2 \times esw)}$$

Where esw is effectively the half-strip width and so must be multiplied by 2 in order to encompass both sides of the transect line.

For years 2012 and 2013, beluga whale data were reported by depth strata (specifically for depths 0-20m and 21-50m) between the longitudes 140°W – 154°W in the Beaufort Sea, in these years we combined the effort and sightings data for the two depth strata and calculated a combined density for each season.

Table 1. A summary of aerial survey effort by year, season and aircraft type.

Year	Seasons	Airplane	Reference
2011	Summer & Fall	Aero Commander	Clarke et al. 2012.
2012	Summer & Fall	Aero Commander	Clarke et al. 2013.
2013	Summer & Fall	Aero Commander	Clarke et al. 2014.
2014	Summer & Fall	Aero Commander	Clarke et al. 2015.
2015	Summer & Fall	Aero Commander	Clarke et al. 2017

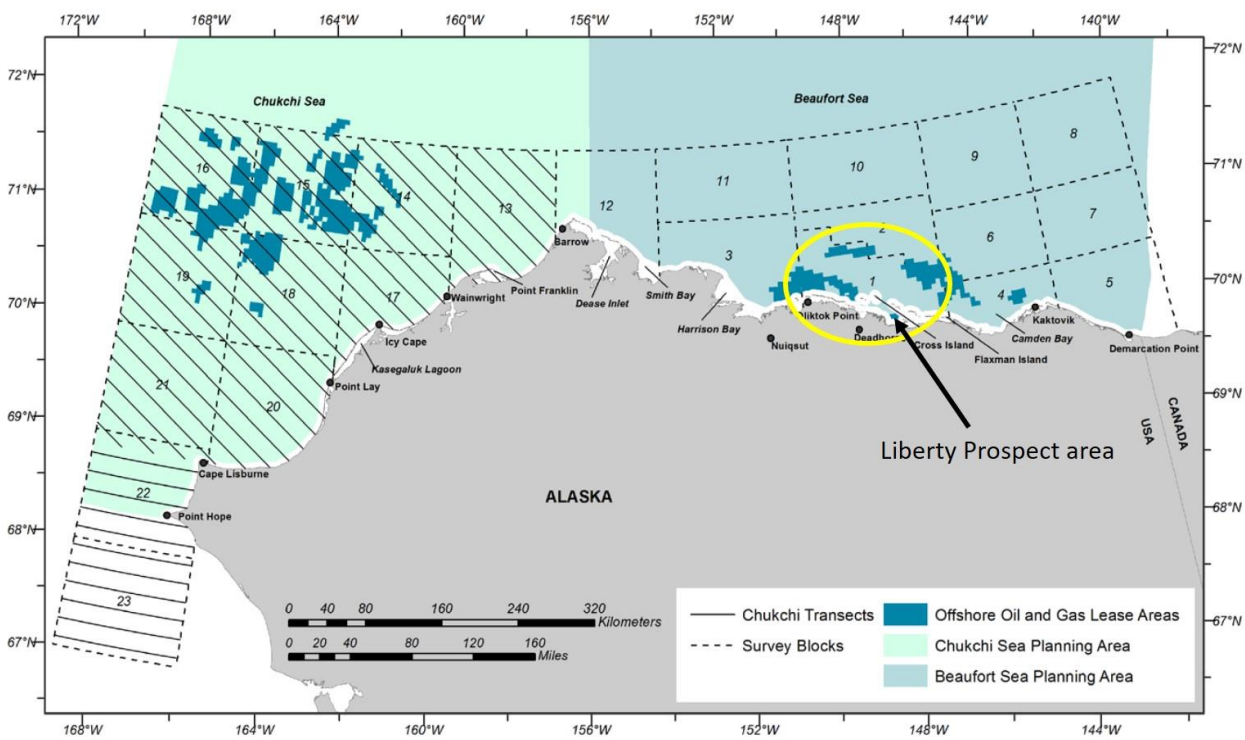

Figure 2. NMFS conducts ASAMM surveys in the Beaufort and Chukchi Seas (http://www.afsc.noaa.gov/nmml/software/bwasp-comida.php). These aerial surveys are conducted within blocks that overlay the Beaufort and Chukchi Seas oil and gas lease sale areas offshore of Alaska. The Liberty site lies within the barrier islands in survey Block 1, however no on-effort sightings data are available for areas south of the barrier islands (highlighted in yellow). Figure from Clarke et al. (2015).

2.2.1.1 Bowhead Whales

During the ice-covered season (winter and spring) bowhead whales will not be present at or near the Liberty site**.** The vast majority of the bowhead population migrate to the Bering Sea during the fall and do not return eastwards through the Beaufort Sea again until the spring. During this eastward migration, the whales are distributed far offshore. While a few whales may occur in the Central Beaufort Sea area throughout the summer, most of the population pass through again during the latter part of summer and fall as they migrate west to over winter in the Bering Sea. The migration trajectory varies annually and is influenced by ice presence (Moore and Reeves 1993); during years with less ice the whales tend to migrate closer to shore, along the barrier islands. However, bowheads are rarely observed within the barrier islands, one mixed group of eight bowhead and gray whales was observed to the southwest of Narwhal Island in 2008 (Aerts et al. 2008), but no bowhead whales have been observed by Protected Species Observers (PSO) during recent shallow hazards surveys at the Liberty Project site (Cate et al. 2015, Smultea et al. 2014). Based on satellite tracking studies conducted 2006-2012 (Quakenbush et al. 2013) migrating (i.e. non-feeding) bowhead whales spend an average of 2 days in the Prudhoe Bay area.

Bowhead whale density was calculated following the methods outlined in section 2.2.1. Using the results provided by Ferguson and Clarke (2013), the modeled esw estimated for bowhead whales observed during aerial surveys conducted from an Aero Commander airplane was 1.15 km (CV = 0.08). This resulted in a mean density estimate for survey Block 1 in summer of **0.004 bowhead whales/km^2** (range = 0.001-0.006), and a mean fall density for survey Block 1 of **0.010 bowhead whales/km^2** (range = 0.004-0.022) (Table 2). These density estimates are expected to be overestimates for the Liberty Project study area as bowhead whales rarely occur within the barrier islands, instead preferring to migrate north of the barrier islands.

Table 2. A summary of survey years, dates, on transect effort, number of on-transect sightings, sightings per effort (whales/km), and density of bowhead whales/km^2. The average density with their respective density ranges (i.e. min to max) for each season across all survey years have also been calculated.

Year	Dates	On Transect Effort (km)	On Transect Sightings	Whales/km	Whales/km^2
2011					
Summer	June-Aug	346	1	0.003	0.001
Fall	Sep-Oct	1130	24	0.021	0.009
2012					
Summer	19 Jul -31 Aug	1493	5	0.003	0.001
Fall	1 Sep-18 Oct	1696	14	0.008	0.004
2013					
Summer	Jul – Aug	1582	21	0.013	0.006
Fall	Sep-Oct	1121	21	0.019	0.008
2014					
Summer	Jul – Aug	1393	17	0.012	0.005
Fall	Sep-Oct	1538	79	0.051	0.022
2015					
Summer	Jul – Aug	1262	15	0.012	0.005
Fall	Sep - Oct	1663	17	0.010	0.004
			Average summer		**0.004**
			Range summer		**0.001-0.006**
			Average Fall		**0.010**
			Range Fall		**0.004-0.022**

2.2.1.2 Beluga Whales

Beluga whales are not present in the Liberty Project area during the ice-covered season. In general, beluga whales are rarely seen close to shore in the Beaufort Sea due to their preference for shelf break habitat. Beluga whales migrate to the Bering Sea during the fall with most of both the Eastern Chukchi Sea and Beaufort Sea populations leaving the Beaufort Sea by November (Hauser et al. 2014).

Density estimates based on survey Block 1 will be higher than is likely to occur within Foggy Island Bay. However, beluga whales are occasionally encountered within the barrier islands; during the summers of 2014 (Smultea et al. 2014) and 2015 (Cate et al. 2015) belugas were encountered in Foggy Island Bay near the Liberty Project site. In July and August 2014, 8 groups of 19 beluga whales were observed in Foggy Island Bay during shallow hazard surveys (Smultea et al. 2014), it is believed that these animals remained within the area for a week (Smultea et al. 2014). In July 2015, 5 beluga whales were recorded by PSOs during shallow hazard surveys in Foggy Island Bay. It is not clear from Cate et al. (2015) how many of these sightings were likely to have been re-sights. In 2014, 4,245km of PSO effort occurred during the marine mammal monitoring and mitigation program conducted over July and August, resulting in a sighting rate of 0.004 whales per km surveyed (Smultea et al. 2014). PSOs could reportedly detect belugas as far as 2,000m away from the vessel (Smultea et al. 2014).

Beluga density was calculated using sighting and effort data collected during ASAMM surveys in survey Block 1 (2014 & 2015) or by densities of combined depth strata 0-20m and 20-50m for 140W – 154W

in the Beaufort Sea (2012 & 2013), following the methods outlined in section 2.2.1. The effective strip width estimated by Ferguson and Clarke (2013) for beluga whales observed from an Aero Commander airplane was 0.614 km (CV = 0.07). This resulted in a mean summer density of **0.012 belugas/km²** (range = 0.006-0.024), and a mean fall density of **0.002 belugas/km²** (range = 0.001-0.005) (Table 3).

Table 3. A summary of ASAMM survey years, season, on transect effort, number of on-transect sightings and sightings per unit effort, and density of beluga whales/km². The average density and density range (i.e. min to max) for each season was also calculated.

Year	Dates	On Transect Effort (km)	On Transect Sightings	Whales/km	Whales/km²
2011	Jun-Oct	1476	0	0	0
2012*					
Summer	Jul- Aug	5001	47	0.008	0.006
Fall	Sep-Oct	4846	5	0.001	0.001
2013*					
Summer	Jul – Aug	4270	75	0.012	0.010
Fall	Sep-Oct	3372	2	0.001	0.001
2014					
Summer	Jul – Aug	1393	13	0.009	0.008
Fall	Sep-Oct	1538	9	0.006	0.005
2015					
Summer	Jul – Aug	1262	37	0.029	0.024
Fall	Sep – Oct	1663	3	0.002	0.001
			Average summer		**0.012**
			Range summer		**0.006-0.024**
			Average Fall		**0.002**
			Range Fall		**0.001-0.005**

2.2.1.3 Gray Whales

Gray whales are rarely encountered in the Beaufort Sea. Gray whales spend the winter on their breeding grounds in Baja Mexico and do not return north until the spring. During the summer, they are mostly distributed in the shallow coastal waters of the Chukchi Sea. However, on occasion, gray whales are sighted in the Beaufort Sea; 1 gray whale was observed in survey Block 1 during the ASAMM survey in September 2014. This resulted in a sighting rate of 0.001 gray whales per km, and **0.000 gray whales/km²** in survey Block 1. We used the modelled esw of 1.20 km (CV =0.07) for grey whales (Ferguson and Clarke 2013).

2.2.2. Pinnipeds

Three species of pinnipeds were considered in this report; ringed, bearded and spotted seals. Data on pinniped density within Foggy Island Bay and surrounding areas are limited. All three species are present in the project area during the summer months and data on their presence and sighting rates are available from a series of monitoring programs that occurred within Foggy Island Bay and

* Data only available by depth strata 0-20 m and 20-50 m in these years. We combined the sightings and effort for each season in these years and calculated the density from the combined data.

neighboring areas in 1996 (Harris et al. 2001), 2008 (Aerts et al. 2008, Hauser et al. 2008), 2012 (HDR 2012) and 2014 (Smultea et al. 2014). Of all the pinniped sightings during monitoring surveys in 1996 (Harris et al. 2001), 2008 (Aerts et al. 2008, Hauser et al. 2008), and 2012 (HDR 2012), 63% were ringed seals, 17% were bearded seals and 20% were spotted seals. Ringed seals and bearded seals are present in the Beaufort Sea year-round, though ringed seals are the most abundant species, especially within the Liberty Project area.

2.2.2.1 Ringed Seals

Ringed seals are present in the nearshore Beaufort Sea waters and sea ice year-round, maintaining breathing holes and excavating subnivean lairs in the landfast ice during the ice-covered season. During this ice-covered season, ringed seals' home ranges are generally < 500 ha in area (Kelly et al. 2005).

Winter densities

Ringed seals overwinter in the landfast ice in and around the Liberty Project area. Relatively few data are available for ringed seal density in the southern Beaufort Sea during the winter months, however several studies on ringed seal winter ecology were undertaken during the 1980s (Kelly et al. 1986, Frost and Burns 1989). These reports, in addition to more recent data associated with the Northstar development (Williams et al. 2001) provide information on both seal ice-structure use (where ice structures include both breathing holes and subnivean lairs), and on the density of ice structures (Table 4).

Both male and female ringed seals maintain a number of breathing holes and haul out in more than one subnivean lair during the ice-covered season. Kelly et al. (1986) found that of their tagged seals, the animals would use between 1 and at least 4 subnivean lairs. The distances between each lair could be as great as 4 km with numerous breathing holes in-between (Kelly et al. 1986). While Kelly et al. (1986) calculated the average number of lairs used by an individual seal to be 2.85 (SD=2.51) per animal, they also suggest that this is likely to be an underestimate.

To estimate ringed seal structure during the winter we calculated an average structure density and divided this by the average number of structures that Kelly et al. (1986) estimated were used by individual seals. Thus, for the winter season we have estimated ringed seal density as the average ice structure density (1.45/km^2) divided by the average number of ice structures used by an individual seal (2.85, SD=2.51) which results in an estimated density of **0.510 ringed seals/km^2**. This density is likely to be overestimated due to Kelly et al.'s (1986) suggestion that their estimate of the average number of lairs used by a seal was an underestimate (the denominator used).

Table 4. Summary of sea-ice structure density from in and around the Liberty Project area.

Year	Ice-structure density /km^2	Source
1982	3.6	Frost and Burns 1989
1983	0.81	Kelly et al. 1983
Dec 1999	0.17	Williams et al. 2001
May 2000	1.2	Williams et al. 2001
Average structure density/km^2	**1.45**	

Spring densities

The most informative data on ringed seal density for the Liberty Project area are provided by spring aerial survey data. Aerial surveys have been flown over Foggy Island Bay and west of Prudhoe Bay during late May and early June (Figure 3, Moulton et al. 2002b, Frost et al. 2002, Richardson and Williams 2003), when the greatest percentage of seals have abandoned their lairs and are hauled out on the ice (Kelly et al. 2010). These aerial surveys were flown as part of the industry monitoring programs for the development of the Northstar production facility. The data were available through previously published reports and peer review journal articles (Table 5).

Table 5. Summary of year, and data sources for spring aerial strip transects for ringed seals.

Years of surveys	Survey sources
1996 -1999	Alaska Department of Fish and Game
1996 - 2002	Industry Northstar monitoring surveys

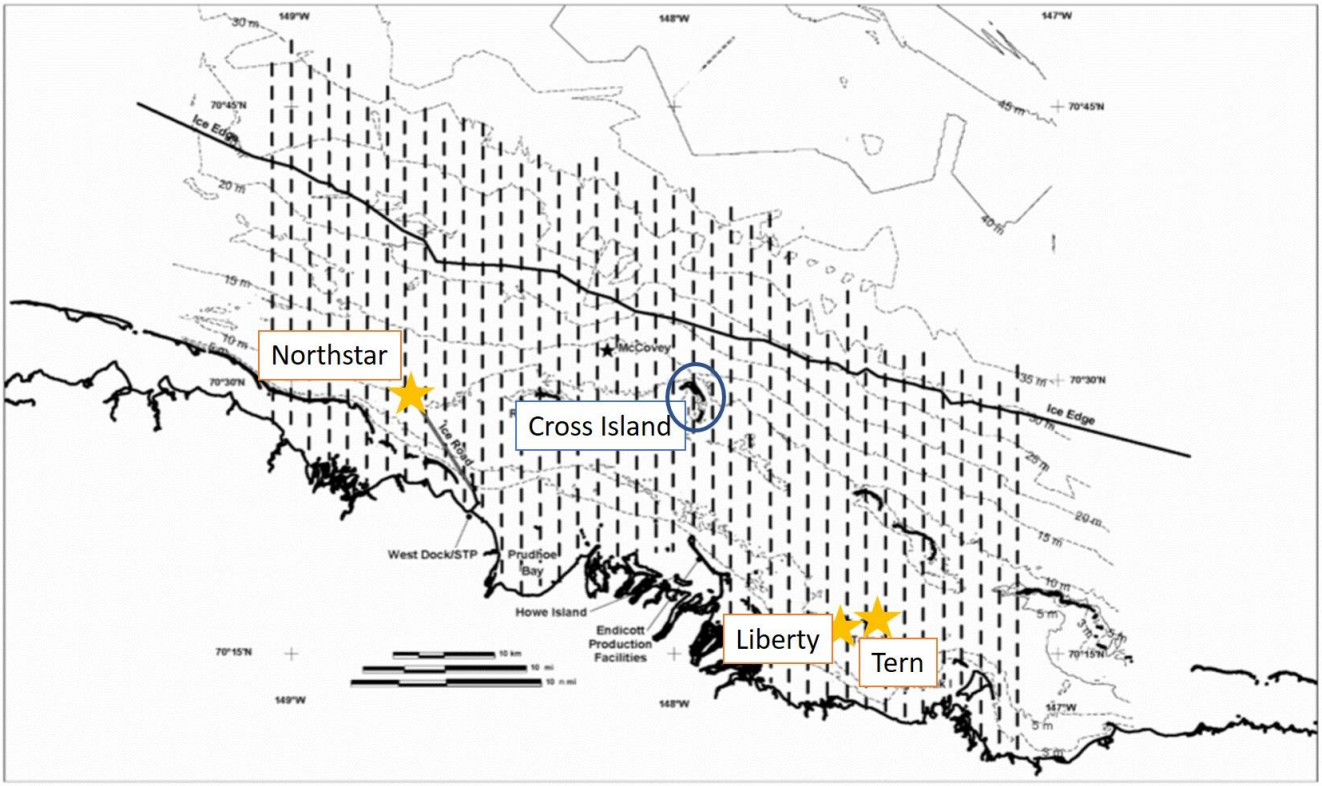

Figure 3. Central Alaskan Beaufort Sea showing locations of Northstar (Seal Island) and Liberty (Liberty and Tern Islands) in relation to aerial survey transects flown twice in May-June 2002. Similar surveys were flown in each year 1997-2001. Figure taken from Richardson and Williams (2002).

