APPENDIX I – EFH ASSESSMENT

DRAFT
Essential Fish Habitat Assessment

Pebble Project

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ACRONYMS AND ABBREVIATIONS

ABBREVIATION	DEFINITION
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ADOT&PF	Alaska Department of Transportation & Public Facilities
APDES	Alaska Pollutant Discharge Elimination System
AWC	Anadromous Waters Catalog
BMP	Best management practices
BSAI	Bering Straits Aleutian Islands
CADoT	California Department of Transportation
C.F.R.	Code of Federal Regulations
CPUE	Catch per unit of effort
EBD	Environmental Baseline Document
EFH	Essential Fish Habitat
ESA	Endangered Species Act
FC	First Creek
FHWG	Fisheries Hydroacoustic Working Group
FMC	Fisheries Management Council
FMP	Fisheries Management Plan
FPL	Frying Pan Lake
GOA	Gulf of Alaska
HDD	Horizontal directional drill
IIE	Iniskin/Iliamna Estuary
KR	Koktuli River
MMPA	Marine Mammal Protection Act
MSFCMA or MSA	Magnuson-Stevens Fishery Conservation and Management Act
NFK	North Fork Koktuli River
NMFS	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
NPFMC	North Pacific Fishery Management Council
NOAA	National Oceanographic and Atmospheric Administration
OHWM	Ordinary high-water mark
PAG	Potentially Acid Generating
PHABSIM	Physical Habitat Simulation System
Project	Pebble Project
PLP	Pebble Limited Partnership
PTS	Permanent threshold shift
RHA	Rivers and Harbors Act
SFK	South Fork Koktuli River

ABBREVIATION	DEFINITION
sp.	Species
SPCC	Spill Prevention Countermeasures and Control Plan
SWPPP	Stormwater Pollution Prevention Plan
TSF	Tailings Storage Facility
TTS	Temporary threshold shift
U.S.	United States
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
UT	Upper Talarik Creek
WMP	Water Management Pond
WTP	Water Treatment Plant
Y	Year

UNITS OF MEASUREMENT

ABBREVIATION	DEFINITION
%	Percent
°C	Degrees Celsius
°F	Degrees Fahrenheit
ac	Acres
cfs	Cubic feet per second
cm	Centimeters
Cu	Copper
dB	Decibel
ft	Foot/feet
ha	Hectares
in	Inches
kg	Kilogram(s)
km	Kilometers
lb	Pound(s)
LD10	Lethal dose 10
LF	Linear foot / feet
m	Meter(s)
m^3	Cubic meters
m^3/sec	Cubic meters per second
mi	Miles
mm	Millimeters
sec	Second
sf	Square feet

ABBREVIATION	DEFINITION
SEL	Sound exposure level
SPL	Sound pressure level
μPa	Micropascals

1 PURPOSE/SCOPE

This document presents the findings of an Essential Fish Habitat (EFH) assessment of the proposed Pebble Limited Partnership (PLP) Pebble Project (Project) in Southwest Alaska and is intended to support EFH consultation under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA or MSA) of 1996. In December 2017, PLP submitted a Department of the Army (DA) permit application pursuant to Section 10 of the Rivers and Harbors Act (RHA) and Section 404 of the Clean Water Act (CWA) for the construction of a mine and ancillary facilities, a port facility, access roads, ferry terminals, and a natural gas pipeline. Other federal authorizations required by the Project are: Bureau of Safety and Environmental Enforcement (BSEE) authorization for the pipeline right-of-way (ROW) in Federal waters; and U.S. Coast Guard (USCG) authorization for bridges across Navigable Waters under Section 9 of the RHA.

Section 305(b)(2) of the MSA requires federal agencies to consult with the National Marine Fisheries Service (NMFS) on all actions or proposed actions authorized, funded, or undertaken by the agencies that may affect EFH for species regulated under a federal Fishery Management Plan (FMP). The Project is within areas designated as EFH for three FMPs: Salmon Fisheries in the Economic Exclusion Zone off the Coast of Alaska (Salmon FMP), Fishery Management Plan for Groundfish off the Gulf of Alaska (GOA) (Groundfish FMP), and the Fishery Management Plan for the Scallop Fishery off Alaska (Scallop FMP).

The EFH Guidelines are contained under 50 Code of Federal Regulation (CFR) 600.05 – 600.930, and outline procedures that federal agencies must follow to satisfy MSA consultation requirements. Federal agencies must provide NMFS with an EFH Assessment if the federal action may adversely affect EFH. The EFH assessment is required to include the following: 1) a description of the action, 2) an analysis of the potential effects of the action on EFH and managed species, 3) the federal agency's view of the effects of the action, and 4) proposed mitigation, if necessary (50 CFR 600.920(e)).

2 ESSENTIAL FISH HABITAT GUIDELINES

The 1996 Sustainable Fisheries Act reauthorized the MSA (Magnuson-Stevens Act; 16 USC.1801, et seq.), and introduced new requirements for:

- Description and identification of EFH in fishery management plans;
- Minimizing adverse impacts on EFH; and
- Proposing actions to conserve and enhance EFH.

EFH guidelines were set forth by the NMFS (also known as NOAA Fisheries) to help Fisheries Management Councils (FMCs) fulfill requirements of the MSA. Consultation between federal permitting or action agencies and the NMFS Habitat Conservation Division is required by the MSA when an action may adversely affect designated EFH. The MSA also requires that the federal permitting or action agency respond to comments made by NMFS.

EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. 1802(10)). For the purposes of interpreting this definition:

- "waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate (50 CFR 600.10);
- "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities (50 CFR 600.10);
- "necessary" means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem (50 CFR 600.10); and
- "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle (50 CFR Part 600.10).

EFH is designated based on the best available scientific information. The MSA defines categories to describe the level of understanding used to designate EFH (NMFS 2005):

- Level 1 - Presence/absence distribution data are available for some or all portions of the geographic range of the species;
- Level 2 - Habitat-related densities of the species are available;
- Level 3 - Growth, reproduction, or survival rates within habitats are available; and
- Level 4 - Production rates by habitat are available.

Pacific salmon, groundfish, and scallop EFH is designated for all species and all life stages based on Level 1 information (NPFMC 2012, NPFMC 2014, NPFMC 2018a). Species identified in the FMP are generally referred to in this EFH assessment as "managed species".

3 PROPOSED ACTION

PLP's proposed action includes activities that require DA authorization under Section 404 of the CWA and Section 10 of the RHA.

For this project (Figure 3-1), activities that require DA authorization under Section 404 of the CWA include: the permanent discharge of dredged or fill material into 3,555.4 acres (ac) (1,438.8 ha) of waters of the U.S., including wetlands, and the temporary discharge of dredged or fill material into 518.3 ac (209.7 ha) of waters of the U.S., including wetlands, for the construction of a mine and ancillary facilities, a port facility, roads, ferry terminals, and a natural gas pipeline.

Construction of the project would result in the following discharges of dredged and fill material:

- The permanent discharge of dredged or fill material into 3,458.3 ac (1,399.5 ha) of waters of the U.S., including wetlands, to construct the mine and ancillary facilities.
- The permanent discharge of dredged or fill material into 13 ac (5.3 ha) of waters of the U.S., including wetlands, and the temporary discharge of dredged or fill material into 5.5 ac (2.2 ha) of waters of the U.S., including wetlands, to construct the port and ferry facilities.
- The permanent discharge of dredged or fill material into 84.1 ac (34 ha) of waters of the U.S., including wetlands, and the temporary discharge of dredged or fill material into 58.6 ac (23.7 ha) of waters of the U.S., including wetlands, to construct roads and materials sites.
- The temporary discharge of dredged or fill material into 454.2 ac (183.8 ha) of waters of the U.S., including wetlands, to construct the natural gas pipeline.

The above proposed activities include permanent discharges of fill into:

- 10.7 ac (4.3 ha) below the high tide line of the Cook Inlet.
- 1.3 ac (0.5 ha) below the ordinary high-water mark (OHWM) of Iliamna Lake.
- 47.4 ac (19.2 ha) below the OHWM of streams and open water.

The area of substrate disturbance for submerged portions of the natural gas pipeline within Cook Inlet and Iliamna Lake, from excavation of the trench and temporary side-casting of material, would create a 30-foot (ft) (9.1-meter [m]) wide swath. The total area of ground disturbance (from permanent or temporary placement of fill material, including any grubbing activities) within Amakdedori Port and ancillary facilities would be up to 2,525 ft long by up to 1,130 ft wide (769 m x 344 m), a total of 39.8 ac (16.1 ha). Within the transportation corridors between Amakdedori Port and the south ferry terminal, including materials sites and Kokhanok Spur Road, the proposed area of ground disturbance would be 193,650 ft (59,025 m) long by up to 300 ft (91 m) wide, a total of 850.3 ac (344.1 ha). Within the transportation corridors between the north ferry terminal and the mine site, including Iliamna Spur Road, the proposed area of ground disturbance would be 152,300 ft (46,421 m) long by up to 300 ft (91 m) wide, a total of 856.5 ac (346.6 ha). The transportation corridors would include the pipeline trench. The total area of ground disturbance at the south ferry terminal and the ferry construction pad would be 27.7 ac (11.2 ha), the ferry terminal would be 340 ft (103.6 m) wide by up to 1,130 ft (344.4 m) long, and the construction pad would be 740 ft (225.6 m) wide by up to 1,200 ft (365.8 m) long. The total size of the proposed mine area would be 42,300 ft (12,893 m) long by 25,600 ft (7,802.9 m) wide, covering an area of 8,085.8 ac (3,272.2 ha).

Activities that require DA authorization under Section 10 of the RHA include: construct a causeway/wharf, install two lighted navigation buoys, install two spread anchor mooring systems (one for each lightering location), and install a natural gas pipeline below the mean high water mark of the Cook Inlet (a navigable water of the U.S.); and construct two ferry terminals, install four mooring/navigation buoys, and install a natural gas pipeline below the OHWM of Iliamna Lake (a navigable water of the U.S.). The BSEE will authorize the natural gas pipeline ROW in Federal waters, and the USCG will authorize bridges across Navigable Waters under Section 9 of the RHA.