Because densities were consistently very low where water depth was <3m (and these areas are generally frozen solid during the ice-covered season) densities have been calculated where water depth was >3m deep (Moulton et al. 2002a,b, Richardson and Williams 2003). Based on the average density

of surveys flown 1997 to 2002 the uncorrected density of ringed seals during the spring is expected to be **0.548 ringed seals/km²**. A summary of available density data and the uncorrected densities available for 1997 to 2002 are provided in (Table 6).

Table 6 Estimated densities (#/km²) of ringed seals during the spring 1997-2002. Estimates derived from aerial surveys conducted by LGL Ltd in support of the construction and production of Northstar (Moulton et al. 2002a,b, Richardson and Williams 2003)

Year	Density (LGL) #/km²
1997	0.43
1998	0.39
1999	0.63
2000	0.47
2001	0.54
2002	0.83
Average	**0.548**

Summer densities

To estimate ringed seal density during the summer we followed the approach presented by LGL (2007). LGL (2007) assumed that ringed seal density in the Liberty Project area was approximately 50% of the spring density of ringed seals (based on the spring aerial survey data used in this report). We estimated the density of ringed seals during the summer to be 50% of the expected spring density (0.548/km²), this resulted in an estimated density of **0.27 ringed seals/km²**.

Fall densities

Ringed seals remain in the water through the fall and in to the winter, however, due to the lack of available data on fall densities within the Liberty Project area we have conservatively assumed the same density of ringed seals as in the summer; **0.27 ringed seals/km²**.

2.2.2.2 Bearded Seals

Winter and spring densities (Ice-covered season)

During the ice-covered season some bearded seals remain in the Beaufort Sea, their distinctive calls are detected throughout the year with an increase in call activity in January. A few of those that remain are encountered in the landfast ice areas, however the majority migrate west into the Bering and the Chukchi Seas. Those that remain are generally encountered farther offshore (20-100 miles) in the pack ice (NMFS 2011a).

At present, there is no official population estimate for bearded seals occupying the Beaufort Sea, particularly in the coastal areas during the winter and spring. Industry monitoring surveys for the Northstar development during the spring seasons in 1999 (Moulton et al. 2000), 2000 (Moulton et al. 2001), 2001 (Moulton et al. 2002) and 2002 (Moulton et al. 2003) counted 47 bearded seals (annual mean of 11.75 seals during an annual mean of 3,997.5 km² of effort, Table 7), while the numbers were

deemed too low to calculate a reliable density estimate in each year, no other on bearded seal presence were available. Therefore, we have estimated a density using the four years of Northstar development data of **0.003/km² bearded seals**. We have assumed that this density is the same over winter.

Table 7 Summary of available data on bearded seal sightings in the Central Alaskan Beaufort Sea encompassing both Northstar development and Liberty Project areas.

Year	No. of Sightings	Effort (km²)	No. / km²	Source
1999	20	3980	0.005	Moulton et al. 2000
2000	15	4245	0.004	Moulton et al. 2001
2001	3	4147	0.001	Moulton et al. 2002
2002	9	3618	0.002	Moulton et al. 2003
Average	**11.75**	**3997.5**	**0.003**	

Summer and fall densities (Open water season)

Bearded seals are most commonly encountered in the Beaufort Sea during the open water season, though the species prefer waters father offshore than the Liberty Project area. Bearded seal density was calculated as a proportion of the ringed seal summer density based on the ratios calculated by Hilcorp (2015) and explained in section 2.2.2. Thus, the density of bearded seals during the open water season (summer and fall) was calculated as 17% of 0.27/km², this being the estimated summer density, of ringed seals in the Liberty Project area. This resulted in an estimated summer density for **bearded seals of 0.05/km²**.

There is no good information available on the presence or densities of bearded seals in the coastal areas of the Beaufort Sea during the fall, we have conservatively assumed that fall densities of ringed and bearded seals in Foggy Island Bay will be the same as the summer densities.

2.2.2.3 Spotted Seals

The spotted seal is a seasonal visitor to the Beaufort Sea and much less abundant with only low numbers (~1,000) occurring near the Alaskan Beaufort Sea coast. Spotted seals return to the Chukchi Sea and continue south to the Bering Sea at the onset of freeze up in the fall to spend the winter and spring in the Bering Sea and thus are not present during the ice-covered season. To estimate a spotted seal density for the summer months of July and August we followed the same approach as that for bearded seals.

Spotted seal density during the open water season (summer and fall) was calculated as 20% of the ringed seal summer density estimate (0.27 seals/km²) in the Liberty Project area. This resulted in an estimated density for **spotted seals of 0.05/km²**.

2.3 Noise Scenarios

Based on a list of construction and operational activities provided by Hilcorp, SLR determined the source levels of those activities and used a combination of modeling and empirical data to estimate the range to the NMFS Level A and Level B noise thresholds underwater during ice-covered and open water conditions as well as in the air. For further details see SLR, (2017). For Level A exposures, only four of the sound sources had the theoretical ability to cause Permanent Threshold Shift (PTS, or hearing damage) using a Sound Exposure Level (SEL) metric, which is considered to be a Level A exposure. The range to these thresholds for these four sound sources are reproduced in Table 8. Because the thresholds are based on 24 hour cumulative SEL which measure the amplitude of a sound exposure over time, the threshold can be achieved by a different combination of duration and distance (which is related to the amplitude of the exposure). Therefore, SLR provided a range of exposure time and distance over which the threshold might be reached. However, we only report the range to threshold for the expected duration of those activities within a 24-hour period (Table 8). NMFS Level A SEL criteria take account of hearing sensitivity and therefore SLR (2017) results vary by different marine mammal hearing group.

Since the Level B thresholds are based on a Sound Pressure Level (SPL), a single median range to that amplitude can be calculated. These are reproduced in Table 9 for the 13 noise scenarios that may occur as part of the Liberty Project. Unlike the NMFS Level A thresholds, Level B thresholds do not account for differences in species hearing groups. The current NMFS recommendation for the Level B threshold of 120 dB is also considered to be very conservative. NMFS assumes that all animals exposed to sound levels of at least 120 dB may exhibit a behavioral change.

Sections 2.3.1 and 2.3.2 report the areas that were ensonified to Level A and Level B thresholds and that were used as inputs into take estimates.

Table 8. Distance to the NMFS Permanent Threshold Shift (i.e. Level A) by marine mammal hearing group as reported by SLR (2017). These exposure thresholds can be achieved by a different combination of time and distance from the noise source. We report the distance associated with the expected duration of that activity during a 24 hour period (SLR, 2017).

Marine Mammal Hearing Group and Species	Distance From Source To PTS Threshold			
	Slope Shaping (9.6 hrs)	Vibratory Sheet Piling (2.5 hrs)	Impact Sheet Piling (40 mins)	Impact Pipe Driving (2 hrs)
Low frequency cetaceans (bowhead, gray whales)	<10 m	50 m	1,940 m	870 m
Mid frequency cetaceans (belugas)	n/a	<10 m	60 m	27 m
Phocid Pinnipeds (bearded, ringed, spotted seals)	<10 m	20 m	526 m	240 m

Table 9. Median distance to the Level B thresholds for the 13 noise scenarios considered, as modelled by SLR (2017). Distance is provided for underwater noise in both ice-covered and open water conditions as well as airborne noise, where appropriate. Impulsive sounds are in italics and have an underwater threshold of 160 dB_{rms} re 1µPa. The remaining sounds are non-impulsive and have a threshold of 120 dB_{rms} re 1µPa if underwater. All airborne noise is estimated to a threshold of 100 dB_{rms} re 20µPa.

Scenario	Median Distance From Source to Behavioral Threshold		
	Underwater Noise (Ice-Covered)	Underwater Noise (Open Water)	Airborne Noise
Ice road construction and maintenance	170 m	n/a	< 15 m
Pipeline construction	210 m	n/a	< 15 m
Island construction	210 m	n/a	< 15 m
Vibratory sheet piling	390 m	14,800 m	15 m
Impact sheet piling	90 m	2,050 m	100 m
Slope shaping, armament installation	n/a	1,160 m	< 15 m
Impact pipe driving	n/a	315 m	100 m
Emergency oil spill response training	170 m	225m	< 15 m
Helicopter (take-off, landing)	n/a	n/a	67 m
Vessel transportation - barge	n/a	1,850 m	< 15 m
Vessel transportation - tug	n/a	880 m	< 15
Vessel transportation – small / crew boat	n/a	260 m	<15
Hovercraft transportation	n/a	70 m	15 m
Drilling & Production	230 m	55 m	30 m
Production only	40 m	45 m	30 m

2.3.1 Level A Exposures

Given the small estimated range and long exposure time needed to reach the Level A exposure threshold for slope shaping and vibratory sheet piling (Table 8), it was not deemed plausible that a marine mammal would be exposed to a Level A exposure from those activities. We therefore focused our Level A exposure estimates on impact sheet piling and impact pipe driving. As mentioned above, Level A exposure thresholds are based on SEL thresholds that can be achieved by a different combination of exposure time and amplitude (which is related to distance from the sound source) of the noise source. As an illustration of this interplay, we used the sound estimate results of SLR (2017) to estimate the relationship between the range of an animal from the impact sheet piling and the duration of exposure needed to reach a Level A exposure (Figure 4). There are multiple curves because the Level A thresholds account for the different hearing sensitivities of marine mammal hearing groups.

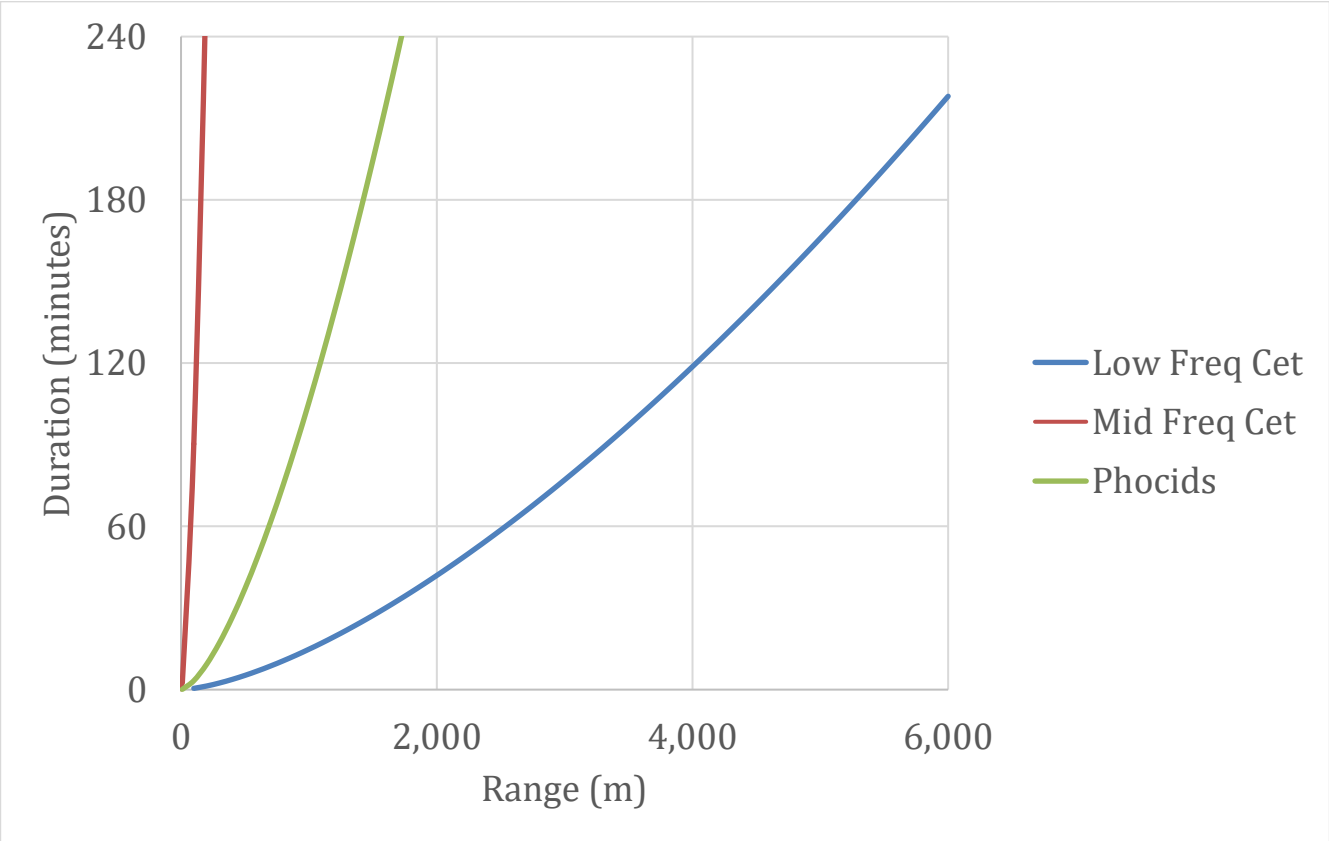

Figure 4. Relationship between the range and duration of exposure to impact sheet piling needed to exceed the Level A threshold for low frequency cetaceans (bowhead whales), mid frequency cetaceans (beluga whales), and phocid seals (ringed, bearded and spotted seals).

Based on SLR (2017) we have assumed that impact sheet piling would occur for 40 minutes per day and that impact pipe driving would occur for 2 hours per day during the days that these are used. Table 10 lists the ranges and areas within which a marine mammal would need to be for the durations listed above to exceed Level A thresholds.

Table 10. Range and the resulting area ensonified to the Level A threshold for impact sheet piling and impact pipe driving.

	Impact sheet Piling (40 mins)		Impact Pipe Driving (2 hrs)	
Species	**Range (m) to Level A threshold**	**Area (km^2)**	**Range (m) to Level A threshold**	**Area (km^2)**
Bowhead whale	1,940	11.82	870	2.38
Beluga whale	60	0.01	27	<0.01
Gray whale	1,940	11.82	870	2.38
Ringed seal	526	0.87	240	0.18
Spotted seal	526	0.87	240	0.18
Bearded seal	526	0.87	240	0.18

2.3.2 Level B Exposures

The areas ensonified to Level B thresholds were calculated from the SLR (2017) reported median distance in Table 9 if the noise source was a point source and SLR modeling suggested the area was a circle. For noise sources that had larger and more complex areas such as underwater vibratory sheet piling (Figure 5), or the vessel transits which were not considered point sources, the area ensonified to the Level B threshold was calculated in ArcGIS 10.1. For vibratory sheet piling, SLR (2017) did not account for the acoustic shadow effect of the constructed island. Since vibratory sheet piling will occur near the periphery of the constructed island, the area ensonified will depend on the side of the island where vibratory sheet piling is occurring. We have therefore calculated the area ensonified for each side of the island, based on the sound only ensonifying the open waters parallel to that shoreline and extending to the median open water distance of the Level B threshold calculated by SLR (2017). The resulting areas ensonified are presented in Table 11, Table 12 and Table 13 for underwater ice-covered, underwater open water and airborne noise scenarios, respectively.

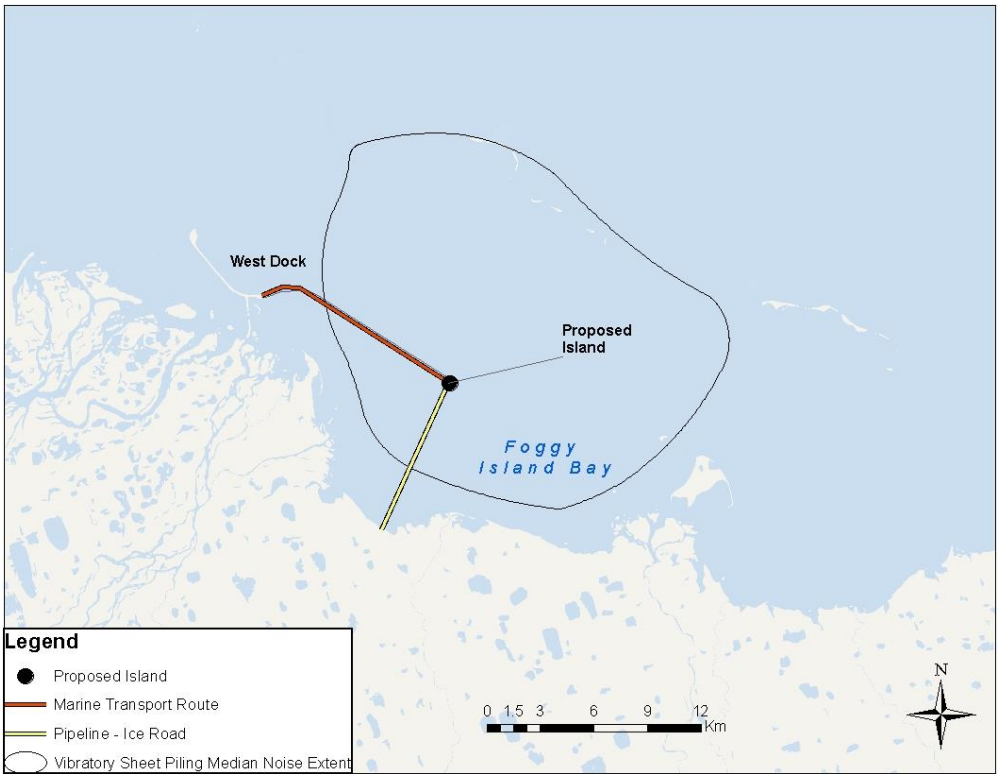

Figure 5 Map of study area showing the main vessel transport route (red line) and the median noise extent for vibratory sheet piling. This area is further subdivided, depending on which side of the island sheet piling is scheduled to occur at, to account for acoustic shadowing of the island.

Table 11. Area ensonified to Level B thresholds for underwater ice-covered noise scenarios.

Scenario name	Area (km^2)
Ice road construction and maintenance	0.09
Pipeline production	0.14
Island construction	0.14
Vibratory sheet piling	0.48
Impact sheet piling	0.03
Impact pipe driving	<0.01
Emergency and Oil Spill Response Training	0.09
Drilling and production	0.17
Production only	0.01

Table 12. Area ensonified to Level B thresholds for underwater open water noise scenarios.

Scenario name	Area (km^2)
Slope shaping, armament installation	4.23
Vibratory sheet piling	
North	263.91
East	229.40
West	109.49
South	101.98
Southwest	63.91
Impact sheet piling	13.20
Impact pipe driving	0.31
Emergency and Oil Spill Response Training	2.86
Vessel transportation - barge	32.95
Vessel transportation – tug	12.99
Vessel transportation – small / crew boat	3.33
Hovercraft Transportation	0.86
Drilling and production	0.01
Production only	0.01

Table 13. Area ensonified to Level B thresholds for airborne noise scenarios for pinnipeds.

Scenario noise	Area (km^2)
Ice road construction and maintenance	0.001
Pipeline production	0.001
Island construction	0.001
Vibratory sheet piling	0.001
Impact sheet piling	0.031
Slope shaping, armament installation	0.001
Impact pipe driving	0.031
Emergency and Oil Spill Response Training	0.001
Helicopter (take-off, landing)	0.014
Vessel Transportation	0.001
Hovercraft Transportation	0.001
Drilling and production	0.003
Production only	0.003

2.4 Exposure Estimates

2.4.1 Level A Exposures

As SLR (2017) reported that Level A exposures were only possible during the open water season, Level A exposures were only calculated during that period. Daily Level A exposures were estimated by multiplying the area ensonified as reported in Table 10, by the seasonal density for each species. This daily Level A exposure was multiplied by the number of days of impact sheet piling (15 days) and impact pipe driving (15 days) proposed in that season and these numbers then rounded up to the nearest integer and summed. Based on discussions with Hilcorp, most sheet piling will occur during the ice-covered season, with only 15 days occurring during the open water season. Based on scheduling, these 15 days of sheet piling would occur on the SW side of the island. This has been accounted for in our calculations.

2.4.2 Level B Exposures

Level B exposure numbers for each species were estimated by multiplying the season specific density estimate for each species expected to be present in Foggy Island Bay with the area ensonified to the Level B threshold by the activities expected to occur on a given day. We have termed the noise source with the largest area ensonified to the Level B threshold for a given day, the 'dominant' noise source. This 'dominant' noise source may not necessarily be the noise source with the highest amplitude. This is due to the different threshold for impulsive (160dB$_{rms}$) and non-impulsive (120 dB$_{rms}$) noise. Because the non-impulsive threshold is 40 dB lower, the threshold can cover a much larger area. Based on the Liberty Development and Production Plan (HAK, 2015) and SLR (2017) modelling results, we could identify the dominant noise source for each day of the 5-year period and multiply the dominant noise source areas by the appropriate seasonal density of marine mammals.

As an example of how Level B takes were estimated, we run through the steps for one day and one species below.

1. Day 121 of Year 1 has Hovercraft as a dominant noise source and an area ensonified of 0.86 km^2.
2. Ringed seal density on that day is estimated to be 0.548/km^2.
3. Multiplying the numbers above results in 0.47 ringed seals exposed to the Level B threshold on day 121 of Year 1.
4. The above approach is repeated for each day of each year for each species. Daily estimates are summed within a year and then rounded up to the nearest whole number.

3. Results

3.1 Level A Exposure Estimates

Level A acoustic exposures were calculated using the methodologies described in section 2.3.1. Level A exposures are only expected to occur during Year 1.

3.1.1 Cetaceans

Level A exposures only occurred during Year 1 when impact sheet piling and impact pipe driving is expected to occur. During the 15 days of impact sheet piling / impact pipe driving **and** with no mitigation measures in place, we conservatively predict the following Level A exposures (Table 14). All estimated Level A exposures were less than 0.02% of the species' populations (Table 14).

Table 14. Estimated Level A exposures for cetaceans during the five years with no mitigation in place. These all occur in Year1.

Species	Level A takes	% of Population
Bowhead whale	2	0.012
Beluga whale	2	0.006
Gray whale	0	0

3.1.2 Pinnipeds

As per cetaceans, Level A exposures for pinnipeds are only expected to occur during Year 1 while impact sheet piling / impact pipe driving is taking place **and** no mitigation measures in place. Our conservative pinniped Level A exposure estimates are provided in Table 15. All estimated Level A exposures were less than 0.001% of the species' populations.

Table 15. Estimated Level A exposures for pinnipeds during the five years with no mitigation in place. These all occur in Year 1.

Species	Level A takes	% of Population
Ringed seal	3	0.001
Spotted seal	2	0.0005
Bearded seal	2	0.0007

3.2. Level B Exposure Estimates

Level B acoustic exposures were calculated using the methodologies described in section 2.3.2. Because of the small number of Level A exposures, and to be conservative, we have not subtracted the number of Level A exposures from the Level B exposure estimates on the days that they co-occur. In years 2, 3, 4 and 5, Level B exposures were dominated by barge activities (Figure 6). During Year 1, when the island is scheduled to be constructed, Level B exposures are dominated by vibratory sheet pile activities that are scheduled to occur in the southwest area of the island during the open water period July 1-July 15, and by barge activities during the remainder of the open-water season. Because bowhead whales are not expected to occur within the regions to the southwest of the island bowhead whales are not expected to be exposed to vibratory sheet pile activities in Year 1, rather bowhead whales may be exposed to barge activity instead.

The following sections 3.2.1 and 3.2.2 summarize the number of Level B exposures expected for each marine mammal species over the 5 years of the Liberty Project in Foggy Island Bay.

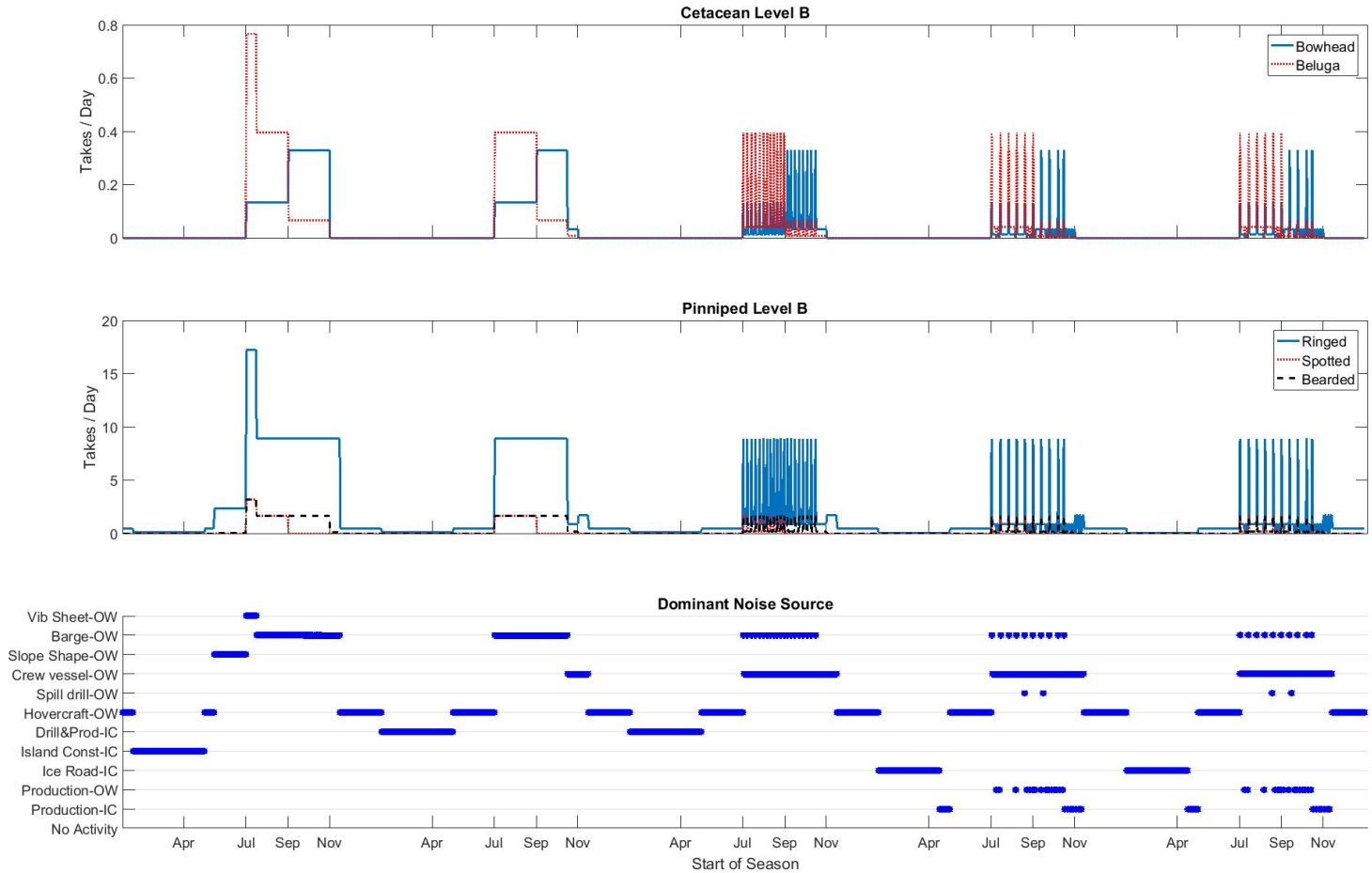

Figure 6 Plot of Level B exposures/day and the 'dominant' noise sources that are driving those exposures. Top trace are cetaceans, middle trace are pinnipeds and bottom trace are sound sources, ranked from smallest area (bottom) to largest area (top). The blue lines indicate time periods when that sound source is dominant during the 5-year period. The two-letter code after each sound source indicates when the activity occurs (OW=open water; IC=ice covered). The start of each season is indicated on the x-axis, where changes in density can occur.

3.2.1 Cetaceans

For each cetacean species considered to be at risk of exposure to Level B thresholds during the development of the Liberty Project estimated exposures per year were less than 0.2% of the species' population Years 1 and 2 and less than 0.05% in the remaining 3 years. While gray whale density is very low, it is possible that a rare whale may pass through the area and thus we have estimated 1 Level B exposure of a gray whale per year. If beluga whales are exposed in years 3 through 5, due to their group size, exposures are likely to be higher than we have calculated. The number of cetaceans that may be exposed to sound levels that exceed Level B thresholds for each year of development are detailed in Table 16.

Table 16 Estimated Level B acoustic exposures for cetacean species that may occur in the Liberty Project area.

Species	*Population Size	Estimated Takes	% of Population
Bowhead whale	16,091		
Yr 1		29	0.19
Yr 2		24	0.15
Yr 3		7	0.04
Yr 4		5	0.03
Yr 5		5	0.03
Beluga whale	32,453		
Yr 1		35	0.11
Yr 2		28	0.09
Yr 3		8	0.02
Yr 4		5	0.02
Yr 5		5	0.02
Gray whale	20,125		
Yr 1		1	<0.01
Yr 2		1	<0.01
Yr 3		1	<0.01
Yr 4		1	<0.01
Yr 5		1	<0.01

* Population estimates for cetaceans represent the best available data; bowhead whales - Givens et al. (2013), beluga whales - NMFS (2011b) gray whales - NMFS (2011c).

3.2.2 Pinnipeds

Due to higher densities, the majority of estimated Level B exposures for the Liberty Project involve pinnipeds. Level B exposures per year were less than 0.6% of each species' population. Ringed seals comprised the majority of exposures for the project with 79.51% of all estimated exposures (including cetacean exposures). Bearded seals comprised 11.19% of the total estimated exposures and spotted seals comprised 6.15% of the estimated exposures. The number of pinniped exposures for each year of development are detailed in Table 17. Because exposures are estimates of the number of individuals potentially disturbed during a day, exposure estimates below may represent exposures of the same animal on different days.

Table 17 Estimated Level B acoustic exposures for pinniped species that may occur in the Liberty Project area.

Species	*Population Size	Estimated Takes	% of total population
Bearded seal	273,676		
Yr 1		229	0.08
Yr 2		180	0.07
Yr 3		51	0.02
Yr 4		33	0.01
Yr 5		33	0.01
Ringed seal	300,000		
Yr 1		1,622	0.54
Yr 2		1,057	0.35
Yr 3		361	0.12
Yr 4		251	0.08
Yr 5		251	0.08
Spotted seal	391,000		
Yr 1		126	0.03
Yr 2		103	0.03
Yr 3		29	0.01
Yr 4		19	0.00
Yr 5		19	0.00

*Population estimates for pinnipeds from latest species status reviews; bearded seals - Cameron et al. (2010), ringed seals - Kelly et al. 2010, spotted seals - Angliss and Allen (2015).

4. Summary and Conclusions

There are six species of marine mammals (3 cetaceans, 3 pinnipeds) which occur at various times of the year in or near Foggy Island Bay which may be exposed to potential Level A and B thresholds from the acoustic sound related to the development and production of the Liberty Project. The objective of this report was to estimate the potential number of Level A and B exposures that might occur during the first five years of the Liberty Project. This was done by combining:

- The construction and production schedule in the Liberty Development and Production Plan (HAK, 2015)
- The acoustic propagation modelling conducted by SLR (2017) of the noise sources identified in HAK (2015)
- And seasonal density estimates of marine mammals in the Project area from the published literature as well as government and industry reports

Level A exposures are only expected during year 1 on the 15 days that impact sheet piling and impact pipe driving is expected to take place. Level B exposures are expected in all five years covered in this report, with the highest number of Level B exposures also occurring during year 1, due to the construction related activities. Level B exposures are predicted to be highest during the open water season (summer and fall), with very few exposures occurring during the winter and spring. Ten sound sources may lead to Level B exposure estimates. In order from largest to smallest area ensonified to the Level B threshold, they are: vibratory sheet piling, barge operations, slope shaping, small / crew boat activities, emergency spill drills, hovercraft operation, drilling and production, island construction, ice road construction and production during open water and ice-covered seasons. Most level B exposures occur from the vibratory sheet piling and barge operations due to their large ensonified area and their temporal overlap with higher marine mammal densities during open-water periods. For cetaceans estimated Level B exposures were less than 0.2% of the species' population, while estimated Level B exposures for pinnipeds were less than 0.6% during Year 1 of the Project.

For every input into our exposure estimates, we have endeavored to identify the best currently available data. When we have had to make assumptions due to lack of data, we have stated them and chosen assumptions we felt were conservative and would result in over estimates of the number of exposures.

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APPENDIX C

LDPI Project

Draft Marine Mammal Mitigation and Monitoring Plan

January 2018

DRAFT

Marine Mammal Monitoring and Mitigation Plan

Liberty Development and Production Project

April 2018

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ACRONYMS AND ABBREVIATIONS

ADFG ..... Alaska Department of Fish and Game
AEWC ..... Alaska Eskimo Whaling Association
BOEM ..... Bureau of Ocean Energy Management
BWCA ..... Barrow Whaling Captains Association
CAA ..... Conflict Avoidance Agreement
dB re 1 µPa rms ..... decibels referenced to one microPascal root mean square
FAA ..... Federal Aviation Administration
ft ..... feet
GPS ..... Global Positioning System
Hilcorp ..... Hilcorp Alaska, LLC
ITA ..... Incidental Take Authorization
ITR ..... Incidental Take Request
km ..... kilometers
KWCA ..... Kaktovik Whaling Captains Association
LDPI ..... Liberty Development and Production Island
LOA ..... Letter of Authorization
m ..... meters
mi ..... miles
MMPA ..... Marine Mammal Protection Act
NSB ..... North Slope Borough
NMFS ..... National Marine Fisheries Service
NWCA ..... Nuiqsut Whaling Captains Association
OCS ..... Outer Continental Shelf
POC ..... Plan of Cooperation
PSO ..... Protected Species Observer
PTS ..... Permanent Threshold Shift
SDI ..... Endicott Satellite Drilling Island
SEL ..... sound exposure level
SLR ..... single lens reflex camera
SEMS ..... Safety and Environmental Management System
UAS ..... Unmanned Aerial Systems
USFWS ..... U.S. Fish and Wildlife Service
VSM ..... vertical support member

1. INTRODUCTION

1.1. Purpose of the Plan

In order to issue a Letter of Authorization (LOA) for an activity, Section 101(a)(5) of the Marine Mammal Protection Act (MMPA) states that the National Marine Fisheries Service (NMFS) must set forth "requirements pertaining to the monitoring and reporting of such taking." This monitoring plan is a component of the application. The MMPA implementing regulations at 50 CFR 216.104 (a)(13) indicate that requests for Incidental Take Authorizations (ITAs) must include the suggested means of accomplishing the necessary monitoring and reporting that would result in an increased knowledge of the species and the level of taking or impacts on populations of marine mammals that are expected to be present in the Action Area.