The construction of the wharf would require the installation of 1,520 linear ft (LF) (463.3 linear m (LM)) of sheet pile using a vibratory hammer (APE 200 or similar) operating from a construction barge. If necessary, an impact hammer (Delmag D36-32) would be used to anchor the last 2 ft (0.6 m) of sheet pile. The remainder of the causeway/wharf would be constructed of earth/rock. The natural gas pipeline would be installed by laying the pipeline on the substrate, or trenching, or directional drilling, using a clam shell dredge, suction dredge, or jet sled, working from barges up to 240 ft long by 60 ft wide (73.2 m long x 18.3 m).

The proposed structures that require DA authorization under Section 10 of the RHA include:

- a 1,900 ft (579.1 m) long by up to 500 ft (152.4 m) wide causeway/wharf; the causeway/wharf would support a fuel pipeline and utility lines;
- two lighted navigation buoys;
- two 2,300 ft by 1,700 ft (701 m x 518.2 m) spread anchor mooring systems in approximately 80 ft (24.4 m) of water, each consisting of 10 anchors and 6 mooring buoys;
- a 115-ft-wide by 155-ft-long by up to 10-ft thick (35.1 m wide x 35.1 m long x 3m thick) south ferry ramp;
- a 200-ft-wide by 160-ft-long by up to 2-ft thick (61 m wide x 48.8 m long x 0.6 m thick) ferry construction ramp with five launching rails, each 15 inches high and extending 36 ft waterward the OHWM, to a water depth of up to 35 ft in Iliamna Lake;
- two mooring buoys attached to anchors at the south ferry terminal;
- two mooring buoys attached to anchors at the north ferry terminal;
- an 85-ft-wide by 105-ft-long by up to 10-ft thick (25.9 m wide x 32 m long x 3m thick) north ferry ramp; and
- 122-miles (196.3 km) of 12-inch (30.5 cm) diameter natural gas pipeline.

The 3-ft (0.9 m) diameter lighted navigation buoys would be anchored by 3 ft by 3 ft by 3 ft (0.9 m x 0.9 m x 0.9 m) concrete blocks or by spiral screw anchors, with an anchoring design that would prevent excessive anchor chain drag or swinging. For the spread anchor mooring system, each 10-ft (3.05 m) diameter mooring buoy would be tethered by lengths of 2-in (5.1 cm) diameter chain attached to 3 gravity anchors; first to a station keeping mass anchor, typically a 3 ft by 3 ft by 3 ft (0.9 m x 0.9 m x 0.9 m) concrete block, and secondly to 2 large mass anchors connected by chain equalizers. The typical large mass anchor is a rock/concrete filled 40 ft by 8 ft by 8 ft (12.2 m x 2.4 m x 2.4 m) shipping container that is lowered to the sea floor. The 3-ft diameter mooring buoys in Iliamna Lake would be anchored by 2-foot (0.6-m) diameter anchors, which would be screwed or drilled into the lake substrate.

The Project includes three primary groups of facilities. The **Mine Site** encompasses the Pebble Deposit and includes all facilities needed for extraction and beneficiation of ore from the deposit. The **Transportation Corridor** would link the Mine Site to a new port in Kamishak Bay near the mouth of Amakdedori Creek on the western shore of Cook Inlet. The third group of facilities would be the **Natural Gas Pipeline and Fiber Optic Cable** and supporting infrastructure.

3.1 Mine Site

The proposed mine site (Figure 3-2) would include facilities for mining, milling, and processing ore; managing tailings, overburden, and water; and supporting infrastructure. Primary facilities include the open pit, the mineral processing facility, two tailings storage facilities (TSFs), water management facilities including a potable water well field and treatment plant; two water management ponds (open pit WMP and main WMP); sediment ponds; seepage collection ponds; two water treatment plants (WTP) (main WTP and open pit WTP) with three discharge locations (UT Creek, NFK River, SFK River); a 270 megawatt power plant; and, on-site roads.

3.2 Transportation Corridor

The Transportation Corridor would link the mine site to Amakdedori Port, a proposed port in Kamishak Bay on the western shore of Cook Inlet (Figure 3-3). The corridor includes roads between Kamishak Bay and Iliamna Lake, a north-south ferry crossing of Iliamna Lake, a road from Iliamna Lake to the mine site, and a spur road to the villages of Iliamna and Newhalen. The ferry system would include a terminal on each side of the lake.

3.2.1 Access Roads

The overland transportation plan includes: a 35-mi (56.3 km) long, two-lane road that would connect the Amakdedori Port and the south ferry terminal on Iliamna Lake west of Kokhanok (south access road); a similar 30 mi (48.3 km) long access road to connect the north ferry terminal on the north shore of Iliamna Lake and the mine site (mine access road); and approximately 9 mi (14.5 km) of spur roads to connect the access road to the villages of Iliamna and Newhalen (Iliamna Spur Road) (Figure 3-3). Construction of access roads would require 80 stream crossing including the construction of seven bridges, and eight culverts to cross Pacific salmon EFH. Construction of the access road would require development of 18 new material sites located within the transportation corridor adjacent to the road.

3.2.2 Ferry Terminals

Transit across 18 mi (28.9 km) of Iliamna Lake would be provided by a purpose-built ferry and would connect the proposed north ferry terminal (Figure 3-4, Figure 3-5) and south ferry terminal (Figure 3-6, Figure 3-7) to the mine access road and south access road.

Facilities common to both terminals include: onshore facilities (storage yards and small modular office and maintenance facilities to support the container operations, and power supply), a ferry ramp, and two 3-ft (0.9 m) diameter mooring buoys that would be anchored by 2-ft (0.6 m) diameter anchors screwed or drilled into the lake substrate. Additionally, the south ferry terminal would include an area for the initial construction and long-term maintenance of the ferry with a construction ramp.

3.2.3 Amakdedori Port, Spread Anchor Mooring Systems, and Navigation Buoys

The marine portion of the proposed Amakdedori Port primarily consists of a rock and earth berm access causeway and a wharf structure for mooring barges and tugs (Figure 3-8, Figure 3-9). The wharf will be an earth-filled sheet pile cell structure and will be constructed using a typical marine barge with crawler crane to vibrate and/or drive (impact) sheet pile segments into the seafloor. The cells will then be filled with select granular fill of rock/gravel. Wharf construction will involve the installation of 1,520 lineal ft (610 lineal m) of steel sheet piles approximately 110 ft (33.5 m) in length, with tie backs into the fill behind the sheets to provide sufficient lateral capacity. The sheet piles will be placed in approximately 15 ft (4.6–6.1 m) of water. The causeway will be constructed by infilling on top of the seabed with competent fill and rock protection for the slopes. The sheet piles will be installed using two vibratory hammers (APE 200 or similar). If bedrock or hard soil is encountered, a small diesel impact hammer (Delmag D36-32 or similar) may be necessary to anchor the last two ft of piling into the ground.

Fill material for construction will be end dumped directly from trucks and/or transferred from shore onto a barge and placed using a clamshell bucket. The causeway will be constructed using a combination of a marine construction rig (barge and crane) to place coarse material for foundation and rip-rap protection, and land-based equipment working from shore to gradually place and compact locally sourced granular material that will be trucked to the site.

Additional structures associated with port operations include two spread anchor mooring systems (one at each lightering location) and two lighted navigation buoys located on the reefs framing the entrance to the Amakdedori Port (Figure 3-8). The 3-ft (0.9 m) diameter navigation buoys would be anchored by 3 ft by 3 ft by 3 ft (0.9 m x 0.9 m x 0.9 m) concrete blocks with an anchoring design that would prevent excessive anchor chain drag or swinging. The 10-ft diameter mooring buoys for the spread anchor mooring systems would be tethered by lengths of 2-inch diameter chain attached to 3 ft by 3 ft by 3 ft (0.9 m x 0.9 m x 0.9 m) concrete positioning blocks, and by lengths of 2-inch diameter chain attached to anchors consisting of either 40 ft by 8 ft by 8 ft (12.2 m x 2.4 m x 2.4 m) shipping containers, large spade anchors, spiral screw anchors, or anchors drilled into bedrock.

3.3 Natural Gas Pipeline and Fiber Optic Cable

The primary energy source for the Project will be natural gas supplied via a 12-in (30.5-cm) pipeline originating near Anchor Point on the Kenai Peninsula. From Anchor Point the pipeline would head 104 miles across Cook Inlet to a landfall at the Amakdedori Port. A fiber optic cable would be buried adjacent to the pipeline (Figure 3-1, Figure 3-3, Figure 3-13).

Placement of the pipeline would vary with location. Along the seabed of Cook Inlet and lake bed of Iliamna Lake, the pipeline would be installed by laying the pipeline on the substrate, or trenching using an extended reach backhoe, clam shell dredge, suction dredge, or jet sled, or horizontal directional drilling (HDD). The area of substrate disturbance for submerged portions of the natural gas pipeline within Cook Inlet and Iliamna Lake, from excavation of the trench and temporary side-casting of material, would create a 30-ft (9.1-m) wide swath. HDD and/or trenching would be used to install the pipeline at the terrestrial-aquatic transitions at the edges of Iliamna Lake and the Cook Inlet seabed. At river, stream and creek crossings along the road, the pipeline may be placed using HDD, trenching, or attached to bridge structures. Marine pipeline construction will require the use of an anchored pipe lay barge. A corridor of 4,101 ft (1,250 m) on either side of the pipeline would be subject to disturbance from the placement of anchors on the seabed. Lake pipeline construction will also require the use of an anchored pipe lay barge. A corridor of 2,461 ft (750 m) on either side of the pipeline would be subject to disturbance from the placement of anchors on the lake bed.