Hilcorp recognizes that monitoring requirements should be designed that improve the understanding of one or more of the following:

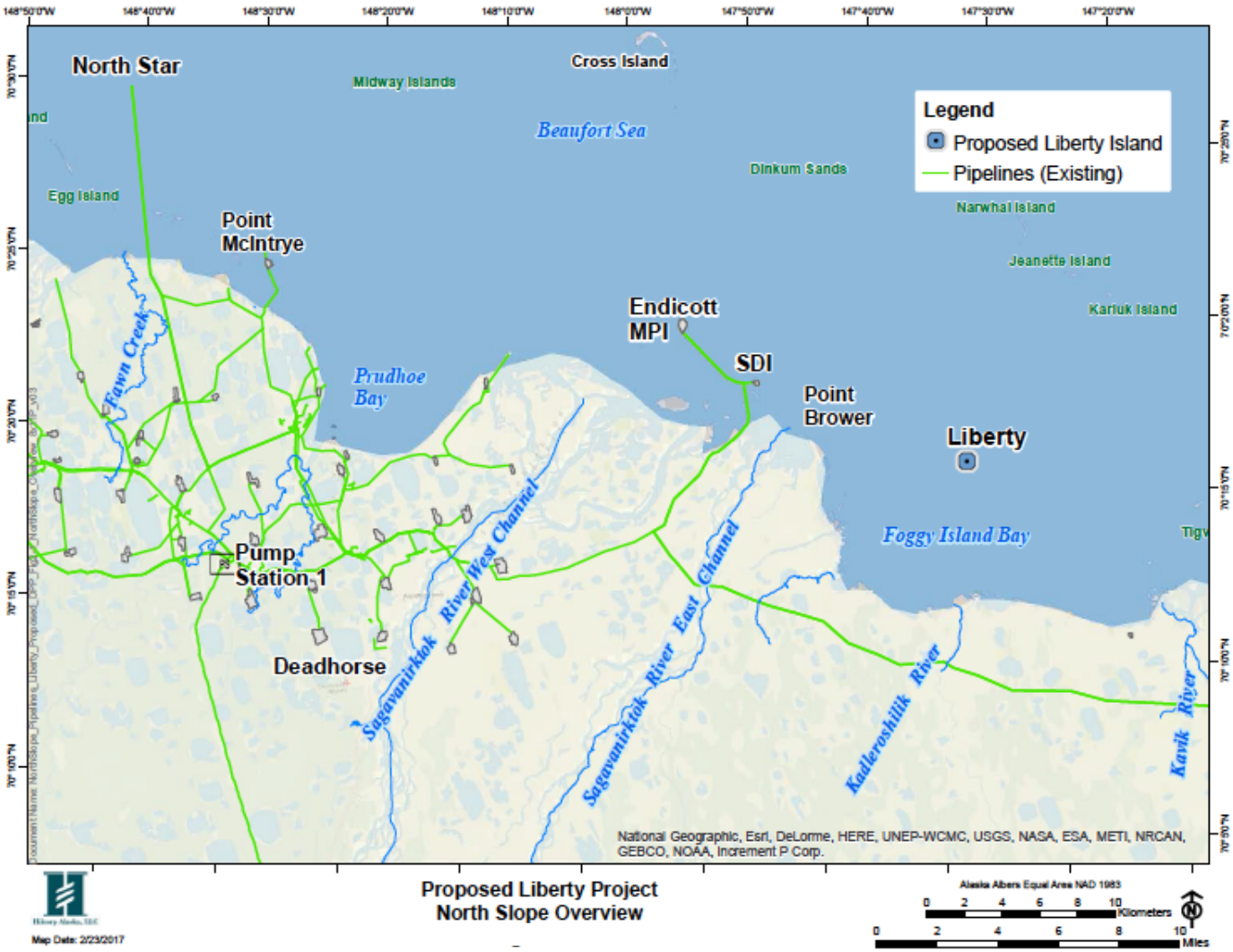
- Occurrence of marine mammal species in the Action Area (e.g., presence, abundance, distribution, density);
- Nature, scope, or context of likely marine mammal exposure to potential stressors/impacts (individual or cumulative, acute or chronic), through better understanding of: 1) action or environment (e.g., source characterization, propagation, ambient noise); 2) affected species (e.g., life history, dive patterns); 3) co-occurrence of marine mammal species with the action; or 4) biological or behavioral context of exposure (e.g., age, calving or feeding areas);
- Individual responses to acute stressors, or impacts of chronic exposures (behavioral or physiological);
- How anticipated responses to stressors impact either: 1) long-term fitness and survival of an individual; or 2) population, species, or stock;
- Effects on marine mammal habitat and resultant impacts to marine mammals; and
- Mitigation and monitoring effectiveness.

In keeping with guidance provided by NMFS, Hilcorp has considered a number of monitoring and reporting opportunities that could contribute to the collective knowledge of marine mammals, marine mammal prey, and marine mammal habitat. However, the potential to conduct meaningful research on impacts of LDPI Project sounds on marine mammals during the LDPI Project is limited for due to the small number of animals anticipated to be in the region and other factors.

1.2. Project Location

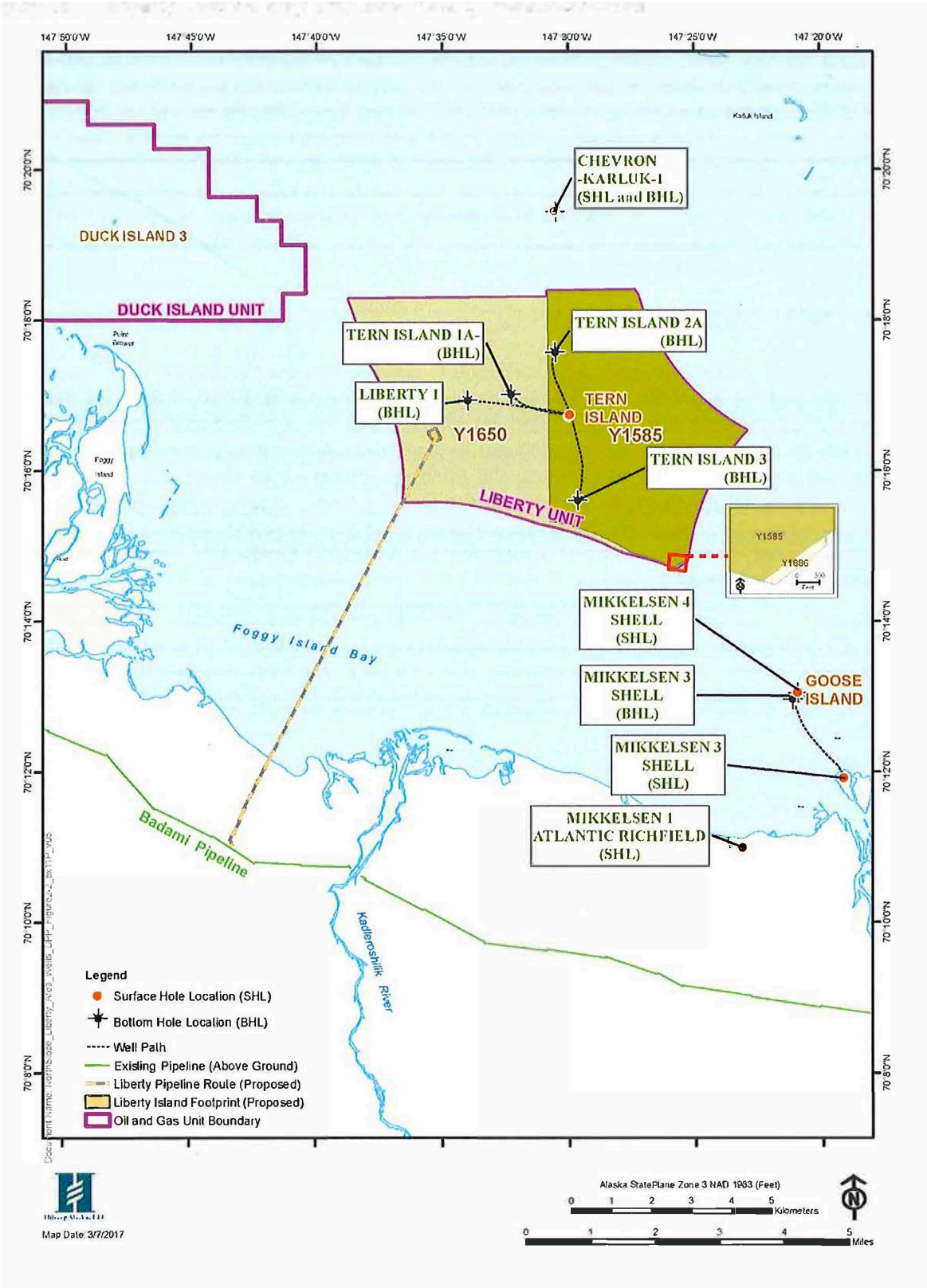
Hilcorp Alaska, LLC (Hilcorp), as the Liberty operator, is proposing to develop the Liberty Oil Field reservoir, located on the Outer Continental Shelf (OCS), in Foggy Island Bay, Beaufort Sea, Alaska (Figure 1-1). The Liberty Oil Field reservoir is approximately 5 to 8 mi (8 to 13 km) to the east of the existing Endicott Satellite Drilling Island (SDI). The proposed Liberty Development includes the Liberty Drilling and Production Island (LDPI), which will be constructed of reinforced gravel in 19 feet (ft) (5.8 meters [m]) of water about 5 miles (mi) (8 kilometers [km]) offshore in Foggy Island Bay. Liberty is located on three leases, OCS-Y-1650, OCS-Y-1886, and OCS-Y-1585 (see Figure 1-2).

FIGURE 1-1. LOCATION OF LIBERTY DEVELOPMENT, NORTH SLOPE, ALASKA



Source: (Hilcorp 2017)

FIGURE 1-2. LIBERTY LEASE BOUNDARY MAP AND AREA WELLS



Source: (Hilcorp 2017)

Foggy Island Bay is located east of Prudhoe Bay and opens north into Stefansson Sound on the central Beaufort Sea coast. The bay and sound are sheltered from the Arctic Ocean by the McClure group of barrier islands which lie northeast, about 9.5 mi (15.5 km) from the coast and 7 mi (11 km) from the proposed LDPI. The coastal and inland physiography is typical of the Arctic Coastal Plain, a low-angle, sloping plain that extends north from the Brooks Range to the Beaufort Sea. Four rivers empty into the Beaufort Sea and form modern deltas south of the proposed Liberty Island location: from west (closest to the LDPI) to east, the Sagavanirktok, Kadleroshilik, Shaviovik, and Canning rivers.

1.3. Project Activities and Associated Noise Sources

The proposed Liberty Project includes the construction of a gravel island, ice roads, development of a mine-site to supply gravel for the construction of the LDPI, and installation of an undersea pipeline that reaches shore from the LDPI, transitions to an above ground, vertical support member (VSM)-mounted pipeline, and then connects to the existing above-ground Badami pipeline. The LDPI is a self-contained offshore drilling and production facility and will contain infrastructure to support construction and operations including a drill rig and associated equipment, utilities, and living quarters.

The expected timing and dates of Project activities that produce noise and have the potential to result in takes of marine mammals in the Action Area are summarized in Table 1-1. Sound source levels for underwater (ice covered and open water) and airborne noise from Project scenarios are shown in Table 1-2.

1.4. Applicable Noise Criteria

Project activities described in Section 1.3 have the potential to generate underwater noise that may expose up to six species of marine mammals to Level A and Level B[1] harassment: bowhead, gray and, beluga whales; and bearded, ringed, and spotted seals. Acoustic thresholds for causing Permanent Threshold Shift (PTS) in marine mammal hearing are provided in *NMFS Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Threshold Levels for Onset Permanent and Temporary Threshold Shifts* (2016). Different thresholds are provided for different marine mammal hearing groups, which are defined in the Technical Guidance. To determine the PTS thresholds, NMFS (2016) uses a dual metric approach considering both cumulative sound exposure and peak sound levels for impulsive sounds. For non-impulsive sounds, only the cumulative sound exposure level was used, unless the impulsive peak level threshold was exceeded. The PTS thresholds corresponding to each hearing group represented in the Action Area are shown in Table 1-3.

NMFS has implemented a behavioral effects threshold (Level B) for impulsive sound of 160 decibels referenced to one microPascal root mean square (dB re 1 µPa rms) and 120 dB re 1 µPa rms for non-impulsive sound for all marine mammals. These thresholds were used to determine the Level A shutdown zone and Level B monitoring zone described in Sections 2.1.6.2 and 2.1.6.3, respectively.

[1] Level A harassment may result in injury, whereas Level B results in disturbance without the potential for injury.

TABLE 1-1. PROJECT ACTIVITY TIMELINE AND POTENTIAL FOR MARINE MAMMAL TAKES[1]

ACTIVITY	TIMING	POTENTIAL FOR TAKE
CONSTRUCTION OPERATIONS		
Summer & Winter Access	Year 1 - Year 3	
Annual Ice Road (#1)	Year 1 - Year 3, January – mid-May	Yes
Support Ice Roads (#2 - #4)	Year 1 – Year 4, December – mid-April	Yes
Sea-going Barges	Year 2 - Year 4, June - November	No
Small Marine Vessels	Year 2 - Year 4, June - November	No
Island Construction[2]	Year 2, February – September[3]	
Pile and Pipe Driving and Slope Shaping	Year 2, July – August[3]	Yes
Facilities Construction	Year 2, August - Year 4, May	No
Pipeline Construction	Year 3, January - May	Yes
DRILLING OPERATIONS		
Summer & Winter Access	Year 2 - Year 4	
Annual Ice Road (#1)	Year 2 - Year 4, January – mid-May,	Yes
Sea-going Barges	Year 2 - Year 4, June - November	No
Small Marine Vessels	Year 2 - Year 4, June - November	No
Rig Mobilization and Well Drilling	Year 2 - Year 4	Yes
First Oil/Commissioning	Year 3, December - Year 4, May	No

Source: (BOEM 2017)
[1] Takes have only been requested though first 5 years due to increase activities at the site (for example, increased number of ice roads and traffic which would diminish after year 5; future LOAs may depend on acoustic monitoring as described in the ITR petition.
[2]No takes are being requested for mine site development.
[2]Planned for Year 2 and would occur in Year 3 only if island construction occurs over two winter seasons as ice conditions allow.

TABLE 1-2. SOUND SOURCE LEVELS FOR CONSTRUCTION SCENARIOS

	Underwater Noise		Airborne Noise
	Ice Covered	Open Water	
Scenario	**Average Sound Pressure Level** (dB re 1µPA at 1m	**Source Sound Pressure Level Peak** (dB re 1µPA at 1m)	**Overall Source Sound Pressure Level at Distance** (dB re 1µPA @ m)
Ice Road Construction and Maintenance (Graders, Augers, Water Pumps)	189.1	n/a	Graders 64.7 (@100 m) Augers 67.9 (@100 m) Water pumps 72 (@100 m)
Pipeline and Island Construction	Trucks on ice road 179.1 Backhoe 177.7 Ditchwitch 169.6	n/a	Trucks on ice road 74.8 (@100 m) Backhoe 78 (@10 m) Ditchwitch 76.3 (@100 m)
Vibratory sheet Piling, Island Perimeter	221.0	185	81 (@100 m)
Slope shaping, armament installation	n/a	167	64.7(@100 m)
Impact Sheet Piling	235.7	210	93 (@160 m)
Impact pipe driving, island interior	171.7	196	93 (@160 m)
Helicopter (take-off, landing)	n/a	n/a	84 (@300 m)
Drilling & Production	170.5	151	80 (@200 m)
Production only[1]	154.5	153	80 (@ 200 m)

Source: SLR 2017 and SMRU 2017.
n/a indicates that the source does not apply
[1]Production includes managing the flow of oil, water, and gas and maintaining equipment to ensure long and reliable service and may include overhauls of rotating equipment.

TABLE 1-3. ACOUSTIC NOISE CRITERIA FOR LEVEL A INJURY EFFECTS

	PTS Onset Acoustic Thresholds (Received Level)		
	Impulsive Sources		Non-impulsive source
Hearing Group	**Peak Pressure Level** *(dB re 1 µPa)*	**Cumulative Auditory-weighted SEL_{24h}** *(dB re 1 µPa²·s)*	**Cumulative Auditory-weighted SEL_{24h}** *(dB re 1 µPa²·s)*
Low-frequency cetaceans[1]	219	183	199
Mid-frequency cetaceans[2]	230	185	198
Phocid pinnipeds water[3]	218	185	201

Source: (NMFS 2016)
Notes: Peak sound pressure is "flat" or unweighted. Cumulative sound exposure level has a reference value of 1µPa2s. Cumulative levels should be appropriately weighted for the hearing group for assessment to the threshold.
[1] Bowhead and gray whales
[2]Beluga whales.
[3]Ringed, bearded, and spotted seals.

2. MITIGATION AND MONITORING DURING CONSTRUCTION

Hilcorp has developed mitigation and monitoring measures to ensure the least practicable impact on affected marine mammal species and stocks, and their habitat. Potential measures include consideration of the following factors: 1) the degree to which the successful implementation of the measure is expected to minimize adverse impacts to marine mammals; 2) the proven efficacy of the specific measure to minimize adverse impacts as planned based on monitoring plans from previous, similar applications for MMPA authorizations that include pile driving; and 3) the practicability of the measure for implementation. Based on these factors, the mitigation and monitoring measures described in this plan will accomplish the following objectives:

- Avoid or minimize injury to or death of marine mammals;
- Minimize the likelihood that impacts will occur to the species, stocks and subsistence use of marine mammals in the occurring in the Action Area of Foggy Island Bay and areas immediately outside of the bay;
- Eliminate the potential for Level A injury takes and eliminate or reduce the potential for Level B harassment takes through the use of Project timing and shutdown zones;
- Avoid overlap of noise producing activities with traditional subsistence hunting locations and events;
- Quantify the number of marine mammals exposed to or taken by harassment (Level B).