3.4 Action Area

The area for this EFH assessment (Action Area) is defined as follows:

The Action Area for the mine site is defined as EFH that is impacted by the placement of fill in waters of the U.S., including wetlands, sedimentation associated with the placement of fill in waters of the U.S., dewatering of the open pit, and blasting, all of which are captured by a 1,000 ft (305 m) buffer around the mine site facilities. It also includes EFH that is impacted by changes in stream flow resulting from the diversion, capture, and release of water associated with the project that results in a modeled reduction in streamflow of more than 2 percent.

This includes the following reaches, or portions of reaches, in the North Fork Koktuli (NFK) and South Fork Koktuli (SFK) rivers:

1) NFK-A, NFK-B, NFK-C, NFK-190, NFK1.200
2) SFK-B, SFK-C, SFK-D, SFK-E, SFK-190, SFK-124

The mine site Action Area is shown in Figure 3-10.

The Action Area for the land portion of the transportation corridor (roads, material sites, ferry terminals, and port) is defined as EFH that is impacted by the placement of fill in waters of the U.S., including wetlands, sedimentation associated with the placement of fill in waters of the U.S., including wetlands, or blasting associated with construction. This includes a 1,000-ft (305 m) buffer around the footprint where blasting is proposed and a 35-ft (10 m) buffer where no blasting is proposed. The transportation corridor intersects 15 streams that are designated as EFH. The Action Area for the transportation corridor is shown in Figure 3-10 and Figure 3-11.

The Action Area for the lake and marine portions of the transportation corridor is defined as EFH that is impacted by the placement of fill in waters of the U.S. (including wetlands), sedimentation associated with the placement of fill in waters of the U.S. (including wetlands), and other construction activities below the OHWM of Iliamna Lake or below the mean high-water (MHW) mark of Cook Inlet. This includes a 328-ft (100 m) buffer around the footprint of the ferry terminal and port below the OHW or MHW marks. For the spread anchor mooring system at the lightering locations this includes the 2,300-ft by 1,700-ft (701 x 518 m) area associated with the mooring spreads and for the navigation buoys this includes a 33-ft (10 m) radius around the buoy anchors. The Action Area for Iliamna Lake is shown in Figure 3-12.

The Action Area for the marine portion of the pipeline and fiber optic cable below the MHWM of Cook Inlet is defined as a 4,100-ft (1,250 m) buffer around the pipeline centerline where anchor placement may occur. The Action Area for the lake portion of the pipeline and fiber optic cable is defined as a 2,460-ft (750 m) buffer around the pipeline centerline where anchor placement may occur. The onshore portions of the pipeline corridor are captured in the Action Area for the road. The Action Area is shown in Figure 3-13.

All activities requiring DA, BSEE, and USCG authorization that impact EFH fall within this Action Area as defined above. No EFH is present within the Project footprint on the Kenai Peninsula.

4 MANAGED FISH SPECIES AND ESSENTIAL FISH HABITAT

The Project is within the geographic boundaries of the areas of three Fishery Management Plans (FMPs): *Salmon Fisheries in the Economic Exclusion Zone off the Coast of Alaska* (Salmon FMP; NPFMC 2012), *Fishery Management Plan for Groundfish of the Gulf of Alaska* (Groundfish FMP; NPFMC 2018a), and the *Fishery Management Plan for the Scallop Fishery Off Alaska* (Scallop FMP; NPFMC 2014). These FMPs describe and identify EFH for fresh and marine water fishes (Table 4-1).

The Salmon FMP includes the five Pacific salmon species. Freshwater EFH designated under the Salmon FMP includes those habitats designated as important Pacific salmon habitat in the *Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes* (also known as Anadromous Waters Catalog [AWC]) (Johnson and Blossom 2017). Marine EFH designated under the Salmon FMP includes the waters of the economic exclusion zone off the coast of Alaska, which includes all of Cook Inlet.

The Groundfish FMP covers the Gulf of Alaska (GOA), and includes 43 species of groundfish, including a forage fish complex. EFH distribution data does not exist for all managed species and life stages within this FMP, such as sharks, forage fish complex, squids, and grenadiers (NPFMC 2018a). EFH has been described for 39 groundfish species within the Project Action Area (Table 4-1). The Scallop FMP covers habitats within Cook Inlet and designates EFH for weathervane scallop.

Table 4-1: Species with designated EFH in the Action Area by FMP.

Salmon FMP	Groundfish FMP	Scallop FMP
1. Chinook salmon	1. Atka mackerel	1. Weathervane Scallop
2. Coho salmon	2. GOA Skates (Rajidae) – (3 species [sp.])	
3. Sockeye salmon	3. Octopus	
4. Chum salmon	4. Pacific cod	
5. Pink salmon	5. Sablefish	
	6. Sculpins (Cottidae) – (3 sp.)	
	7. Walleye pollock	
	8. Rockfish (Sebastes) – (20 sp.)	
	9. Flatfish – (8 sp.)	
	10. Sharks[1]	
	11. Forage fish complex- (> 8 sp.)[1]	
	12. Squids[1]	
	13. Grenadiers[1]	

Note:
1 No EFH description determined due to insufficient information (NPFMC 2017), but species identified in Action Area sampling.

4.1 Pacific Salmon

The Bristol Bay watershed produces all five species of Pacific salmon found in North America: sockeye salmon (*Oncorhynchus nerka*), coho salmon (*O. kisutch*), Chinook salmon (*O. tshawytscha*), chum salmon (*O. keta*), and pink salmon (*O. gorbuscha*). Pacific salmon in Bristol Bay drainages are targeted by commercial, subsistence and sport fisheries. Pacific salmon EFH in Alaska is designated based on Level 1 (i.e., information based on distribution) (NPFMC 2012). The Salmon FMP identifies EFH for each species' life stage based on either the general distribution of the life stage or the general distribution of the life stage in waters identified in the AWC (Johnson and Blossom 2017) which shows where spawning adults, rearing fry/juveniles, and presence/absence observations have been documented, much of which has been collected and submitted to the AWC through PLP research efforts. AWC data and detailed PLP data are used throughout this analysis. Freshwater EFH within the Action Area is designated by those waters included in the AWC based on distribution data of each species and life stage. Because eggs and larval salmon within the gravels are not specifically identified in the AWC, EFH for eggs and larvae have been quantified by assuming that areas documented for spawning by adult Pacific salmon or identified as spawning habitats by PLP researchers are also EFH for eggs and larvae. The AWC does not always include comprehensive information on rearing habitats. For purposes of quantification of juvenile Pacific salmon EFH, the most detailed survey data—PLP or AWC survey data, whichever was most comprehensive—has been used to delineate the distribution of early, freshwater stage juvenile Pacific salmon. Marine EFH for late juvenile and adult Pacific salmon within the Action Area in Cook Inlet is calculated based solely on the acreage with the Action Area defined in Cook Inlet.

A total of 193,596 LF (59,008 LM) of stream freshwater EFH used by adult, larval and embryonic (eggs) Pacific salmon in the Action Area has been identified; 280,082 LF (85,369 LM) is used by early, freshwater, juvenile Pacific salmon. The portion of Iliamna Lake located within the Action Area has 11,187 ac (4,527 ha) of potential early juvenile, adult, egg, and larval Pacific salmon habitat. The portion of Cook Inlet located within the Action Area (the Amakdedori Port Site and ancillary facilities and the pipeline crossing of Cook Inlet) has 103,205 ac (31,457 ha) of EFH for late juvenile and adult Pacific salmon.

EFH for Pacific salmon is present within all components of the Area in both freshwater and marine waters and could potentially be affected by Project activities. Life stages expected to be exposed to proposed Project activities include: freshwater eggs, freshwater juveniles and adults, estuarine juveniles and adults, and marine juveniles and adults, depending on location (Table 4-2). All waters within Cook Inlet are designated as EFH for marine juvenile (late juvenile) and adult Pacific Salmon.

All designated EFH in the Salmon FMP which occurs in the Action Area are depicted in Figure 3-10 through Figure 3-13.

To supplement the AWC during the early phases of Project planning and exploration, PLP contractors completed 13 freshwater fish resource surveys within the Bristol Bay watershed and the majority of these data are now included in the AWC. In instances where PLP data were more extensive than indicated by the AWC, PLP data has been used to identify EFH. All figures depicting freshwater EFH identify the areas documented in the AWC as well as areas identified only in PLP data. Additional surveys were conducted in 2018 to determine fish use of drainages along the south transportation corridor between Iliamna Lake and the proposed Amakdedori Port in Kamishak Bay; these data are not yet represented in the AWC but will be nominated and included in the future. This analysis considers those areas determined in 2018 as being used by Pacific salmon as EFH.

Table 4-2: Pacific salmon species life stages[1] by drainage present in the Action Area.

Salmon Species	Amakdedori Creek	Gibraltar River	Iliamna Lake	Newhalen River	Upper Talarik Creek	First Creek	South Fork Koktuli River	North Fork Koktuli River
Chinook salmon	--	--	p	s, p	s, r	p	s, r	s, r
Sockeye salmon	S	s	s, r	s	s, r	s	p, r, s	s, r
Coho salmon	s, p	--	p	p	s, r	s, r	s, r	s, r
Chum salmon	s, p	s	p	--	s, p	--	s, r	s, r
Pink salmon	s, p	--	p	--	--	--	--	--

Note:
1 Pacific salmon life stages present within the primary drainages within the Action Area: p = present; s = spawning; r = rearing (Johnson and Blossom 2017).

Essential fish habitat for all Pacific salmon, except pink salmon, was found within the three major drainages of the Action Area near the mine site (NFK River, SFK River, and UT Creek) surveyed from 2004 to 2008 (PLP 2011). Only the UT Creek drainage had EFH for all five species. Additional surveys in 2009 and 2018 by PLP contractors support these distributions. Because the AWC is based solely on distribution data to identify EFH, analysis depicted throughout this assessment rely on densities of Pacific salmon by species and life stage to identify the location of specific EFH and to indicate the relative quality of EFH within various portions of the Action Area.