To meet these objectives Hilcorp will use the following monitoring methods (described in detail in Section 2.2), timing, and management practices:

- Two Protected Species Observers (PSOs) will be stationed on the island during pile and pipe driving (approximately July 1-15 Year 2) to visually monitor for marine mammals in the Level A zone and shut down work if necessary;
- A third island-based PSO will work closely with an aviation specialist to monitor the Level B zone during the pile and pipe driving using an unmanned aircraft system (UAS). This third PSO and the UAS pilot will be located on the island. UAS monitoring will also be used during slope shaping, which may occur in open water intermittently until August 31 of Year 2. UAS will not be used after Year 2.
- If UAS deployment is not possible, the third PSO could conduct marine mammal monitoring from a vessel located at the edge of the Level A zone between July 1 and August 31st of Year 2.
- During Years 3-4, a PSO (and an alternate) will be placed on the island for approximately 4 weeks during the month of August to monitor for the presence of marine mammals around the island;
- During the open water season of Years 2-5 Hilcorp is proposing to conduct underwater acoustic monitoring (see Section 13.2).
- Based on the results of PSO monitoring and underwater acoustic data and in consultation with NMFS, Hilcorp would determine whether PSO monitoring is needed during Year 5 to monitor for presence and behavior of marine mammals that may occur within the island vicinity.

- The soft-start technique will be used at the beginning of impact pile driving each day, or if pile driving has ceased for more than thirty minutes;
- As much as possible of the noise producing work associated with island and pipeline construction will be done during the ice-covered winter months to minimize exposure to marine mammals;
- Ice road and ice pad construction will be initiated prior to March 1 to ensure that denning seals will not be crushed by road and pad construction techniques. All on-ice activities will be conducted at least 500 ft (150 m) from any observed ringed seal lair;
- All activities associated with the construction at the LDPI will be conducted in accordance with all federal, state and local regulations and in coordination with NMFS, U.S. Fish and Wildlife Service (USFWS), Bureau of Ocean Energy Management (BOEM) Alaska Region, and Alaska Department of Fish and Game (ADFG);
- The existing Plan of Cooperation (POC) between Hilcorp and the subsistence users in the region, will be renewed and construction activities will be coordinated with the North Slope Borough (NSB), representatives and whaling captains (Alaska Eskimo Whaling Association [AEWC], and the Barrow [BWCA], Nuiqsut [NWCA], and Kaktovik [KWCA] Whaling Captains Associations) to minimize potential interference between operational, maintenance, and training activities with the fall subsistence hunt for bowheads whales;
- Opportunities to employ Native observers to collect traditional knowledge will be explored.
- The existing Conflict Avoidance Agreement (CAA) between Hilcorp and the AEWC, will be followed for all North Slope oil and gas activities to minimize potential interference with bowhead subsistence hunting. Hilcorp will attend and participate in the CAA future meetings.

2.1. Mitigation Measures

2.1.1. General Best Management Practices

Construction activities will follow all requirements of Hilcorp's Safety and Environmental Management System (SEMS) to avoid and minimize impacts on the environment, Endangered Species Act (ESA)-listed species, designated critical habitats and species protected under the MMPA. The SEMS addresses water quality, air quality, waste management, wildlife interactions, and response to spills.

Best Management Practices (BMPs) that will be followed during LPDI and pipeline construction activities include:

- Toxic or hazardous material specifications, inventories, separation, confinement, and handling which will be determined, documented, and communicated to appropriate personnel;
- Properly sized equipment to be used to drive piles and sheet pile; and
- Emergency response and control plans in place and ready for immediate implementation if needed.

2.1.2. Vessel Management to Avoid Ship Strikes and Disturbance

As described in the 2012 Biological Opinion for Northstar (NMFS 2012), between 1976 and 1992, whalers observed injuries from ship strikes on 236 bowhead whales. Bowhead whales have been

documented to allow slow moving vessels that do not change direction or speed suddenly to approach within several hundred meters, indicating some level of tolerance of vessel presence (Richardson, *et al.* 1995, Heide-Jorgensen*, et al*. 2003). Ocean-going barges and other larger vessels associated with the Liberty project would be inshore of the bowhead whale migration corridor. Further, these vessels would not overlap with their fall migration in August/September (heading west from the Canadian Beaufort Sea) or November (heading west and south). Small crew vessels would be operating between shore and LDPI within Foggy Island Bay where bowhead whales are not known to occur (see Section 8.2 of the ITR petition).

During the spring and fall, most beluga whales in the central and eastern Beaufort Sea migrate along the ice edge in deep offshore waters more than 60 mi (96.5 km) north of the coast migration (Clarke, *et al.* 2012, 2013). While beluga whales may occur within Foggy Island Bay, the potential for these cetaceans to interact with a vessel is not likely to occur due to proposed mitigation measures including the slow vessel speeds, avoidance of groups of whales, and the fact that belugas would likely avoid vessel interactions by swimming away from the disturbance.

While observers routinely observe bearded and ringed seals during oil and gas exploration activities, there have been no ringed or bearded seals ship-strike incidents documented in Alaska (BOEM 2011). Bearded seals are more likely to be farther out from shore, further reducing the risk of ship/seal interactions.

Therefore, ship strikes from vessel movements to and from the LDPI are not likely and no takes have been requested for vessel movements or ship strikes of marine mammals. However, the following mitigation measures will ensure that no ship strikes occur and marine mammals will not be disturbed due to the physical presence of vessels:

- Reducing speed to less than 5 kn (9.26 km/hr) prior to coming within 900 ft (274 m) of whales. The reduction in speed will vary based on the situation but must be sufficient to avoid interfering with the whales. Those vessels capable of steering around such groups should do so. Vessels may not be operated in such a way as to separate members of a group of whales from other members of the group. A group is defined as being three or more whales observed within a 1,641ft (500 m) area and displaying behaviors of directed or coordinated activity (e.g., group feeding). It should be re-emphasized that bowhead whale occurrence in the proposed Action Area is considered very limited therefore the need to steer around whales should be minimal;
- Avoiding multiple changes in direction;
- Reducing vessel speed when visibility is poor;
- Checking the waters immediately adjacent to the vessel to ensure that no whales will be injured when the vessel's propellers are engaged;
- Not allowing tow lines to remain in the water or trash to be thrown overboard.

Regarding North Pacific right whales and Steller sea lions (applicable for the sea going barge):

- The vessel operator will not approach within 2,624 ft (800 m) of a North Pacific right whale;
- The vessel shall avoid transiting within designated North Pacific right whale critical habitat. If transit within North Pacific right whale critical habitat cannot be avoided, vessel operators are requested to exercise extreme caution and observe the 10 kn (18.52 km/h) vessel speed

restriction. If transiting through North Pacific right whale critical habitat, ocean going barges will have PSO's actively engaged in sighting marine mammals; and

- The vessel shall not approach within 3 nm (5.5 km) of a Steller sea lion rookeries or major haulouts.

2.1.3. Aerial Traffic

Potential disturbance to mammals from helicopter flights to support LDPI construction will be minimized by limiting the flights to an established corridor that represents the shortest route from the LPDI to the mainland, and, except when limited by weather and during landing and takeoff, will maintain a minimum altitude of 1,500 ft (457 m). If a marine mammal is observed, then a horizontal radii of 1,000 ft (305 m) would be maintained. Hilcorp intends to establish the shortest route from mainland to island that safety and weather conditions will allow. By restricting, as practicable, aerial flights within an established flight corridor, potential disturbance to marine mammals will be minimized.

Helicopter and other air traffic will be coordinated as needed with the NSB and AEWC to avoid disrupting subsistence hunting. If safe to do so, air routes can be altered to prevent disturbance to specific subsistence activities.

2.1.4. Ice-Covered Conditions

2.1.4.1. Pipeline, Ice Road and Ice Pad Construction

Hilcorp will begin winter construction activities in December or as soon as ice conditions allow safe access. Initiation of winter, on-ice activities (ice road construction, ice pad development, and pipeline trenching) prior to March 1, will allow ringed seals to avoid disturbed areas as they establish birthing lairs.

Williams *et al.* (2006) concluded that ringed seal breathing holes and lairs were established in the landfast ice before and during construction activities within a few meters of the Northstar Island oil development. Many of these structures were maintained by seals for up to 163 days, despite the presence of low-frequency industrial noise and vehicular use of ice roads. Considering proposed mitigation measures to avoid seals and based on literature as well as research conducted for Northstar described here, the potential for injury or mortality to ringed seals from crushing is highly unlikely assuming ice road construction and activities commence prior to March 1 each year. Also, as summarized by Williams *et al.* (2006), disturbance to seals from vehicle activity on ice roads is not likely to result in biologically significant effects.

All on-ice activities will be conducted at least 500 ft (150 m) from any observed ringed seal lair. Female ringed seals establish their birth lairs before pupping in late March to April. If the ice road construction activities cannot be initiated prior to March 1, undisturbed areas will be surveyed before activity begins using a subsistence advisor. To determine the number of structures in the vicinity of winter construction, the subsistence advisor will survey a buffer zone along the ice road corridor to identify breathing holes. Surveys will occur in areas where water depth is greater than 9.8 ft (3 m). Identified ringed seal structures will be avoided by a minimum of 492 ft (150 m), minimizing any disturbance to located seal structures.

Hilcorp will develop a detailed survey plan and additional mitigation measures in coordination with the subsistence advisor before initiation of on-ice activities in the event this mitigation measure is needed.

2.1.4.2. Island Construction

Island construction will commence in early winter and will include cutting of ice blocks and placement of gravel, island shaping and armoring, and installation of a vertical sheet pile wall. The wall protects the work surface of the island from ice and wave impacts. It is also intended to prevent most marine mammals from entering the work area. This design will be similar to that at the Northstar Production Island constructed by BPXA in 2000.

Construction, with the exception of sheet pile driving, conductor pipe drilling, and slope shaping, is planned to occur from January through mid-April which helps further minimize potential impacts to marine mammals. For the purposes of this mitigation and monitoring plan, it is assumed ice-covered conditions will be present until July 1, a total of 4 months (120 days). During winter and spring activities on the sea ice, the ringed seal is the only marine mammal species under the jurisdiction of NMFS that is likely to be encountered near the LDPI. As described in Section 2.1.4.1, winter activities will commence on the sea ice as early as practical (i.e., December).

2.1.5. Broken Ice Conditions

The period spanning mid-May through July is characterized by warming temperatures, over-flooding of the rivers, the formation of melt ponds, and the degrading surface ice (break-up). However, many of the activities supporting construction in winter are appropriately employed well into the broken ice season. Hovercraft, amphibious personnel carriers, amphibious ditchwitch trenchers, and backhoes can be used during break-up and in varying ice conditions. Hovercraft and amphibious vehicles have been used to transport personnel and light equipment on the North Slope in a variety of conditions for many years.

Assuming construction activities begin in early winter, ice roads are initiated prior to March 1, and other on-island construction is completed by mid-April, work during broken ice conditions will not require any additional mitigation measures. However, as animals begin to move in and out of the broken ice flows, pinniped movements may become more obvious. During Year 2, construction activities that may result in Level A takes (e.g., impact pipe and sheet pile driving, and vibratory pile driving) may occur during broken ice and open water conditions for a period of approximately 15 days (~July 1-15). As described in Section 2.2, island-based PSOs will monitor the Level A zones and will stop work if necessary. This will mitigate the potential for Level A takes. Generally, beluga and bowhead whales are not likely to be present during broken ice conditions because they arrive much later in the open water season.

2.1.6. Open Water Conditions

Although ice-covered conditions or broken ice conditions can last into July, it is assumed that open water conditions will be present beginning approximately July 1. To the extent practicable, Hilcorp intends to complete as much island construction as possible by mid-April, but during Year 2 some aspects of island construction may require pile and pipe driving during approximately 15 days of open water conditions. During this time, PSOs will be used to monitor the Level A zone and stop work if necessary (see Section 2.2). Sheet pile driving around the island perimeter is expected to be completed prior to beluga whales

being present in the Action Area later in July or early August. Bowhead whales generally occur outside of the barrier islands as described in detail in Section 4.1.2 of the ITR petition.

Slope shaping may be necessary during Year 2 between approximately July 15 and August 31st during open water conditions. Slope shaping would not likely occur every day, if at all. If slope shaping is needed during this period, a PSO will work closely with the UAS pilot(s) to monitor the Level B zone to record potential takes of marine mammals in that zone (see Section 2.2.2). If any slope shaping or pile driving is required in Year 3 of construction, PSOs and UAS would be used as described for Year 2.

All work will be consistent with the existing CAA for open water season in the Beaufort Sea. Mitigation of noise producing activities described in the following subsections will result in the reduction of exposures to noise and potential takes to marine mammals.

2.1.6.1. Soft Start Technique

Hilcorp will use the soft-start technique at the beginning of impact pile driving each day, or if pile driving has ceased for more than thirty minutes. Soft-start procedures would be used prior to pile (or sheet pile) installation to allow marine mammals to leave the area prior to exposure to maximum noise levels. For vibratory hammers, the soft start technique would initiate noise from the hammer for short periods at a reduced energy level, followed by a brief waiting period. This cycle would repeat two additional times. For impact driving, an initial set of three strikes would be made by the hammer at 40 percent energy, followed by a one-minute waiting period. As with vibratory hammers this cycle is repeated two additional times.

2.1.6.2. Level A Zones and Shutdown Procedures

Construction activities that may result in a Level A take including impact pipe and sheet pile driving, and vibratory pile driving (Table 2-1). These activities are expected to be completed in Year 2 prior to the open water season, but it is possible they could continue for about 15 days into the open water season (approximately July 1 – 15). As described in Section 2.2, island-based PSOs will monitor the Level A shut down zones during this period.

While slope shaping activities occurring during this time and possibly until August 31may exceed the Level A threshold, the distance to that threshold is less than 33 ft (10 m) from the island (see Table 2-1). Animals are not expected to approach that close to the island during construction, particularly for any given amount of time that could cause PTS. Therefore, slope shaping is not included in the monitoring and assessment for Level A take. If pile or pipe driving activities extend beyond the anticipated 15-day period, or into Year 3, PSOs will be used to monitor the Level A shutdown zone as in Year 2.

Active impact sheet pile driving is likely to occur for 10 to 20 minutes total per day; however, to be precautionary, the maximum duration of 40 minutes has been used to estimate the ensonified area and shutdown zones shown in Table 2-1. Impact conductor pipe driving is likely to occur only 2 hours total per day.

TABLE 2-1. DISTANCE FROM NOISE SOURCE TO NMFS LEVEL A THRESHOLDS

Marine Mammal Hearing Group and Species		Distance From Source To PTS Threshold		
	Slope Shaping (9.6 hrs)	Vibratory Sheet Piling (2.5 hrs)	Impact Sheet Piling (40 mins)	Impact Pipe Driving (2 hrs)
Low frequency cetaceans (bowhead, gray whales)	<0.01 km (33 ft)	0.05 km 164 ft	1.94 km 6,365 ft	0.87 km 2,854 ft
Mid frequency cetaceans (belugas)	n/a	<0.01 km 33 ft	0.06 km 197 ft	0.03 km 98 ft
Phocid Pinnipeds (bearded, ringed, spotted seals)	<0.01 km (33 ft)	0.02 km 66 ft	0.53 km 1,706 ft	0.24 km 787 ft

Note: During Year 2, Open Water Period.

The Level A shutdown zone of 6,365 ft or 1.94 km for large low frequency whales (see Table 2-1) will be monitored during all pipe driving, sheet-pile driving and vibratory sheet-piling activities. Level A zones for beluga whales and pinnipeds are considerably smaller than those for bowhead whales (see Table 2-1).

The waters will be scanned by PSOs (both land-based and using UAS) 30 minutes prior to commencing pile driving at the beginning of each day, and prior to commencing pile driving after any stoppage of 30 minutes or greater. If marine mammals enter or were observed within the designated marine mammal shutdown zone 30 minutes prior to pile or pipe driving, the PSO will notify the on-site construction manager to not begin until the animal has moved outside the designated zone.

For an animal to reach Level A exposure thresholds, it would need to spend between 40 minutes and 9.6 hours within the zone as reported in the top row of Table 2-1. In the unlikely event that a low frequency cetacean (i.e., bowhead whale) enters their designated Level A zone (1.94 km for sheet pile driving 0.87 km for pipe driving), work would be shut down. If a mid-frequency cetacean (beluga) or pinniped (seal) enters their Level A zone (up to 0.06 km and 0.53 km, respectively), Hilcorp proposes to complete setting that pile (estimated to require less than 10-15 minutes[2]) but will not initiate driving of new piles until the mid-frequency cetacean or pinniped has left their Level A zone. During this time, PSOs will monitor the animal and record behavior. If after 20 minutes the animal is still within the Level A zone and Hilcorp has not completed setting the pile, shut down procedures will be initiated and no new pile driving will begin until the marine mammal has left the Level A zone. This practical and precautionary measure will minimize the potential for injury given that an animal must remain in the Level A zone for a total of 40 minutes to experience PTS. This is a precautionary measure considering that the criteria for Level A harassment are sound exposure level (SEL)-based and animals would need to remain in the Level A zone for approximately 40 minutes before PTS would occur. This approach minimizes the potential for harm to marine mammals. The observation would be reported and recorded as a Level A take.

Subsequent pile driving activities will not begin until the animal is clear of the shutdown zone. Generally, any marine mammal observed approaching the Level A zone will have already been exposed to Level B thresholds and recorded as a potential take. If this occurs, observed animal behaviors will be documented.

[2] During sheet pile driving at Northstar Island, it was observed that "a typical vibrahammer operation lasted for 1 minute or less" (Shepard et al, 2001).

2.1.6.3. Level B Monitoring Zones

The predicted distances from the noise source to the underwater behavioral impact thresholds (Level B zones) for marine mammals for each of the project scenarios considered in the open water summer season are shown in Table 2-2.

TABLE 2-2. BEHAVIORAL THRESHOLD DISTANCES AND ENSONIFIED AREAS DURING ISLAND CONSTRUCTION

Scenario	Underwater Noise (Open Water)	
	Distance to Level B Threshold (km)	Ensonified Area (km^2)
Vibratory sheet piling[1]	14.8 (9.2 mi or 48,556 ft)	N–264 (65,000 acre) E–229 (57,000 acre) S–102 (25,000 acre) W–109 (27,000 acre) SW–64 16,000(acre)
Impact sheet piling	2.5 (1.6 mi or 8,202 ft)	19.6 (4,843 acres)
Slope shaping, armament installation	1.16 (0.7 mi or 3,806 ft)	4.2 (1,038 acres)
Impact pipe driving	0.31 (0.2 mi or 1,017 ft)	0.3 (74 acre)

Source: (SLR 2017) and (SMRU 2017).
[1]Since vibratory sheet piling will occur near the periphery of the constructed island, the area ensonified will depend on the side of the island where vibratory sheet piling is occurring.

The farthest distances shown in Table 2-2 represent the maximum behavioral (Level B) threshold distances from the sound source during Year 2 construction activities. Hilcorp will use an island-based PSO and UAS to monitor Level B zones during pile driving and slope shaping activities (see Section 2.2). Vibratory sheet pile driving has potential to produce underwater noise above the behavioral effect threshold over the largest area from the island, within up to 0.24 mi (0.39 km) under ice-covered conditions and 9.2 mi (14.8 km) in open water. It is assumed that vibratory sheet pile driving will be completed within 4 months under ice-covered conditions, but additional work may be required for about 15 days in open water conditions. If pile or pipe-driving is necessary in open water, Hilcorp will use UAS during the approximately 15 days (July 1 – 15) of construction to monitor Level B harassment zones to record any takes by harassment. Between July 15 and August 31st, if slope shaping is necessary, a PSO and UAS will be used to monitor the Level B zone of approximately 4.2 km^2 (see Section 2.2). Any marine mammal documented within a Level B harassment zone will be considered a Level B take (harassment) and will be recorded along with behavior (See Section 2.6.2).

2.1.7. Subsistence Activities

Based on results of previous programs similar to the Liberty Project, the proposed mitigation measures would result in the least practicable impact on marine mammal species or stocks and their habitat, and ensure that there is no adverse impact on the availability of any stocks for subsistence purposes.

In April 2018, Hilcorp submitted a POC to NMFS in accordance with 50 CFR 216.104(a)(12) for development of the Liberty Oil Field. The POC documents Hilcorp's stakeholder engagement activities with subsistence communities within the North Slope Region including Nuiqsut, Barrow and Kaktovik; the closest communities to the proposed LDPI site. The POC includes a description of the project, how

access to the Project Area will occur, pipeline and island construction techniques, and drilling operations. The plan also describes measures implemented by Hilcorp to minimize adverse effects on marine mammal subsistence species and all activities related to subsistence hunting. The POC is a living document and will be updated throughout the LDPI review and permitting process. As such, Hilcorp intends to maintain open communication with all stakeholders throughout the Liberty permitting and development process.

In addition to the POC, Hilcorp has signed a CAA in coordination with the AEWC and North Slope communities' Whaling Captains' Associations, which outlines activities that will minimize disturbances to marine mammals with respect to subsistence hunting. One element of the agreement states that impact hammering will not occur during the period for Nuiqsut/Cross Island bowhead whale subsistence hunting which usually occurs from the last week in August thru mid-September to ensure disturbance to marine mammals and subsistence hunts is avoided to all practical extent. Further, any non-essential boat, hovercraft, barge, or air traffic will be scheduled to avoid approaching the harvest area around Cross Island during this period. This will avoid potential conflicts with the timing of the Cross Island bowhead hunt as described in the CAA.

Between 1994 and 2003, generally three to four whales were harvested per year in Kaktovik and a similar number were taken in Nuiqsuit, (Bacon, *et al.* 2009, Clarke, *et al.* 2013). Since that time, the same number of whales have typically been harvested each year (BPXA 2009). In all whaling seasons documented since 2001, avoidance of the proposed Action Area by Cross Island whalers probably would have had a negligible adverse effect on the success of those hunts (BOEM 2017). The proposed Action Area was only part of the whale search area during 2005 and 2006, and no whales were struck or landed. Whales were seen and heard in or near the proposed Action Area during those two seasons but could not be approached close enough to make a strike. Therefore, while hunters may pass through the bay in transit, and have observed whales in the area on occasion, Foggy Island Bay has not been reported as a traditional whaling location in recent years.

Beluga whales are taken opportunistically during the bowhead harvest and throughout ice-free months. Generally, no operations are suspended for beluga hunts in this area as they are sporadic and incidental to other subsistence related activities such as fishing. This is different than the beluga whale harvest in the Chukchi where beluga whale occurrence is predictable due to foraging at river mouths on fish moving into area.

Nuiqsut and Kaktovik residents hunt seals in ice-free months primarily July-August in rivers outside of Foggy Island Bay. The most important seal hunting area for Nuiqsut hunters is off the Colville Delta (BOEM 2017) extending as far west as Fish Creek and as far east as Pingok Island (149º40'W). Pingok Island, the closest edge of the main sealing area, is east of Foggy Island Bay. Sealing occurs in this area by snow machine before break-up and by boat during the summer. Cross Island is a productive area for seals, but is too far from Nuiqsut to be used on a regular basis. During the whaling season, the hunters at Cross Island concentrate on bowhead whales, not seals.

In summary, the LDPI Action Area is recognized as an area that is sometimes used for subsistence activities by residents of Nuiqsut, but rarely Kaktovik and Barrow. Hilcorp understands the importance of subsistence to these communities. Hilcorp follows the established CAA to mitigate noise and traffic impacts of offshore oil and gas production related activities on subsistence whaling. Hilcorp will

continue to meet with the communities of Nuiqsut, Kaktovik, and Barrow to discuss the LDPI Project and ongoing North Slope operations.

In coordination with AEWC, Hilcorp currently adheres to the existing CAA for North Slope oil and gas activities to minimize potential interference with bowhead subsistence hunting. Hilcorp will continue to attend and participate in the CAA meetings. The CAA describes the following measures to minimize any adverse effects on the availability of bowhead whales:

- Hilcorp will comply with the POC and CAA terms to address plans to meet with the affected community to resolve conflicts and notify the communities of any changes in the operation. More detailed information about the mitigation measures that will be implemented to reduce impacts to marine mammals are outlined in Section 11 of the ITR petition;
- Vessels will be operated in a manner to avoid areas and times where hunting is occurring;
- Communications and conflict resolution are detailed in the CAA. Since 2017, Hilcorp has hosted the Communications Center at Endicott. For the Liberty Project, Hilcorp plans to continue to support and participate in the Communications Center that is operated annually during the bowhead subsistence hunt;
- Communications with the village of Nuiqsut is of particular importance as their traditional subsistence hunting areas are closest to the Project. Hilcorp will meet with the community to discuss community questions or concerns including all subsistence hunting activities; and
- Hilcorp and contractors will follow a Polar Bear and Pacific Walrus Awareness and Interaction Plan addressing food and waste management, personnel training, and safety and communication regarding polar bears.

2.2. Monitoring Methods

2.2.1. Land Based Monitoring

To monitor the Level A shutdown zones described in Section 2.1.6.2 , two dedicated PSOs (and an alternate) will be located on the LPDI during construction activities that may occur during open water conditions (approximately July 1 – July 15) of Year 2. If these activities extend beyond the 15-day period or into Year 3, monitoring of the Level A zones during open water would continue as necessary.

PSOs will be located at vantage points to monitor from the island out to 6,365 ft (1.94 km) when conditions allow. Elevated platforms will be used to maximize the potential for viewing marine mammals in the Level A zone. Assuming the average height of an observer is 5 ft 5 inches (1.8 meters), height of the island is 15 ft (4.6 m), and reticle binoculars (5 mils) are used, platforms ~16.5 ft (5 m) high would allow viewing out to a distance of 1.42 mi (2.28 km). This would be sufficient to see any marine mammals approaching the Level A zone. For additional information on PSO equipment see Section 2.2.5.

To provide 360 degree coverage around the island, one PSO will be placed on the side where construction activities are taking place and the other placed on the opposite side. The elevated PSO stations will be moved around the island as needed during construction activities to provide full coverage. PSOs will be switched out such that they will observe for no more than 4 hours at a time and no more than 12 hours in a 24-hour period (see Section 2.3.1).

Distances to nearby marine mammals will be estimated with binoculars containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon. Observers may use a laser rangefinder to test and improve their abilities for visually estimating distances to objects in the water. However, previous experience has shown that a civilian grade laser rangefinder was not able to measure distances to seals more than about 230 ft (70 m) away. The device was very useful in improving the distance estimation abilities of the observers at distances up to about 1,968 ft (600 km)—the maximum range at which the device could measure distances to highly reflective objects such as other vessels. Humans observing objects of more-or-less known size via a standard observation protocol, in this case from a standard height above water, quickly become able to estimate distances within about ±20% when given immediate feedback about actual distances during training.

The PSOs will monitor the Level A shutdown zones during all pile and pipe driving activities and for 30 minutes before and after work has stopped. If necessary, PSOs will initiate shutdown procedures as described in Section 2.1.6.2.

In addition to the PSO monitoring the Level A shutdown zones, a third island-based PSO will work closely with an aviation specialist to monitor the Level B zones described in Section 2.1.6.3 using UAS. UAS monitoring of the Level B zones will take place during vibratory and impact pile driving (~July 1-15), and during slope shaping, which could occur intermittently until August 31st of Year 2. This PSO will rotate with an alternate to allow for sufficient breaks. Details regarding monitoring using the UAS are provided in Section 2.2.2. UAS monitoring will not be used after Year 2 unless pile driving or slope shaping activities are extended.

During Years 3 – 4 when drilling activities are occurring, a PSO (and an alternate) will be stationed on the island for approximately 4 weeks during the month of August to monitor for the presence of marine mammals around the island. The Level B zone is expected to be only about 180 ft (55 me) around the island during this time. The PSO would scan waters around the island using equipment described in Section 2.2.5 and following protocols described in Section 2.3.1. ASAMM surveys are typically scheduled for August; therefore, data collected by this PSO could be compared to sighting data collected during ASAMM surveys.

Based on the results of PSO monitoring and underwater acoustic data (see Section 3) and in consultation with NMFS, Hilcorp would determine whether a PSO is needed during Year 5 to monitor for presence and behavior of marine mammals that may occur within the island vicinity. If, for example, exposure of marine mammals to noise levels that exceed regulatory thresholds is not anticipated, either based on the lack of mammals in the area or because the results of acoustic monitoring indicate the propagation of underwater sound (that exceeds thresholds) during production is exceedingly small, a PSO monitoring during Year 5 may not be needed.

In summary, Hilcorp will monitor a Level A zone shutdown zone during open water construction activities for a 15 day period in July of Year 2. Monitoring will be accomplished using two island-based PSOs. If a bowhead whale or other low frequency cetacean enters the Level A zone, pile or pipe driving would be shut down. If a beluga whale or pinniped enters the Level A zone, work would continue until the pile is completed (estimated to require only ~15-20 minutes), but additional pile driving would not be imitated until the animal has left the Level A zone. During this time, PSOs will monitor the animal and record behavior. If after 20 minutes the animal is still within the Level A zone and the pile has not been

completely set, shut down procedures will be initiated and no new pile driving will begin until the marine mammal has left the Level A zone.

A third land-based PSO will work closely with the UAS pilot(s) using real-time video to monitor the larger Level B take zones and to document any approach of animals to the Level A shutdown zone throughout the same 15-day open-water period of Year 2. During slope shaping activities that may be necessary between July 15 and August 31st, the PSO and UAS will monitor the Level B zone during that activity, and will record any marine mammals that occur within that zone as a Level B take. UAS will not be used beyond Year 2 unless for open water pile driving and slope shaping is extended into Year 3.

During Years 3-4, a land-based PSO (and an alternate) will monitor for the presence of marine mammals around the island for approximately 4 weeks during the month of August. Based on the results of that monitoring Hilcorp, along with NMFS, will determine if monitoring needs to occur during Year 5.

2.2.2. Monitoring Using Unmanned Aircraft System (UAS)

During pile- or pipe-driving or slope shaping construction activities that could occur in open water conditions in Year 2, a third PSO will work closely with the UAS pilot to monitor Level B harassment zones to both record any takes by harassment, and to monitor and observe he behavior of any animals that may be approaching in the Level A shutdown zone. A second UAS pilot will be available to allow for sufficient breaks during monitoring. Pile and pipe-driving activities are likely to only occur during the first two weeks of July (July 1 – 15) and would be the dominant noise source at this time. Between July 15 and August 31st, slope shaping may occur (if needed). If slope shaping is needed after July 15, the PSO will continue to monitor the Level B zone to record any takes by harassment. UAS will not be used after Year 2, unless these activities extend into Year 3.

Recent developments in the technical capacity and civilian use of UASs, defined as vehicles flying without a human pilot on board, have led to investigations into the potential use of these systems for monitoring and conducting aerial surveys of marine mammals (Koski, *et al.* 2009, Hodgson, *et al.* 2013, Duke 2015). UAS operating under autopilot mounted with global positioning systems (GPS) and imaging systems, have been used and evaluated in the Arctic (Koski, *et al*. 2009). These small aircraft have the potential to replace traditional manned aerial surveys and provide an additional method for monitoring marine mammal populations.

Hilcorp will use a fixed wing UAS, mounted with a live-stream, digital single lens reflex (SLR) camera for monitoring marine mammals. Examples of typical UAS that may be used for monitoring are the ScanEagle (Figure 2-1)) and the Puma (Figure 2-2). The ScanEagle has a zero-length catapult launch and snag line recovery system. It has a payload of ~3 kg, loaded weight of <50 lbs. and endurance of up to 24 hours, depending upon configuration and flight conditions. The Puma AE (AeroEnvironment) is a fully waterproof, small UAS designed for land and maritime operations. It is capable of landing in water or on land, providing operational flexibility. The enhanced precision navigation system with secondary GPS provides positional accuracy and reliability. A common ground control system allows the operator to control the aircraft manually or program it for GPS-based autonomous navigation.

FIGURE 2-1. PHOTO OF SCANEAGLE

FIGURE 2-2. PHOTO OF PUMA

The UAS will fly at an altitude of 500 ft (152 m) (or other altitude determined appropriate based on the platform) and a transect width to be determined through discussions with NMFS. UAS will be used to monitor the entire Level B zone.

Hodgson *et al.* (2013) conducted marine mammal surveys using a ScanEagle UAS flown at 500 ft. The survey consisted of 10 transects spaced at 235 ft (72 m) intervals (the width of view of the water surface within the images). The width of view at each altitude was the effective transect strip width. The image capture rate was set to achieve 10 percent overlap in images. The overlap in images was useful in detecting animals masked by reflection on the sea surface or animals at awkward body angles. A similar approach is suggested for Liberty but specific details can be determined based on the specifications of the UAS to be used and through discussions with NMFS.

Transects over the Action Area would likely be divided into sections that are 30 minutes of longitude across, as done by ASAMM. End points for the survey transects may be selected at random but would

specifically cover the Action Area and allow for a continuous flight path within the survey area. If small boats are observed, the UAS pilot will truncate the transect to avoid interference with subsistence activities. The UAS will not be used to circle marine mammals. If it is too windy, or other weather condition prevent use of a UAS, activities would be adjusted accordingly and a backup plan of using a PSO based on land or, if necessary on a vessel, would be implemented. During the fall subsistence hunt of bowhead whales, a minimum altitude will be used near Cross Island. If that altitude cannot be maintained, transects will be truncated to avoid a specific radius around each whaling area (following similar ASAMM protocol for aerial surveys). Sightings recorded by video will be considered "off effort" following ASAMM protocol for recorded data (i.e., processed at a later point in time by a trained PSO).

To maintain consistency of data acquisition with previous years, PSOs responsible for processing recorded video will be trained according to NMFS protocols. UAS surveys are tentatively planned during periods when ASAMM would not be conducting surveys in order to maximize data collection on marine mammal presence in the area. Additional details on survey schedule and duration (i.e., number of days per survey), survey speed, altitude, and other methods will be further refined in consultation with NMFS.

These monitoring measures should result in an effective program that will supplement data collected by PSOs on marine mammal presence and behavior. These data will also be effective in minimizing takes by expanding the area being monitored beyond that which could be done visually by PSOs.

If necessary, Hilcorp will seek a waiver from the Federal Aviation Administration (FAA) to operate the UAS above 400 ft (122 m) and beyond the line of sight of the pilot. Ground control for the UAS will be located on the LPDI, SDI, or other shore-based facility close to Liberty.

The UAS will not be used to circle marine mammals. If it is too windy, or other weather condition prevent use of a UAS, activities would be adjusted accordingly and a backup plan of using a PSO based on land or, if necessary on a vessel, would be implemented.

2.2.3. Vessel-Based Observations as Needed

If needed as a back-up to or instead of using the UAS system, a vessel-based PSO could be positioned at the edge of the Level A zone. An observer onboard a vessel at this location would be able to monitor marine mammals out to a distance of 0.9 miles (1.5 km) and record any exposures in the Level B zone out to that distance, and not any animals that may be approaching the Level A zone.

This is considered a less desirable option than using the UAS due to increased underwater noise from the vessel and safety concerns for the observer.

2.2.4. Monitoring At Night and During Poor Visibility Conditions

Hilcorp plans to conduct 24-hr operations. Darkness will not be an issue throughout most or all of the open water season as there will be no periods of darkness in the Action Area until after August. Current scheduling should prevent this condition from occurring. Therefore, PSOs and the UAS will not be on duty during darkness. However, if poor environmental conditions during the open water period restrict the use of the UAS or the PSOs' ability to see within the marine mammal Level A shutdown zone (e.g. excessive wind or fog, high Beaufort state), sheet pile and pile installation will cease unless the operation began prior to poor visibility, with the assumption that no marine mammals would enter the area once the noise was active. UAS systems have been used during poor visibility and windy conditions using, for

example, infra-red imaging with minimal impact in the ability to detect marine mammals (Hodgson, Kelly and Peel 2013). However, Hilcorp will consider this only if poor weather conditions persist and require consideration of monitoring other than with a PSO.