Adult salmon counts were conducted using aerial surveys from July to October during 2004 to 2008. Where possible, large-scale densities were calculated using stream segment lengths and fish counts by stream segment. The total peak daily counts from adult surveys are summarized by river to facilitate run size comparisons across years (Table 4-3). Densities of adult salmon by river reach and species were determined most comprehensively during 2008 aerial surveys; to illustrate the distribution of adult fish throughout each river and its tributaries, fish observations from the survey demonstrating the most widespread fish distribution for each species is presented in Table 4-4. Furthermore, to more specifically depict the spawning distribution throughout each river, cumulative observations of spawning salmon and densities by reach are presented in Table 4-4. The general spawning distribution of Pacific salmon as shown on the AWC within drainages near the mine site is shown in Figure 4-1. Salmon distribution by species from the AWC are depicted in figures 4-2 through 4-11. The distribution of peak adult salmon counts from PLP surveys near the mine site are shown in figures 4-2, 4-4, 4-6 and 4-8. The majority of adult fish and spawning observations for all adult Pacific salmon occurred downstream of waters directly affected by proposed mine facilities (Table 4-4, Table 4-5). This is consistent with the baseline results of instream flow modeling that showed increasing acreages of suitable spawning habitat along the river from headwater areas to downstream reaches (PLP 2011). Baseline characterizations for each of the Pacific salmon species present in these rivers are presented below in Sections 4.1.1 to 4.1.5. Studies were conducted using metric

Table 4-3: Peak daily counts and densities (fish per stream kilometer) of adult salmon by stream and year based on aerial surveys 2004 to 2008.[1,2]

Species	Year	North Fork Koktuli River			South Fork Koktuli River			Upper Talarik Creek		
		Count[3]	Density (#fish/km)[4]	Survey Length (km)	Count[3]	Density (#fish/km)[4]	Survey Length (km)	Count[3]	Density (#fish/km)[4]	Survey Length (km)
Chinook Salmon										
	2004	2,800	62.4	44.9	2,780	82.5	33.7	272	4.5	60.9
	2005	2,889	60.4	47.8	1,660	30.3	54.8	100	1.6	60.9
	2006	740	16.5	44.9	327	9.1	35.8	90	1.5	60.9
	2007	531	9.6	55.6	387	7.1	54.8	152	2.5	60.5
	2008	434	7.8	55.5	590	13.5	43.8	102	1.6	62.5
Chum Salmon										
	2004	435	13.1	33.2	--	--	--	--	--	--
	2005	350	7.8	44.9	361	10.1	35.8	3	0.1	58.2
	2006	753	16.8	44.9	866	24.2	35.8	9	0.1	60.9
	2007	833	18.6	44.9	189	3.4	54.8	10	0.2	60.5
	2008	1,432	31.9	44.9	917	17.9	51.2	44	0.7	62.5
Coho Salmon										
	2004	378	14.6	25.9	270	4.5	60.3	2,621	43.0	60.9
	2005	361	7.6	47.8	565	10.3	54.8	1,041	30.1	34.6
	2006	1,074	23.9	44.9	1,394	38.9	35.8	6,413	110.0	58.3
	2007	114	2.1	55.6	340	5.6	60.3	4,359	72.2	60.4
	2008	1,704	30.7	55.5	1,955	34.4	56.9	5,248	90.3	58.1
Sockeye Salmon										
	2004	563	12.5	44.9	1,730	48.3	35.8	33,070	543.0	60.9
	2005	1,140	25.4	44.9	2,051	40.8	50.3	13,698	224.9	60.9
	2006	1,385	30.8	44.9	2,952	53.9	54.8	11,334	186.1	60.9
	2007	2,188	39.4	55.6	4,112	75.0	54.8	10,557	174.5	60.5
	2008	1,907	34.4	55.5	6,133	140.0	43.8	50,317	805.1	62.5

Note:
1 Peak densities for main channel only.
2 PLP 2018a – SEBD, Appendix 15B2, densities and fish per river km.
3 Count data reflect the highest number of fish of each species observed on a single survey event.
4 Density calculated by dividing the number of fish by the survey length.

Table 4-4: Adult salmon counts from mainstem and tributary surveys and mainstem density (fish/km) estimates observed during the survey that had the most widespread adult distribution in each basin, 2008.[1]

River km/ Tributary	Reach[2]	Chinook Salmon			Chum Salmon			Coho Salmon			Sockeye Salmon		
		Count	Density (#fish/ km)	%	Count	Density (#fish/ km)	%	Count	Density (#fish/ km)	%	Count	Density (#fish/ km)	%
North Fork Koktuli River		Survey Date - 8/4-5/2008			Survey Date – 7/30-31/ 2008			Survey Date - 9/28/2008			Survey Date - 7/30-31/2008		
0.0 8.7	NFK/SFK Confluence NFK1.40, NFK-01	189	21.8	43.5	57	6.6	8.9	209	24.1	12.0	1,047	120.6	57.7
14.5	**NFK-02**	**53**	**9.1**	**12.2**	**0**	**0.0**	**0.0**	**174**	**29.9**	**10.0**	**4**	**0.7**	**0.2**
22.2	**NFK-03**	**96**	**12.4**	**22.1**	**70**	**9.0**	**10.9**	**280**	**36.2**	**16.0**	**7**	**0.9**	**0.4**
33.2	**NFK-04**	**82**	**7.5**	**18.9**	**516**	**47.3**	**80.1**	**880**	**80.7**	**50.4**	**640**	**58.7**	**35.3**
36.5	**NFK05**	**13**	**3.9**	**3.0**	**1**	**0.3**	**0.2**	**23**	**6.8**	**1.3**	**0**	**0.0**	**0.0**
44.9	NFK-06	1	0.1	0.2	0	0.0	0.0	51	6.1	2.9	1	0.1	0.1
48.1	NFK-07	0	0.0	0.0	0	0.0	0.0	11	3.5	0.6	0	0.0	0.0
55.5	NFK-08	0	0.0	0.0	0	0.0	0.0	76	10.2	4.4	0	0.0	0.0
Tributary	**NFK 1.190**	**0**		**0.0**	**0**		**0.0**	**27**		**1.5**	**0**		**0.0**
Tributary	NFK 1.240							12		0.7			
Tributary	NFK 1.240.P1				0		0.0				3		0.2
Tributary	NFK 1.240.20.P1	0		0.0	0		0.0				111		6.1
Tributary	NFK 1.260				0		0.0	1		0.1	0		0.0
Tributary	NFK 1.270				0		0.0				0		0.0
Tributary	NFK 1.280							2		0.1			
	TOTAL	**434**			**644**			**1,746**			**1,813**		
South Fork Koktuli River		Survey Date - 8/4/2008			Survey Date - 7/15-16/2008			Survey Date - 9/29/2008			Survey Date - 7/30/2008		
0.0 2.2	NFK/SFK Confluence SFK-01	42	19	7.1	35	15.8	3.7	49	22.2	3.1	229	103.6	3.7
8.0	SFK-02	114	19.7	19.3	23	4	2.4	274	47.2	17.3	511	88.1	8.3
11.0	SFK-03	139	47.1	23.6	49	16.6	5.2	101	34.2	6.4	308	104.4	5.0
12.8	SFK-04	25	13.9	4.2	29	16.1	3.0	25	13.9	1.6	1,130	627.8	18.4
18.7	SFK-05	77	13	13.1	59	10	6.2	162	27.4	10.3	297	50.3	4.8
21.6	SFK-06	22	7.6	3.7	4	1.4	0.4	39	13.5	2.5	0		0.0
24.9	SFK-07	60	17.9	10.2	132	39.4	13.9	59	17.6	3.7	1	0.3	0.0
30.1	SFK-08	93	17.9	15.8	267	51.3	28.1	304	58.5	19.2	600	115.4	9.8

River km/ Tributary	Reach[2]	Chinook Salmon			Chum Salmon			Coho Salmon			Sockeye Salmon		
		Count	Density (#fish/ km)	%	Count	Density (#fish/ km)	%	Count	Density (#fish/ km)	%	Count	Density (#fish/ km)	%
34.3	**SFK-09**	**18**	**4.3**	**3.1**	**312**	**74.8**	**32.8**	**444**	**106.5**	**28.1**	**3,057**	**733.1**	**49.8**
35.9	**SFK-10**	**0**		**0.0**	**7**	**4.4**	**0.7**	**5**	**3.2**	**0.3**	**0**		**0.0**
43.8	**SFK-11**	**0**		**0.0**	**0**		**0.0**	**13**	**1.6**	**0.8**	**0**		**0.0**
51.2	**SFK-12**				**0**		**0.0**	**6**	**0.8**	**0.4**			
56.9	**SFK-13**							**0**		**0.0**			
Tributary	**SFK 1.130**	**0**		**0.0**	**6**		**0.6**	**48**		**3.0**	**0**		**0.0**
Tributary	**SFK 1.190**	**0**		**0.0**	**28**		**2.9**	**50**		**3.2**	**0**		**0.0**
Tributary	**SFK 1.240**	**0**		**0.0**	**0**		**0.0**	**1**		**0.1**	**1**		**0.0**
	TOTAL	**590**			**951**			**1,580**			**6,134**		
Upper Talarik Creek		Survey Date - 8/8/2008			Survey Date - 8/8/2008			Survey Date - 9/22/2008			Survey Date - 7/29/2008		
0.0	Confluence of UT & Iliamna Lake	10	0.7	9.5	0	0.0	0.0	362	25	9.7	21,554	872.6	50.2
14.5	UT-01												
24.7	UT-02	40	3.9	38.1	4	0.4	8.5	275	26.9	7.4			
32.3	UT-03	1	0.1	1.0	4	0.5	8.5	804	106.8	21.5	2,137	283.8	5.0
44.9	**UT-04**	**49**	**3.9**	**46.7**	**18**	**1.4**	**38.3**	**716**	**56.7**	**19.2**	**1,435**	**113.6**	**3.3**
51.0	UT-05	2	0.3	1.9	0		0.0	271	44.6	7.3	29	4.8	0.1
54.3	UT-06	0		0.0	0		0.0	85	25.7	2.3	56	16.9	0.1
58.1	UT-07	0		0.0	0		0.0	161	42.3	4.3	8	2.1	0.0
60.4	UT-08	0		0.0	0		0.0	16	6.9	0.4			
62.5	UT-09	0		0.0	0		0.0	1	0.5	0.0			
Tributary	**UT 1.160 (First Creek)**	**0**		**0.0**	**0**		**0.0**	**420**		**11.3**	**17,667**		**41.1**
Tributary	UT 1.190	1		1.0	0		0.0	0		0.0			
Tributary	UT 1.350	0		0.0	0		0.0	571		15.3	0		0.0
Tributary	UT 1.390	0		0.0	0		0.0	8		0.2	53		0.1
Tributary	**UT 1.410**	**2**		**1.9**	**21**		**44.7**	**43**		**1.2**	**30**		**0.1**
	TOTAL	**105**			**47**			**3,733**			**42,969**		

Note:
1 PLP 2018a – based on aerial surveys reported in SEBD, Tables B2-5, B-10, and B-15.
2 Stream reaches or potions of stream reaches within the Action Area are in bold.
3 Bold text signified the stream reach is included in the EFH Action Area.