2.2.5. Field Equipment

Hilcorp will provide or arrange for the following specialized field equipment for use by the land-based PSOs: reticle binoculars, GPS unit, laptop computer(s), digital still and possibly digital video cameras.

2.3. Protected Species Observers

2.3.1. PSO Protocols - Roles and Responsibilities

Hilcorp intends to work with PSOs who have had previous experience. All PSOs shall be trained and approved by NMFS. Island-based PSO(s) will be dedicated to the observation task and will not have any other construction-related duties.

PSOs will be on duty in shifts of a maximum of 4 hours at a time, a maximum of 12 hours watch time per day per PSO; although the exact shift schedule will be established prior to Project initiation.

Two PSOs will scan the area around the island systematically with reticle binoculars and with the naked eye while the third PSO will work with the UAS pilot(s) to monitor the video footage from the UAS in real time. Each PSO will have an alternate and a second UAS pilot will be available to relieve those monitoring. This ensures sufficient breaks are provided for PSOs and the UAS pilot. Because the main purpose of the PSOs on the island is detecting marine mammals for the implementation of mitigation measures according to specific guidelines, information to be recorded will be as concise as possible (see Section 2.5). This will allow the observers to focus on detecting marine mammals.

2.3.2. PSO Qualifications and Training

Observers will complete a training and refresher session on marine mammal monitoring, to be conducted shortly before the anticipated start of the open-water season construction activities.

Primary objectives of the training include:

- Review of the marine mammal monitoring plan for this project, including any amendments specified by NMFS, BOEM, or by other agreements in which Hilcorp may elect to participate;
- Review of marine mammal sighting, identification, and distance estimation methods;
- Review of operation of specialized equipment (UAS, reticle binoculars and GPS system);
- Review of, and classroom practice with, data recording and data entry systems, including procedures for recording data on marine mammal sightings, monitoring operations, environmental conditions, and entry error control. These procedures will be implemented through use of a customized computer database and laptop computers;

2.3.3. PSO Handbook

A PSO's Handbook will be prepared for Hilcorp's LPDI land- and UAS-based monitoring program. Handbooks contain maps, illustrations, and photographs, as well as text, and are intended to provide

guidance and reference information to trained individuals who will participate as PSOs. The PSO Handbook for the Hilcorp Liberty project will include:

- Summary overview descriptions of the project, marine mammals and underwater noise, the marine mammal monitoring program (roles and responsibilities), the LOA and other regulations, permits or agencies, and relevant information from the MMPA;
- Monitoring and mitigation objectives and procedures, including safety radii;
- Responsibilities of staff regarding the marine mammal monitoring plan;
- Instructions for construction crew regarding the marine mammal monitoring plan;
- Data recording procedures;
- List of species that might be encountered (identification and natural history);
- Reticle binocular distance scale;
- Table of wind speed, Beaufort wind force, and sea state codes;
- Data quality-assurance/quality-control, delivery, storage, and backup procedures;
- Safety precautions; and
- Scheduling of watches.

2.4. Communication Procedures

If marine mammals are detected within the designated Level A shutdown zones, monitoring and shutdown procedures will be implemented as described in Section 2.1.6.2. To assure prompt implementation of these procedures and timing, multiple channels of communication between the PSOs and the construction supervisor will be established. During the shutdown, the PSO(s) will continue to maintain watch to determine when the animal(s) are outside the shutdown zones. Sheet pile and pipe driving can be resumed if the observers have visually confirmed that the animal(s) moved outside the safety zone, or if the animal(s) were not observed within the shutdown for 30 minutes (See Section 2.1.6.2). Direct communication with the construction supervisor will be maintained throughout these procedures.

2.5. Field Data Recording, Verification, Handling, and Security

The following information will be collected:

- Environmental conditions – consisting of sea state (in Beaufort Scale according to NOAA), visibility (in km, with 10 km indicating the horizon on a clear day), and sun glare (position and severity). These will be recorded at the start of each shift, whenever there is an obvious change in one or more of the environmental variables, and whenever the observer changes shifts.
- Project activity – number of sheet piles or conductor pipes driven, duration of slope shaping, etc.
- Sighting information – consisting of the species (if determinable), group size, position and heading, behavior, movement, and distance relative to the island (initial and closest approach). These will be recorded upon sighting a marine mammal or group of animals.

The observers will record their real-time observations directly into computers. Paper datasheets will be available as backup if necessary. The accuracy of the data entry will be verified in the field by

computerized validity checks as the data are entered, and by subsequent manual checking of the database printouts. These procedures will allow initial summaries of data to be prepared during and shortly after the field season, and will facilitate transfer of the data to statistical, graphical or other programs for further processing. Quality control of the data will be facilitated by the start-of-season training session, and ongoing data checks during the field season.

In addition to routine PSO duties, observers will have available Traditional Knowledge and Natural History datasheets and voice recorders to document observations that are not captured by the sighting or effort data. Copies of these records will be available to observers for reference if they wish to prepare a statement about their observations. If prepared, this statement would be included in the 90-day and final reports documenting the monitoring work.

2.6. Reporting

2.6.1. Data Collection and Field Reports

Throughout the survey program, observers will prepare a report each day or at such other intervals as required, summarizing the recent results of the monitoring program. The reports will summarize the species and numbers of marine mammals sighted. These reports will be provided to NMFS and to the survey operators. An example observation sheet is provided as Figure 2-3.

Among the pieces of information recorded, the PSOs will record detailed information about any implementation of shutdowns, including the distance of animals to the construction activity, description of specific actions that ensued and resulting behavior of the animal, if any. Num,bers of animals observed in the Level B zones will be recorded along with their behaviors while in the zone. At a minimum, the following information will be collected on the observer forms:

- Date and time that monitored activity begins or ends;
- Construction activities occurring during each observation period;
- Weather parameters (e.g., percent cover, visibility);
- Water conditions (e.g., sea state, tide state);
- Species, numbers, and, if possible, sex and age class of marine mammals;
- Description of any marine mammal behavior patterns, including bearing and direction of travel and distance from construction activity;
- Distance from construction activities to marine mammals and distance from the marine mammals to the observation point;
- Description of implementation of mitigation measures (e.g., shutdown or delay);
- Locations of all marine mammal observations; and
- Other human activity in the area.

2.6.2. 90-Day and Annual Monitoring Reports

The results of the Liberty marine mammal monitoring program including estimates of “take by harassment”, will be presented in 90-day and final technical reports. Reporting will address the requirements established by NMFS.

The technical report(s) will include:

- Summaries of monitoring effort: total hours, total distances, and distribution of marine mammals through the study period accounting for sea state and other factors affecting visibility and detectability of marine mammals;
- Summaries of sound-producing activity start and end dates and duration, type of equipment, and sound source verification of sound producing activities;
- Analyses of the effects of various factors influencing detectability of marine mammals including sea state, number of observers, and fog/glare;
- Species composition, occurrence, and distribution of marine mammal sightings including date, water depth, numbers, age/size/gender categories(for example, coloration in beluga whales may indicate a difference between adult whales and subadults or calves), group sizes, and ice cover;
- Analyses of the effects of construction operations;
- Sighting rates of marine mammals during periods with and without construction activities (and other variables that could affect detectability);
- Initial sighting distances versus construction activity (impulse or vibratory driving or slope shaping);
- Observed behaviors and types of movements versus construction activity;
- Numbers of sightings/individuals seen construction activity;
- Complete descriptions of any work shutdowns, total number of animals exposed to noise levels that may exceed take thresholds;
- Distribution around the island versus construction activity;
- Estimates of "take by harassment."
- If applicable a summary of any injured or dead marine mammals discovered.

Results and a complete description of methods used to survey for ringed seals will be submitted as part of the annual report. The annual monitoring report will summarize the type of activities conducted and completed, all findings and observations and compare those findings to other similar reports (i.e., from Northstar and other Beaufort Sea offshore and nearshore developments). This information will add to the overall data and knowledge of marine mammals in the Action Area and to a larger extent marine mammal use of coastal waters inside the barrier islands.

In the unanticipated event that the specified activity at LDPI clearly causes the take of a marine mammal in a manner prohibited by the LOA, such as an unforeseen injury or mortality to a pinniped, the observer will report the incident to Hilcorp, who will report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS and NMFS Alaska Region Office. This communication will occur as soon as practicable. In the event of a ship strike, operations would not cease, but the PSO would report the incident to NMFS and Hilcorp, and Hilcorp would work with NMFS to determine appropriate follow on actions. A report documenting the incident will include:

- Time, date, and location (latitude/longitude) of the incident;
- Description of event;
- Name and type of vessel involved (if applicable);
- Vessel's speed during and leading up to the incident (if applicable);
- Description of the incident;
- Status of all sound source use in the 24 hours preceding the incident;
- Water depth;
- Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
- Description of all marine mammal observations in the 24 hours preceding the incident;
- Species identification or description of the animal(s) involved;
- Fate of the animal(s); and
- Photographs or video footage of the animal(s) (if equipment is available).

In the event that an observer discovers an injured or dead marine mammal, the cause of the injury or death is unknown, and the death is relatively recent (i.e., in less than a moderate state of decomposition), Hilcorp will report the incident to the NMFS Chief of the Permits and Conservation Division, Office of Protected Resources in Silver Spring, Maryland and the Alaska Stranding Coordinator in Juneau, Alaska, as soon as practicably possible. The report will include the same information identified in the paragraph above. Activities would be allowed to continue while NMFS reviews the circumstances of the incident. NMFS will work with Hilcorp to determine whether modifications in the activities are appropriate.

Under such circumstances that the injury or death is not associated with or related to the activities authorized in the LOA (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), Hilcorp will report the incident to the NMFS Chief of the Permits and Conservation Division, Office of Protected Resources or by email to the Alaska Stranding Coordinator within 48 hours of the discovery. Hilcorp will provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network.

FIGURE 2-3. EXAMPLE MARINE MAMMAL OBSERVATION SHEET

Example Marine Mammal Observation Sheet:

Marine Mammal Observations
Project Name:_____

Date: _____ Sheet _____ of _____ for this day
Monitor: _____ Monitoring Location: _____

Sighting #	Time of Day	Weather	Species	# of Individuals	Location*	Behavior/Construction Activity

*E.g., Direction, Distance Estimate or Mark on Figure with Sighting Number

3. ACOUSTIC MONITORING PLAN

3.1. Objectives and General Methods

Passive Acoustic Monitoring will be undertaken using autonomous sound recorders deployed to the seabed at the start of the open water season in Years 2-5[3] (approximately in July, dependent on ice conditions) and will record sounds continuously through to the end of each open water season (approximately through October, dependent on ice conditions). Recorders will be positioned to simultaneously record sound levels at multiple ranges from the project activities. Data recorded during times with no project activities, if such times exist, will be analyzed for ambient sound level statistics. JASCO's PamLab software will be used for automated calculation of sound level statistics and distances to marine mammal impact thresholds will be determined through a regression of the sound level versus range data. The detailed Acoustic Monitoring Plan is included as Appendix D of the ITR petition.

Open water season construction, drilling and production activities are expected to occur according to the following tentative timeline:

- Year 2: slope shaping, armament installation, sheet pile installation, equipment mobilization
- Year 3-5: equipment mobilization, drilling and production.

The recorder arrangement will be configured each year based on the anticipated activities for that season and the modelled sound propagation estimates for the relevant sources. The recorders will provide data on ambient noise conditions and characterize or verify the long-range propagation of sounds emanating from the LDPI during construction activities at an offshore location.

3.2. Analysis of Results and Reporting

Acoustic recordings will be processed at the end of each season using JASCO`s customized PAMLab software to compute sound level statistics from the recorded data. Within 90 days of each season, Hilcorp will provide a summary report describing results of the monitoring as described in more detail in the Acoustic Monitoring Plan (Appendix D).

[3] Year 1 accounts for the first winter of construction, and only includes December.

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APPENDIX D

LDPI Project

Acoustic Monitoring Plan

April 2018

Acoustic Monitoring Plan

Hilcorp Alaska Liberty Development Project

Submitted to:
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Version 1.0

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1. Introduction

This Acoustic Monitoring Plan (AMP) has been developed for Hilcorp Alaska, LLC (Hilcorp) by Jasco Applied Sciences (JASCO). It describes the equipment and methods that will be used to measure and quantify the underwater sound levels from noise sources associated with the Liberty Development Project.

Hilcorp proposes to conduct underwater passive acoustic monitoring in the open water season in Years 2-5 of the Liberty Development Project in the Beaufort Sea (Foggy Island Bay, Alaska). (Year 1 accounts for the first winter of construction and only includes December; Year 2 is the first full year of construction and first open water season.) Acoustic monitoring will be conducted for the purposes of sound source verification, to verify distances from noise sources at which underwater sound levels reach thresholds for potential marine mammal harassment.

In August 2016, after substantial public and expert input into three draft versions, the National Marine Fisheries Service (NMFS) finalized and promulgated technical guidance for assessing the effect of anthropogenic sound on marine mammal hearing (NMFS 2016). The guidance describes injury criteria (for Level A Harassment) with new thresholds and frequency weighting functions for the five hearing groups described by Finneran and Jenkins (2012). Table 1 provides the recommended thresholds for the species that could occur in the area of interest.

NMFS currently uses SPL thresholds for behavioral response (Level B Harassment) of 160 dB re 1 µPa for impulsive sounds and 120 dB re 1 µPa for non-impulsive sounds for all marine mammal species (NMFS 2016), based on observations of mysticetes (Malme et al. 1983, Malme et al. 1984, Richardson et al. 1986, Richardson et al. 1990). As of 2018, NMFS applies these disturbance thresholds as a default, but makes exceptions on a species-specific and sub-population specific basis where warranted.

Table 1 Marine mammal injury (PTS onset) thresholds peak sound level (PK) and frequency-weighted sound exposure level accumulated over 24 hours of exposure (Weighted SEL 24 h) based on NMFS (2016).

Hearing Group	Impulsive Source		Non-Impulsive Source
	PK	Weighted SEL (24 h)	Weighted SEL (24 h)
Low-frequency cetaceans	219	183	199
Mid-frequency cetaceans	230	185	198
Phocid pinnipeds in water	218	185	201

The following noise sources, if they are present in the open water season, will be characterized through the AMP:

- Equipment for slope shaping and armament installation
- Vibratory hammer for sheet pile driving
- Impact hammer for sheet pile driving
- Impact hammer for conductor pipe installation
- Drilling and production

Hilcorp determined, through acoustic modeling (SLR, 2017), distances from these sources to the NMFS thresholds for Level A and Level B marine mammal harassment described in Tables 2-1 and 2-2 of the Marine Mammal Monitoring and Mitigation Plan (4MP). The acoustic monitoring recorder locations proposed in this plan are based on those modeled distances.

2. Methods

2.1. Approach

JASCO will perform Passive Acoustic Monitoring using autonomous sound recorders that will be deployed to the seabed at the start of the open water season in Years 2-5 (approximately in July, dependent on ice conditions) and will record sounds continuously through to the end of each open water season (approximately through October, dependent on ice conditions). (Year 1 accounts for the first winter of construction, and only includes December). Recorders will be positioned to simultaneously record sound levels at multiple ranges from the project activities. Data recorded during times with no project activities, if such times exist, will be analyzed for ambient sound level statistics. JASCO's PamLab software will be used for automated calculation of sound level statistics and distances to marine mammal impact thresholds will be determined through a regression of the sound level versus range data.

Open water season construction, drilling and production activities are expected to occur according to the following tentative and approximate timeline:

- Year 2: slope shaping, armament installation, sheet pile installation, equipment mobilization
- Year 3-5: equipment mobilization, drilling and production.

The recorder arrangement will be configured each year based on the anticipated activities for that season and the modelled sound propagation estimates for the relevant sources (**Figure 1**). Details on the recorder arrangements for each type of measurement are given in the subsections that follow.

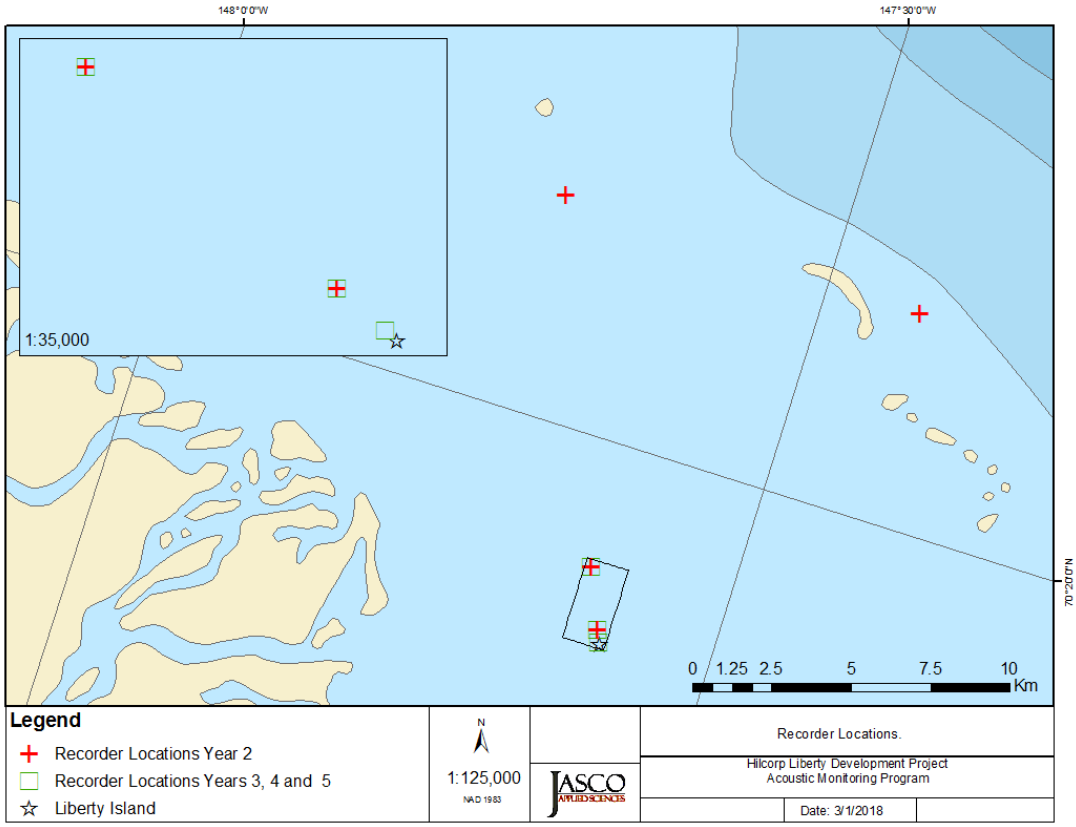

Figure 1: Map of proposed underwater acoustic recorder locations

2.1.1. Slope Shaping, Armament Installation and Sheet Pile Installation:

Construction in the open water season of Year 2 could consist of slope shaping, armament installation and/or sheet pile installation using vibratory and/or impact hammers. Sound levels from these activities will be collected by placing three autonomous recorders along a line, at increasing ranges from the noise sources. The proposed recorder arrangement is shown in Figure 2, with AMARS at 0.5, 2, and 15 km range from the middle of the north-western edge of the island (**Figure 1**), to verify the distances to the corresponding impact thresholds in Tables 2-1 and 2-2 of the 4MP. Recorders will be positioned along a radial oriented in the direction of maximum sound propagation based on the acoustic modelling (SLR, 2017), nominally toward Dinkum Sands. An additional recorder will be deployed at 15 km range to the north east of the island, outside of the barrier islands.