Table 4-5: Aerial observations of spawning salmon by stream reach in the North Fork Koktuli River, South Fork Koktuli River and Upper Talarik Creek, 2008.[1]

River km	Reach	Chinook Salmon				Chum Salmon				Coho Salmon				Sockeye Salmon			
		# of Surveys	Count	#fish/ km	%	# of Surveys	Count	#fish/ km	%	# of Surveys	Count	#fish /km	%	# of Surveys	Count	#fish/ km	%
North Fork Koktuli River (2008)																	
0.0-13.7	NFK-A	5	567	41.4	57.3	7	344	25.1	12.0	11	1,164	85	22.9	8	4,284	312.7	62.5
13.7-21.1	NFK-B	5	189	25.5	19.1	5	255	34.5	8.9	10	746	100.8	14.7	5	25	3.4	0.4
21.1-36.6	NFK-C	5	234	15.1	23.6	7	2,279	147	79.2	13	2,725	175.8	53.7	9	2,029	130.9	29.6
36.6-48.4	NFK-D		0	0	0		0	0	0	7	185	15.7	3.6	9	514	43.6	7.5
48.4-52.5	NFK-E		0	0	0		0	0	0	5	259	63.2	5.1		0	0	0
52.5-57.7	NFK-F		0	0	0		0	0	0		0	0	0		0	0	0
	TOTAL		**990**				**2,878**				**5,079**				**6,852**		
North Fork Koktuli River (2008)																	
0.0-24.9	SFK-A	7	1,300	52.2	81.8	7	605	24.3	35.4	12	2,352	94.5	41.3	9	7,333	294.5	37.5
24.9-34.3	SFK-B	5	289	30.7	18.2	7	1,103	117.3	64.6	14	3,295	350.5	57.8	8	12,237	1,301.8	62.5
34.3-51.7	SFK-C		0	0	0		0	0	0	6	49	2.8	0.9	1	1	0.1	0
51.7-54.7	SFK-D		0	0	0		0	0	0		0	0	0		0	0	0
54.7-64.2	SFK-E		0	0	0		0	0	0		0	0	0		0	0	0
	TOTAL		**1,589**				**1,708**				**5,696**				**19,571**		
Upper Talarik Creek (2008)																	
0.0-5.9	UT-A	3	11	1.9	7.4	1	7	1.2	9.6	11	1,090	184.7	11.3	10	103,233	17,497.1	58.1
5.9-16.8	UT-B	5	26	2.4	17.4	3	5	0.5	6.8	8	438	40.2	4.6	9	41,475	3,805.0	23.3
16.8-24.8	UT-C	3	38	4.8	25.5	2	5	0.6	6.8	10	453	56.6	4.7	6	16,937	2,117.1	9.5
24.8-36.3	UT-D	5	14	1.2	9.4	4	25	2.2	34.2	14	2,632	228.9	27.4	5	13,358	1,161.6	7.5
36.3-45.1	UT-E	4	55	6.3	36.9	4	13	1.5	17.8	12	3,514	399.3	36.6	6	2,355	267.6	1.3
45.1-59.1	UT-F	2	5	0.4	3.4	2	18	1.3	24.7	8	1,477	105.5	15.4	6	284	20.3	0.2
59.1-62.4	UT-G		0	0	0		0	0	0	2	6	1.8	0.1		0	0	0
	TOTAL		**149**				**73**				**9,610**				**177,642**		

Note:
1 PLP 2018a – based on aerial surveys reported in EBD Tables 15.1-16,15.1-29,15.1-42.

units of measure (meters and kilometers) and these are provided as the primary unit of measure in Sections 4.1.1 to 4.1.5 to describe river distances, survey lengths and densities.

Sampling for juvenile salmon conducted from 2004 through 2009 and in 2018 characterized the distribution and densities of juvenile salmon throughout the mainstem channels and selected tributaries of the NFK and SFK rivers, and UT Creek. Sample metrics include observation by species, life stage, geographic information, and sampling method, survey length and survey width. To generate densities, a survey area was calculated with the survey length and width. Densities in terms of fish count and survey area were then scaled to 1,076 sf (100 m^2). Table 4-6 presents mainstem and tributary juvenile Pacific salmon densities from 2004-2008 (PLP 2011). Table 4-7 presents juvenile salmon densities from mainstem index surveys summarized by stream reach (PLP 2018a). Table 4-8 presents juvenile salmon densities for selected tributary and mainstem sampling sites from 2008 and 2018 (PLP 2011; PLP 2018c).

Table 4-6: Mainstem and tributary densities of juvenile Pacific salmon by EBD reach, 2004-2008 (PLP 2011).

EBD Reach	Tributary/ Mainstem	Total Area Surveyed (m^2)	Fish Density (fish/100m^2)			
			Chinook Salmon	Chum Salmon	Coho Salmon	Sockeye Salmon
KR	Mainstem	4,515.3	71.22	0.31	16.85	3.41
North Fork Koktuli River						
NFK-A	Mainstem	1,415.0	1.84	0.21	17.67	0.14
NFK-B	Mainstem	1,121.1	30.68	0.36	34.52	0.27
NFK-C	Mainstem	51,454.9	4.85	0.04	25.37	0.31
	Tributary	27,319.3	0.19	0.00	1.35	0.00
NFK-D	Mainstem	--	[a]	--	--	--
NFK-E	Mainstem	--	[a]	--	--	--
NFK-F	Mainstem	--	[a]	--	[b]	--
South Fork Koktuli River						
SFK-A	Mainstem	2,096.0	24.90	0.00	37.40	1.96
SFK-B	Mainstem	3,082.5	0.19	0.06	6.88	0.62
	Tributary	16,792.9	0.05	0.00	2.30	0.00
SFK-C	Mainstem	2,326.0	0.00	0.00	0.64	0.00
	Tributary	21,685.9	0.11	0.00	10.02	0.30
SFK-D	Mainstem	475.3	0.00	0.00	2.52	0.00
SFK-E (with FPL)	Mainstem	5,322.0	0.00	0.00	0.70	0.02
	Tributary	7,239.8	0.00	0.00	0.00	0.00
Upper Talarik Creek						
UT-C	Mainstem	6,534.8	11.31	0.00	67.24	2.28
	Tributary	1,133.7	0.00	0.00	0.88	0.00
UT-D	Mainstem	10,134.7	3.61	0.01	49.03	0.39
UT-E	Mainstem	10,672.8	4.77	0.00	42.17	2.14
UT-F	Mainstem	4,045.7	1.53	0.00	124.40	0.67

EBD Reach	Tributary/ Mainstem	Total Area Surveyed (m^2)	Fish Density (fish/100m^2)			
			Chinook Salmon	Chum Salmon	Coho Salmon	Sockeye Salmon
	Tributary	16,226.0	0.01	0.01	27.06	0.55
UT-G	Mainstem	538.7	0.00	0.00	9.47	0.00
	Tributary	2,277.9	0.00	0.00	1.93	0.00

Notes:
a In 2008, 8 juvenile Chinook Salmon were observed in NFK-D, 0 in NFK-E, and 4 in NFK-F.
b From 2004- 2008, 849 juvenile coho Salmon were observed in NFK-D, 51 in NFK-E and 0 in NFK F; however, densities were not generated for these reaches as habitat data did not support density calculations.

Pacific salmon rearing habitats within the Action Area footprint are restricted primarily to Chinook, coho and sockeye salmon, which all generally exhibit freshwater rearing periods that may extend one or more summer seasons post emergence. Chum salmon, while identified in some late winter/early spring sampling as present within some drainages flowing out of the mine site area, are not considered further in this evaluation as they immediately smolt at break-up and exhibit almost no residency in the Action Area. Mainstem habitats within the NFK and SFK rivers, and UT Creek had the highest quality habitats as inferred by densities of rearing juvenile salmon when compared to tributary habitats and generally exhibited increasing densities with distance downstream from headwater sampling sites.

Freshwater EFH for Pacific salmon is based on the AWC (Johnson and Blossom 2017), per the Salmon FMP, which shows where spawning adults, rearing fry/juveniles, and general presence/absence have been documented, much of which has been collected and submitted to the AWC through PLP research efforts. AWC data and detailed PLP data are used throughout this analysis and delineated separately on figures where they deviate.

Table 4-7: Densities of juvenile Pacific salmon by EBD reach from mainstem index snorkel surveys, 2009.[1]

EBD Reach	Total Area (m^2)	Juvenile Pacific Salmon Density (fish/100m^2)			
		Chinook Salmon	Chum Salmon	Coho Salmo	Sockeye Salmon
North Fork Koktuli River					
NFK-A	3,939.1	18.81	--	7.74	--
NFK-B	1,644.0	5.78	--	11.31	--
NFK-C	2,220.0	8.15	--	2.45	1.89
NFK-D	843.0	--	--	--	--
NFK-E	30.0	--	--	--	--
South Fork Koktuli River					
SFK-A	5,249.1	19.13	--	7.96	0.95
SFK-B	1,400.0	0.71	--	2.21	--
SFK-C	1,545.0	--	--	1.88	--
SFK-D	901.1	--	--	0.12	--
SFK-E	16.9	--	--	--	--
Upper Talarik Creek					

EBD Reach	Total Area (m^2)	Juvenile Pacific Salmon Density (fish/100m^2)			
		Chinook Salmon	Chum Salmon	Coho Salmo	Sockeye Salmon
UT-A	5,124.0	0.20	--	0.64	--
UT-B	2,321.7	2.54	--	39.50	--
UT-C	2,624.0	3.82	--	14.98	--
UT-D	2,144.9	0.93	--	31.52	--
UT-E	856.0	0.12	--	115.43	--
UT-F	542.9	--	--	17.15	--
UT-G	19.6	--	--	1.22	--

Note:
1 Data source: PLP 2018a – SEBD Table 15-12.

Table 4-8: Juvenile salmon densities for North Fork Koktuli River, South Fork Koktuli River and Upper Talarik Creek mainstems and tributaries, 2008 and 2018 .[1,2]

EBD Reach	Stream (river km)	Total Area Surveyed (m^2)	Chinook Salmon	Chum Salmon	Coho Salmon	Sockeye Salmon
			Juvenile	Juvenile	Juvenile	Juvenile
North Fork Koktuli River						
NFK-C	NFK 1.0 (21.1-36.6)	50,856.4	4.88	--	25.33	<0.00
	NFK 1.190 and Tributaries	25,947.3	0.11	--	1.24	--
NFK-D	NFK 1.200 and Tributaries	15,360.99	0.08	--	2.24	--
South Fork Koktuli River						
SFK-B	SFK 1.190 and Tributaries	15,768.4	0.05	--	2.38	--
SFK-C	SFK 1.240 and Tributaries	21,166.6	0.11	--	10.25	0.28
	SFK 1.260	184.3	--	--	0.54	3.26
SFK-E	SFK 1.0 (54.7-64.2)	4474.2	--	--	0.63	0.02
	SFK 1.310 and Tributaries	2,907.2	--	--	--	--
	SFK 1.320	23.7	--	--	--	--
	SFK 1.330	561.0	--	--	--	--
	SFK 1.340	751.2	--	--	--	--
	SFK 1.350	616.7	--	--	--	--
	SFK 1.370	183.7	--	--	--	--
	SFK 1.380	952.0	--	--	--	--
	SFK 1.400	288.2	--	--	--	--
Upper Talarik Creek						
UT-F	UT 1.360 and Tributaries	2,240.6	--	--	0.40	--
	UT 1.370 and Tributaries	2,718.2	--	--	42.12	--
	UT 1.380 and Tributaries	4,183.5	0.02	--	39.13	0.31
	UT 1.390 and Tributaries	2,914.3	--	--	2.81	0.34
	UT 1.400	14.0	--	--	--	--

EBD Reach	Stream (river km)	Total Area Surveyed (m²)	Chinook Salmon	Chum Salmon	Coho Salmon	Sockeye Salmon
			Juvenile	Juvenile	Juvenile	Juvenile
	UT 1.410 and Tributaries	2,375.2	--	--	43.45	--
	UT 1.420	260.7	--	--	45.26	--
	UT 1.430	234.4	--	--	16.21	--
	UT 1.440	59.7	--	--	--	--
	UT 1.460	652.0	--	--	10.58	--
	UT 1.470	149.8	--	--	115.49	--
UT-G	UT 1.0 (59.1-62.4)	418.0	--	--	12.20	--
UT-G	UT 1.490	56.0	--	--	32.14	--
UT-G	UT 1.500	2,221.9	--	--	1.17	--

Note:
1 Date source: PLP EBD Appendix B Tables B.3-8, Table B.8-8, Table B.9-8, Table B.11-8, Table B.17-8, Table B.18-8, R2, 2018 Table A2
2 Densities calculated from catch using multiple gear types.

4.1.1 Chinook Salmon

Chinook salmon spawn in rivers and streams throughout Interior, Southcentral, and Southwest Alaska. Migration and spawning within the study area occurs from July into August. Females typically deposit 2,000 to 5,000 eggs, although sometimes more than 17,000, in gravel beds where they develop throughout the winter (Healey 1991). Fry typically emerge between April and May the following year but have been detected as early as March within the Action Area. Most juvenile Chinook salmon in Alaska remain in freshwater until the following spring when they move toward marine habitats. Rearing juvenile Chinook salmon are present year-round and out-migrating smolts leave the system from April through June (NPFMC 2012). However, within the Bristol Bay basin this trend may not be the norm. Fish surveys within NFK River and SFK River drainages reported up to two or three age classes of juvenile Chinook salmon, suggesting overwintering for at least two seasons within both drainages. Chinook salmon smolts feed on plankton and insects in fresh water. After migrating to sea, young Chinook salmon initially feed in shallow nearshore areas along the coast. As they grow, they gradually move offshore into deeper water. Chinook salmon remain within the coastal area throughout their marine phase. Prey initially include a variety of marine plankton, including copepods, amphipods, euphausiids, and small fishes. With increasing size, fish become the dominant food item, with Pacific herring (*Clupea pallasii*) and Pacific sand lance (*Ammodytes hexapterus*) providing a high percentage of the diet. Squid and larger crustaceans are also consumed.

EFH within Action Area by life stage for Chinook salmon:

Eggs: 149,521 LF (45,574 LM) of freshwater stream habitat.

Larvae: 149,521 LF (45,574 LM) of freshwater stream habitat.

Early Juveniles: 177,079 LF (53,974 LM) of freshwater stream habitat; 11,187 ac (4,527 ha) of lake habitat (in Iliamna Lake).

Late Juveniles: 103,205 ac (41,766 ha) of marine habitat (in Cook Inlet).

Adults: 49,521 LF (15,094 LM) of freshwater stream habitat; 11,187 ac (4,527 ha) of lake habitat (in Iliamna Lake); 103,205 ac (41,766 ha) of marine habitat (in Cook Inlet).

All marine/estuarine life stages of Chinook salmon have designated EFH within Cook Inlet, including the shoreline and nearshore areas of Amakdedori beach proposed by PLP for a port and pipeline landing. Chinook salmon EFH exists within the Action Area and includes the NFK River, SFK River, UT Creek, First Creek (FC), Newhalen River, Iliamna Lake, and Cook Inlet (Table 4-2; Figure 4-2, Figure 4-3; Johnson and Blossom 2017, PLP 2018a). Within NFK River, SFK River, UT Creek and their tributaries, Chinook salmon spawn predominately in the larger river reaches, lower in the drainage basin. Within the NFK River and SFK River, the majority of Chinook salmon adults and spawners were observed in the lower portions of the rivers (Table 4-4, Table 4-5; PLP 2011) suggesting the presence of higher quality habitat or simply adequate quantities of suitable habitat is readily available to accommodate the numbers of Chinook salmon entering the streams without the need to distribute further upstream. The AWC shows spawning Chinook salmon have also been documented up to river km 48 and river km 53 in the NFK and SFK Rivers, respectively (Figure 4-1). Spawning Chinook salmon were not observed in surveyed tributaries to the NFK or SFK rivers indicating either less suitable or unneeded habitat exists in those tributaries for Chinook salmon spawning. highest count of adult Chinook salmon ever observed upstream of river km 36.5 in the NFK River was two in 2008 and the highest count observed upstream of river km 30.1 in the SFK River was 20 (PLP 2018a). The 2008 spawner counts in both forks documented 100 percent of Chinook salmon spawning downstream from river km 36.6 (PLP 2011) suggesting the presence of higher quality habitat or simply adequate quantities of suitable habitat is readily available to accommodate the numbers of Chinook salmon entering the streams without the need to distribute further upstream. The AWC shows spawning Chinook salmon have also been documented up to river km 48 and river km 53 in the NFK and SFK Rivers, respectively (Figure 4-1). Spawning Chinook salmon were not observed in surveyed tributaries to the NFK or SFK rivers indicating either less suitable or unneeded habitat exists in those tributaries for Chinook salmon spawning. Two was highest count of adult Chinook salmon ever observed upstream of river km 36.5 in the NFK River in 2008 and 20 was the highest count observed upstream of river km 30.1 in the SFK River (PLP 2018a). The 2008 spawner counts in both forks documented 100 percent of Chinook salmon spawning downstream from river km 36.6 (Table 4-5). Within the SFK River, all adult Chinook salmon observations from 2004 - 2008 were downstream of Frying Pan Lake, and in 2008 all documented spawning occurred downstream of the confluence of SFK1.190 at approximately river km 34.3 (Table 4-5; PLP 2018a). The peak daily counts of adult Chinook salmon within the NFK and SFK rivers consistently occurred between late July and early August (PLP 2018a).

Within UT Creek, adult Chinook salmon have been documented throughout much of the drainage (Table 4-4; Johnson and Blossom 2017, PLP 2011, PLP 2018a). In 2008, comprehensive spawner surveys found all spawning adult Chinook salmon were located downstream of river km 59.1 and that 37 percent of spawners were in the 8.8 km (5.5 mi) reach between river km 36.3 and 45.1 (Table 4-5), suggesting the highest quality Chinook salmon spawning EFH exists within this reach, outside the Action area. The AWC shows spawning Chinook salmon have also been documented up to river km 47 (Figure 4-1) as well as in the nearby Newhalen River (Figure 4-2). All documented spawning reaches in the AWC and adult counts for 2008 within NFK River, SFK River and UT Creek are depicted in Figure 4-5.

Adult Chinook salmon were most frequently observed in NFK River, followed by SFK River and UT Creek (Table 4-3; PLP 2018a). NFK River supported the largest run of Chinook salmon among the three watersheds in the mine study area with peak counts ranging from 434 in 2008 to 2,889 in 2005 (Table 4-3). Within the SFK River, peak counts ranged from 327 in 2006 to 2,780 in 2004. Chinook salmon peak counts within UT Creek ranged from 90 in 2006 to 272 in 2004 and were the lowest among the three drainages (Table 4-3; PLP 2018a).