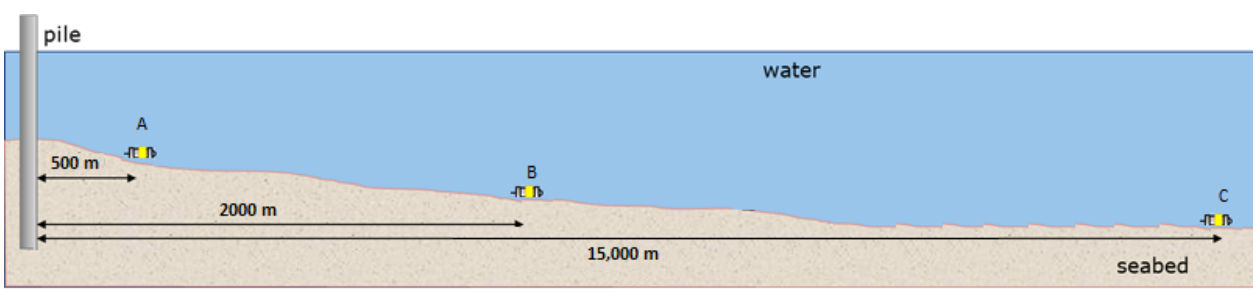

Figure 2: Side-view of an example layout for sound source characterization of slope shaping, armament installation and sheet pile installation.

2.1.2. Drilling and Production Measurements:

Years 3-5 are expected to consist of drilling and production at the Liberty Island. Sounds from drilling and production will be monitored and analyzed similarly to the slope shaping, armament installation, and sheet pile installation sound levels, though the recorder spacing will be adjusted based on the acoustic model results. For drilling and production sound level monitoring, we propose to position the recorders at 100, 500, and 2000 m from the middle of the north-western edge of the island (**Figure 1**). An additional recorder will be deployed at 15 km range to the north east of the island, outside of the barrier islands.

2.2. Equipment

JASCO will make acoustic measurements using its specialized Autonomous Multichannel Acoustic Recorder (AMAR) systems (Figure 3). These systems will be deployed on the seabed and will record continuously at 256 kHz sample rate and 24-bit samples. The AMARS will be equipped with a hydrophone with nominal sensitivity of -165 dB re 1V/μPa. For measuring impact pile driving, a less-sensitive hydrophone with sensitivity of -200 dB re 1V/μPa will be added to the close-range recorder to avoid overloading the recorder sensitivity. The AMAR frames will sit directly on the seabed and will be attached to a ground line with a small weight at its end (**Figure 3**, right). The hydrophones will sit approximately 50 cm above the seafloor. JASCO has successfully used this simple mooring design to record sounds at the Liberty location, and surrounding areas, since 2006.

Figure 3: Left: Autonomous Multichannel Acoustic Recorder (AMAR; JASCO Applied Sciences). Right: Standard AMAR being deployed in the Chukchi Sea.

2.3. Analysis

Acoustic recordings will be processed at the end of each season using JASCO`s customized PAMLab software to compute sound level statistics from the recorded data. The software is often applied to compute ambient sound level statistics but the processed results from selected time periods can also be used to provide a statistical assessment of the sound levels during slope shaping, armament installation, sheet pile driving, drilling and production. For such analyses, JASCO will require that Hilcorp provide activity logs, with time-stamped records of when specific activities take place.

PAMLab will be used to generate three graphical presentations: band level plots, spectrograms, and spectral density percentiles (Figure 4). The broadband and decade band level plots (Figure 4) show the sound pressure levels (SPL) versus time. This plot helps us to understand the temporal variations of the recorded sounds during each activity. The spectrogram plot (Figure 4) shows the spectral density levels as function of time (horizontal axis), and frequency (vertical axis). The spectral density level is the sound pressure level in 1 Hz wide bands, averaged each minute with 50% overlap. For this plot the data are compressed by picking the maximum value in time and frequency for each display pixel so that the entire

deployment period is visible in one figure. These plots provide information on how the sound energy is distributed in time and frequency. These results are useful to help understand the sources of noise and their respective importance for audibility to different species – because hearing sensitivity varies with frequency for each species. From these plots we can also identify times during which the recorded sound levels might be influenced by external sources such as passing vessels.

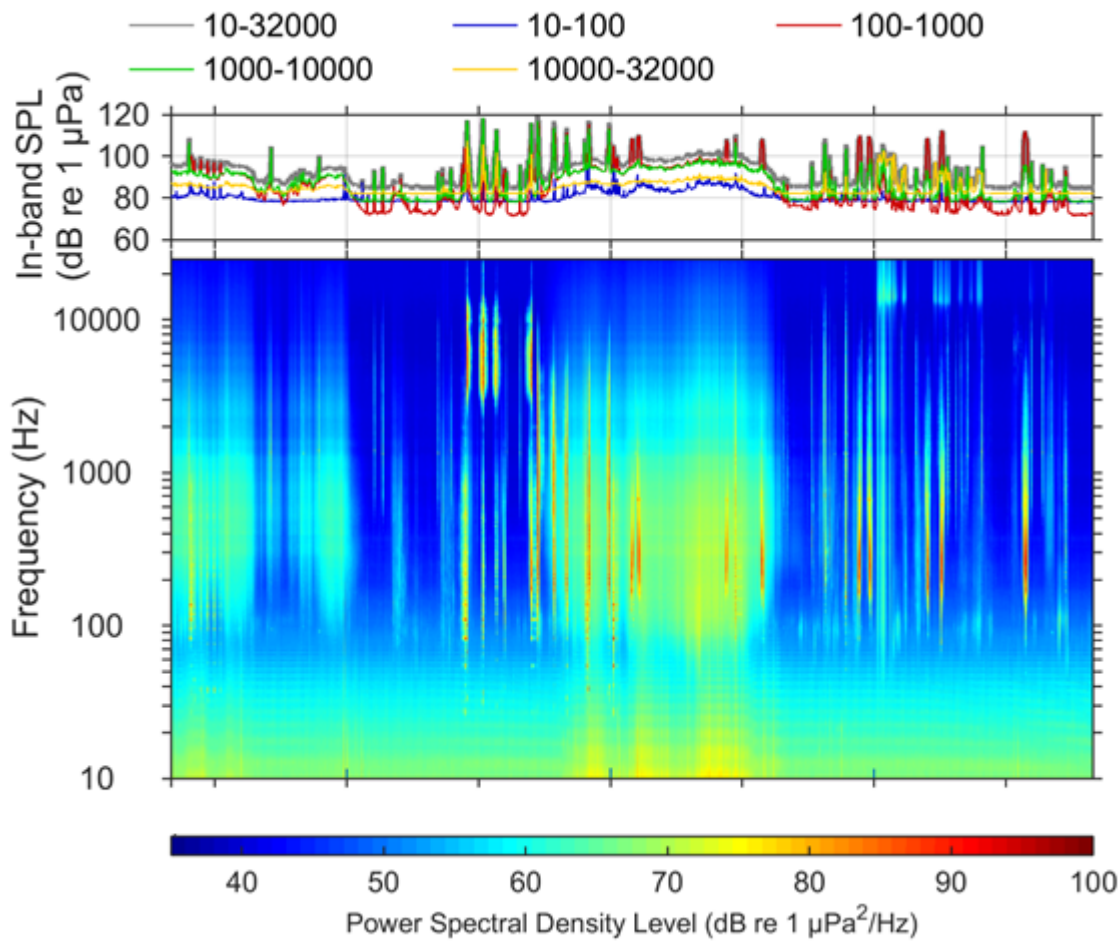

Figure 4 (Top) Band level plots showing the total SPL in each band as a function of time. (Bottom) Typical spectrogram plot showing measured sound levels as a colour, with time on the horizontal axis and frequency on the vertical axis.

The distribution of noise levels is shown via percentile spectral levels plots (Figure 5). The raw data for these plots are the 1-min averaged spectral density data used for the spectrograms and band-level plots above. For each 1 Hz wide frequency bin we compute a histogram of the spectral density values, then plot the 5th, 25th, 50th, 75th, and 95th percentiles. The 50th percentile (L_{50}) is equal to the median of the spectral distribution. The 95th percentile (L_{95}) is the level exceeded by 95% of the data. In other words, 95% of the time, the spectra level was above the 95th percentile, and 5% of the time, it was below. The 95th percentile represents the quietest noise state that can be expected to occur during the activity. The 5th percentile (L_5) typically represents the noise level associated with occasional loud events and may be caused by things like passing vessels. The percentile plots are especially useful for comparing to the Wenz curves, which represent the contributions of various sources to ambient noise in the ocean see National Research Council 2003). The limits of prevailing noise from the Wenz curves (L_{wenz})are overlaid on the quartile plots as dashed lines for ease of comparison.

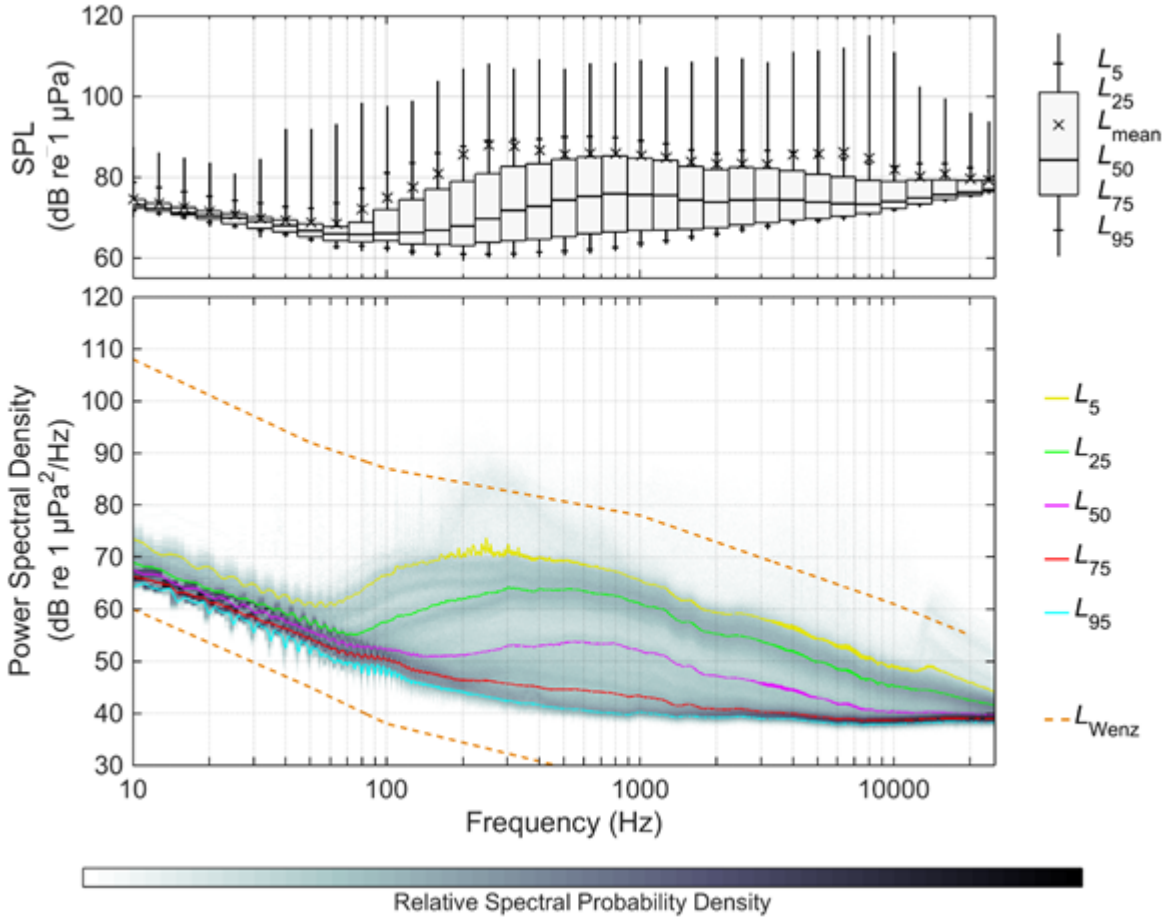

Figure 5 Example plot of statistical distributions of 1/3-octave band SPL and power spectral density. (Top) 1/3-octave band SPL (1-min). The box edges indicate the first (25%), second (50%), and third (75%) quartiles. The 'x' indicates the linear mean. (Bottom) Exceedance percentiles of ambient noise power spectral density levels (1-min average) over the recording period. The *N*th percentile corresponds to the sound level that was exceeded by *N*% of the data. The relative spectral probability density is shown in gray scale, and the limits of the prevailing noise from the Wenz curves are shown in the dashed orange lines (L_{Wenz}).

JASCO will also select clean acoustic recordings (i.e. samples that do not contain noise from passing vessels, for example) for each activity period and use regression methods to determine the distances to the sound level thresholds for marine mammal harassment, for each activity. For impact driving of sheet piles in particular, the peak sound level, SPL and SEL will be computed for individual pile driving events, and cumulatively for each 24-hour period. For Level B harassment, the one-minute SPL data from each receiver range will be fit to an empirical propagation loss curve (example in Figure 6). Statistics of the peak sound levels and the 24-hour cumulative SEL, frequency-weighted for the functional hearing groups of interest, will be computed and distances at which thresholds for Level A harassment may have been reached will be quantified by linear interpolation between the receiver ranges.

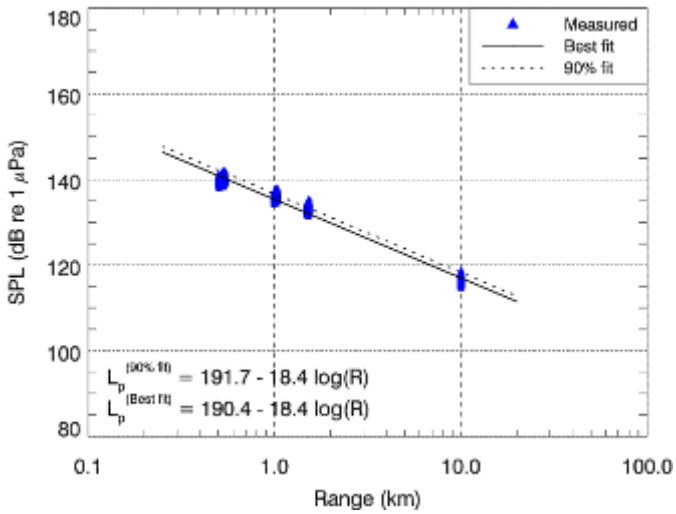

Figure 6 Example plot showing a regression of SPL measured at four different ranges.

3. Reporting

Within 90-days of the end of each season JASCO will prepare a summary report that will include:

- A description of the activities that took place during the acoustic monitoring
- Details about the acoustic monitoring equipment and deployment locations
- Distances from the acoustic monitoring equipment and the sound sources
- The analysis results described in Section 2.3
- A summary of the computed distances to the various marine mammal impact thresholds (Level A and Level B).
- A comparison of the observations made at Liberty to results from previous Northstar studies to add to the overall understanding of underwater sounds during construction activities.

4. Data Quality Plan

A GRAS 42AC pistonphone calibrator, which is NIST traceable, will be used to verify the sensitivity of the recording apparatus as a whole (i.e., the hydrophone, pre-amplifier, and AMAR) in JASCO's warehouse and again immediately prior to deployment and after retrieval in the field. During calibration, the pistonphone and its adapter are placed over the hydrophone and produce a known pressure signal on the hydrophone element (a 250 Hz sinusoid at 152.2 dB re 1 μPa) which verifies the pressure response of the recording system. The sensitivity of the system is measured independently of the software that performed the data analysis, which allows an independent check on the correct calibration of the analysis software as well. The calibrations performed prior to the field deployment will be verified for consistency with the warehouse measurements before we perform the data analysis. The post-retrieval calibration will allow us to ensure no loss of sensitivity occurs over the course of the deployment.

JASCO Applied Sciences will follow their Quality Assurance and Quality Control (QA/QC) Policies and Procedures for equipment mobilization, equipment field deployment, data analysis and reporting. The QA/QC Procedures include field checklists and standardized field logs to ensure adherence to the policies. All data analysis will undergo internal scientific review.

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