Within the NFK River mainstem and tributary sampling reaches from 2004 through 2009 and 2018, juvenile Chinook salmon were found throughout the mainstem and in several tributaries (Table 4-6, Table 4-8). In reaches upstream of river km 48, juvenile Chinook salmon observations were limited to two juveniles collected just upstream of river km 52.5 (see Appendix 15B, PLP 2011; Figure 4-2). Juvenile Chinook salmon were most common in mainstem, fast-water habitats in the NFK River with average sample densities of 1.84 to 30.68 fish/100m^2 (1,076 ft^2) from the confluence with the SFK up to river km 36.6 (Table 4-6, Table 4-7, Table 4-8). Sampling in NFK documented lower densities of Chinook salmon juveniles, with average sample densities consistently less than 1 fish/100m^2 (Table 4-6, Table 4-8). The average densities for sample sites within NFK 1.190 and 1.200 were 0.11 and 0.08 fish/100m^2 (EBD Chapter 15 Table B3-8; Table 4-8).

For the SFK River mainstem reaches sampled from 2004 through 2009, average juvenile Chinook salmon densities were highest in the lowest reach. From river km 0 to 24.9 juvenile Chinook salmon densities ranged from 19.1 to 24.9 fish/100m^2 (Table 4-6, Table 4-7). Average densities from tributary sample sites were lower than mainstem densities and were consistently less than 1 fish/100m^2 (Table 4-6, Table 4-8). No juvenile Chinook salmon were documented upstream of Frying Pan Lake, above approximately river km 54.7.

Within UT Creek, juvenile Chinook Salmon were found throughout the mainstem from the confluence with Iliamna Lake to approximately river km 59 (PLP 2011). Similar to the NFK and SFK rivers, sample densities were relatively greater in the UT Creek mainstem habitat where average densities ranged from 0.12 to 11.31 fish/100m^2 as compared to tributaries where average densities were consistently less than 0.1 fish/100m^2 (Table 4-6, Table 4-7, Table 4-8). The highest densities of juvenile Chinook salmon, greater than 3 fish/100m^2, were documented in the middle UT reaches between approximately river km 16.8 and 45.1 (Table 4-7).

Along the transportation corridor, Chinook salmon EFH is present at three stream crossings. Chinook salmon rearing was documented downstream of crossing A044 (Table 4-9) in UT Creek and both Chinook salmon spawning and rearing EFH has been documented within UT Creek outside the Action Area. In the Newhalen River Basin, Chinook Salmon were documented from the confluence with Iliamna Lake up to Lake Clark (AWC 2018; Figure 4-2). Chinook salmon spawning EFH extends as far as the proposed crossing location (AWC 2018). Crossings over both Chinook salmon EFH streams would be with bridges; a single span bridge design over UT Creek and a multi-span design over the Newhalen River.

Table 4-9: Stream crossings.

Stream Crossing ID	AWC Code[2]	Pacific Salmon Species[3] and Life Stage[4]	Access Road Crossing	Pipeline and Fiber Optic Cable Crossing
Amakdedori Port to South Ferry Terminal				
A001	--	COr	Yes	Yes
A002	243-40-10010-2008 (Amakdedori Creek Tributary)	COsr, Ss	Yes	Yes
A067	--	COr	Yes	Yes
A003	--	COr	Yes	Yes
A023	--	COr	Yes	Yes
A028	(Gibraltar Creek Tributary)	COr, Ss	Yes	Yes
A052	(Gibraltar Creek Tributary)	COr	Yes	Yes
A029	(Gibraltar Creek Tributary)	COr	Yes	Yes
A030	324-10-10150-2196 (Gibraltar Creek)	COpr, CHs, Pp, Ssr	Yes	Yes
North Ferry Terminal to Mine Site				
A035	324-10-10150-2183-3010 (First Creek)	COs	Yes	Yes
A037	324-10-10150-2183-3050 (Mini Creek)	COr	Yes	Yes
A038	324-10-10150-2183 (UT Creek)	COsr, Ksr, Ssr, CHs	Yes	Yes
A039	324-10-10150-2183-3057 (UT Creek Tributary)	COr	Yes	Yes
A044[5]	324-10-10150-2183-3307 (UT Creek Tributary)	COr, Kr	Yes	Yes
Iliamna Spur Road				
NS005	324-10-10150-2207 (Newhalen River)	COpr, Kps, Ssr	Yes	No

Notes:
1 PLP 2018b RFI 086 Fish/Waterbody Crossings. October 1, 2018.
2 Johnson and Blossom 2017.
3 Pacific salmon codes: CO = coho salmon; S = Sockeye salmon; CH = chum salmon; K = Chinook salmon.
4 Pacific salmon life stages: p = present; s = spawning; r = rearing (Johnson and Blossom 2017).
5 Crossing A044 is located more than 984 ft (300 m) up stream of AWC upper extent in tributary 324-10-10150-2183-3307

4.1.2 Coho Salmon

Coho salmon migration and spawning typically begins in late July/early August and continues through ice up in October (PLP 2018a). Females can deposit 2,000 to 4,500 eggs and fry emerge the following year between April and May. Juvenile coho salmon usually rear from one to three winters in freshwater. Juvenile coho salmon can establish winter territories in freshwater pools and lakes. In Spring, juveniles may move between brackish estuarine water and move into freshwater feeding habitats during the summer and fall (ADF&G 2007b). Juvenile out-migration is typically from April through June.

EFH within Action Area by life stage for coho salmon:

Eggs: 188,850 LF (57,562 LM) of freshwater stream habitat.

Larvae: 188,850 LF (57,562 LM) of freshwater stream habitat.

Early Juveniles: 241,515 LF (73,614 LM) of freshwater stream habitat; 11,187 ac (4,527 ha) of lake habitat (in Iliamna Lake).

Late Juveniles: 103,205 ac (41,766 ha) of marine habitat (in Cook Inlet).

Adults: 188,850 LF (57,562 LM) of freshwater stream habitat; 11,187 ac of lake habitat (in Iliamna Lake); 103,205 ac of marine habitat (in Cook Inlet).

All marine/estuarine life stages of coho salmon have designated EFH within Cook Inlet, including the shoreline and nearshore areas of Amakdedori Beach proposed by PLP for a marine and pipeline landing. Coho salmon EFH exists within NFK River, SFK River (including Frying Pan Lake), UT Creek, FC, Iliamna Lake, Newhalen River, and Amakdedori Creek (Table 4-2; Figure 4-4, Figure 4-5**;** Johnson and Blossom 2017, PLP 2011, PLP 2018a). Within the NFK River, SFK River, and UT Creek drainages, coho salmon predominately spawn between September and November in larger river reaches. Peak daily counts of adult coho salmon within the NFK and SFK rivers consistently occurred in September; peak daily counts in UT Creek ranged from late August to mid-September (PLP 2018a).

Much like Chinook salmon, coho salmon spawning was not observed in the uppermost reaches of the NFK River and SFK River (Table 4-5). Although small numbers of adult fish were observed throughout the NFK River and in the SFK River up to river km 51.2, more than 90 percent of spawning observations were downstream of river km 36.6 in the NFK River and 99 percent were downstream of river km 34.3 in the SFK River, suggesting higher quality spawning EFH or more than adequate quantities of spawning EFH are present in the lower reaches of drainage to support the numbers of returning fish (PLP 2011, Table 4-4, Table 4-5). During the aerial survey when coho salmon were most widespread in the basin, less than three percent of adults were observed in the four surveyed tributaries to the NFK River; 1.5 percent were observed in NFK 1.190 further suggesting that prime spawning EFH is not located within the tributaries of either drainage (Table 4-4). Less than 7 percent of adult coho salmon were observed in the three tributaries to the SFK River (Table 4-4). All documented spawning reaches in the AWC and adult counts from 2008 within NFK River, SFK River and UT Creek are depicted in Figure 4-4.

Within UT Creek, coho salmon spawning was documented throughout much of the drainage (Table 4-5; Johnson and Blossom 2017, PLP 2011, PLP 2018a). In 2008, during the aerial survey with the most widespread fish distribution, 72 percent of adult coho salmon were observed in the mainstem, while 28 percent were observed in the four tributaries (Table 4-4). Approximately 58 percent of the adults were located in the lower 44.9 km (27.9 mi) of the creek (Table 4-4; Figure 4-4). UT Creek by far supported the largest run of coho among the three watersheds in the mine study area, with peak counts ranging from 6,413 in 2006 to a low of 1,041 in 2005 (Table 4-3). Within UT Creek, peak densities of coho ranged from 30.1 fish/km in 2005 to 110.0 fish/km in 2006 (Table 4-3). Within SFK River, peak counts ranged from 1,955 in 2008 to 270 in 2004; peak densities ranged from 38.9 fish/km (2006) to 4.5 fish/km (2004) (Table 4-3). coho salmon peak counts within NFK ranged from 1,704 in 2008 to 114 in 2007; densities in NFK ranged from 30.7 coho/km in 2008 to 2.1 coho/km in 2007 and were the lowest among the three drainages (Table 4-3; PLP 2018a).

Juvenile coho salmon were the most widely dispersed and the most abundant juvenile salmon species observed. They were found year-round within all three drainages and length-frequency data indicate there are at least four age classes of early freshwater juveniles (0+, 1+, 2+, 3+) within the mine Action Area (PLP 2011). Within the NFK River mainstem and tributary sampling reaches from 2004 through 2009 and 2018, juvenile coho salmon were found throughout the mainstem and in several tributaries. In reaches upstream of river km 48.4, juvenile coho salmon observations were limited to 51 juveniles that were collected across multiple years (Table 4-6; PLP 2011). Juvenile coho salmon were most common in mainstem (NFK 1.0) habitats with average sample densities from the confluence with the SFK to river km 36.6 that ranged from 2.45 to 34.52 fish/ 100m^2 (Table 4-6, Table 4-7, Table 4-8). Sampling in tributary streams that drain into this reach of the NFK found densities of coho salmon juveniles on the lower end of that range, with average sample densities less than 2 fish/100m^2 (Table 4-6, Table 4-8). The average densities for sampled sites within NFK 1.190 and NFK 1.200 were 1.24 and 2.24 fish/100m^2 respectively (Table 4-8). The distribution of catch densities for coho salmon juveniles suggests that within the Action Area, EFH nearest the proposed mine is of lower quality or that habitats further downstream are more than adequate in quality and quantity to support the numbers of juveniles in the drainage.

For the SFK River, juvenile coho salmon were most common in mainstem habitats but densities were more variable than the NFK. From river km 0 to 51 (downstream of Frying Pan Lake) juvenile coho salmon sample densities ranged from 0.64 to 37.4 fish/100m^2 with a general tendency for higher densities downstream closer to the confluence with NFK (Table 4-6, Table 4-7). Average densities from tributary samples downstream of Frying Pan Lake were less variable than mainstem densities, ranging from 0.54 to 10.25 (Table 4-6, Table 4-8). Juvenile coho salmon density in the mainstem SFK within or upstream of Frying Pan Lake (river km 54.7) ranged from 0.12 to 2.52 fish/100m^2 (Table 4-6, Table 4-7, Table 4-8). No juvenile coho salmon were documented in tributaries upstream of Frying Pan Lake (Table 4-6, Table 4-8).

Within UT Creek, juvenile coho salmon were found throughout the mainstem from the confluence with Iliamna Lake to river km 62.4 (Table 4-7, Table 4-8; PLP 2011). Sample densities were highly variable in the mainstem reaches ranging from 0.64 to 124.40 fish/100m^2 and with highest densities in the middle UT reaches between approximately river km 16.8 and 59.1 (Table 4-6, Table 4-7). Juvenile coho salmon densities were similar in the UT tributaries ranging from 0.88 to 115.49 fish/100m^2 (Table 4-6, Table 4-8).

Coho salmon EFH is present at 15 stream crossings along the primary transportation corridor (Table 4-9) (R2 2018 studies, PLP EBD Chapter 15, 2018 AWC). Stream crossings consist of eight culverts and seven bridges (Table 4-9). Spawning coho salmon have been documented near three of the proposed crossings;

Amakdedori Creek tributary, First Creek and the upper section of UT Creek would all consist of single span bridges (Table 4-9; AWC 2018, PLP 2011). In UT Creek, upstream spawning was observed at its lowest numbers in 2008 (between UT-6 and UT-7) (Table 4-9; Figure 4-4). Rearing coho salmon EFH is located near all but one of the 15 crossings; the exception is one single span bridge crossing in First Creek (Table 4-9; AWC 2018).

4.1.3 Sockeye Salmon

Sockeye salmon typically spawn in lakes or rivers associated with lake systems, although they can occur in river systems without lakes. During migration, adult sockeye salmon are present from June through August (ADF&G 2014). Sockeye salmon adults spawn both in tributary streams and rivers, like UT Creek, and within Iliamna Lake itself where upwelling groundwater or wave action provide clean water and oxygen to the developing eggs (Demory et al. 1964, Olsen 1968). Tributary spawning in Iliamna Lake is much like that described above: fish enter the lake in June and July, move into tributaries in July, and spawn in July and August. Female sockeye salmon deposit 2,000 to 5,000 eggs in nests of cobble, gravel, or coarse sand. After incubating in the gravel, eggs hatch and sockeye salmon fry emerge in the spring and early summer. Lake spawning sockeye salmon, by contrast, spawn earlier, and in at least some locations, the fry emerge a few months later than those in tributaries (Kerns and Donaldson 1968). This pattern of earlier spawning and later emergence may be an adaptation to avoid lake level drops and ice scour that occur during the winter on the lake. Sockeye salmon juveniles normally leave freshwater and enter marine waters from April to June (ADF&G 2014).

EFH within Action Area by life stage for sockeye salmon:

Eggs: 112,336 LF (34,240 LM) of freshwater stream habitat.

Larvae: 112,336 LF (34,240 LM) of freshwater stream habitat.

Early Juveniles: 143,684 LF (43,795 LM) of freshwater stream habitat; 11,187 ac (4,527 ha) of lake habitat (in Iliamna Lake).

Late Juveniles: 103,205 ac (41,766 ha) of marine habitat (in Cook Inlet).

Adults: 112,336 LF (34,240 LM) of freshwater stream habitat; 11,187 ac (4,527 ha) of lake habitat (in Iliamna Lake); 103,205 ac (41,766 ha) of marine habitat (in Cook Inlet).

All marine/estuarine life stages of sockeye salmon have designated EFH within Cook Inlet. Juvenile sockeye salmon were consistently collected in estuarine surveys from 2004 to 2012 (PLP 2013) and were often one of the dominant salmonids captured north of the Amakdedori Port. They were also regularly collected at Amakdedori Beach, and again often represented one of the dominant salmonid species. This pattern of consistent and widespread collections indicates that sockeye salmon rear throughout the marine habitats along Amakdedori Beach, Ursus Cove, and areas sampled by PLP further north. Sockeye salmon freshwater EFH exists within the entire Action Area and includes NFK River, SFK River, UT Creek, First Creek, Newhalen River, Iliamna Lake, Gibraltar River, and Amakdedori Creek (Table 4-2; Figure 4-6, Figure 4-7; Johnson and Blossom 2017, PLP 2011).

Sockeye salmon were the most numerous salmon species observed during adult surveys from 2004 through 2008, particularly in UT Creek. Within all three river systems, EFH for sockeye salmon spawning was most heavily used lower in the drainage basins, again suggesting either higher quality spawning habitat or more than adequate quantities of suitable spawning habitats to limit upstream numbers of fish (Table 4-5). The highest number of spawning observations was observed in UT Creek, followed by the SFK and NFK rivers (Table 4-5). During 2008 surveys, over 98 percent of the sockeye salmon spawning observations in UT Creek occurred from the confluence of Iliamna Lake to 36.3 km (22.5 mi) upstream (Table 4-5). Spawning observations in 2008 totaled 177,642 over ten surveys with the highest number per km being 17,497 between river km 0 and 5.9 (Table 4-5). During the survey with the most widespread adult distribution, less than 1 percent of sockeye salmon were observed in the mainstem UT Creek upstream of river km 44.9 (Table 4-4). Over 41 percent (17,667 individual fish) were observed spawning in the tributary UT 1.160 (Table 4-4) indicating high quality spawning habitat in that drainage. All documented spawning reaches in the AWC and adult counts from 2008 within NFK River, SFK River and UT Creek are depicted in Figure 4-6.

Densities of adult sockeye salmon were considerably less in SFK and NFK rivers. During the most widespread distribution of sockeye salmon surveyed, a total of 6,134 sockeye salmon were observed along the length of the lower mainstem SFK River up to Frying Pan Lake, including a single fish in one of three reaches surveyed (Table 4-4). Nearly 50 percent of the sockeye were in a 4.2 km (2.6 mi) reach located 30.1 km (18.7 mi) upstream of the confluence with the NFK River (Table 4-4). Within the NFK River, a total of 6,852 observations of spawning sockeye salmon were documented, of which over 62 percent were located less than 5.6 mi (13.7 km) from the confluence with SFK River, and over 90 percent were within 36.6 river km (22.7 mi) of the confluence indicating a substantial portion of spawning EFH is located outside of the Action Area around the mine (Table 4-5). During the aerial survey with the most widespread sockeye salmon distribution, 6.3 percent of adult sockeye salmon were observed in tributaries, all in pond/lake habitats in the NFK 1.240 basin (Table 4-4). No sockeye salmon EFH was identified in tributary NFK 1.190 (Table 4-4).

Adult sockeye salmon were most frequently observed in UT Creek, followed by SFK River and NFK River (Table 4-3; PLP 2018a). UT Creek supported the largest run of sockeye salmon among the three watersheds, with peak counts ranging from 50,317 in 2008 to a low of 10,557 in 2007. Peak densities of sockeye salmon in UT Creek ranged from 805.1 fish/km in 2008 to 174.5 fish/km in 2007 (Table 4-3). Within the SFK River, peak counts ranged from 6,133 in 2008 to 1,730 in 2004, associated densities ranged from 140.0 fish/km (2008) to 40.8 fish/km (2005). Sockeye salmon adult peak counts in the NFK River ranged from 2,188 in 2007 to 563 in 2004. The associated sockeye salmon densities ranged from 39.4 fish/km in 2007 to 12.5 fish/km in 2004 and were the lowest densities each year among the three drainages (Table 4-3; PLP 2018a).

Essential fish habitat for early juvenile sockeye salmon was documented in all three drainages. Based on length frequency data, only one age class (0+) of juvenile sockeye was identified (PLP 2011). Juveniles were observed in the middle NFK River in April corresponding to the expected period of out-migration and were also found in the lower NFK River during summer sampling (August), indicating extended rearing of fry in the mainstem and a later out-migration period for at least some juveniles (PLP 2011).

In the NFK, juvenile sockeye salmon were found from the confluence with the SFK upstream to river km 36.6 (Table 4-6). The average sample densities of sockeye salmon juveniles in mainstem NFK habitats ranged from less than 0.01 to 1.89 (Table 4-6, Table 4-7, Table 4-8). Juvenile sockeye salmon were not collected from any NFK tributary sampling during the open water period; but, since spawning has been documented in Big Wiggly Lake, within the NFK 1.240 drainage, it is assumed fry rearing occurs in the lower reached of this tributary.

Within SFK, juvenile sockeye salmon distribution was generally similar to the adult count and spawner distributions; however, low densities of sockeye salmon juveniles (0.02) were observed upstream of Frying Pan Lake indicating either lower quality EFH or adequate quantities of quality EFH downstream of the area to support the numbers of fish present, likely in Frying Pan Lake (river km 54.7; Table 4-6, Table 4-8). This finding is consistent with the existing literature in that juvenile sockeye are known to swim upstream in search of a lake for rearing (Healey 1991). The average densities for sockeye salmon juveniles in SFK mainstream habitats ranged from 0.02 to 1.96 fish/100m^2 (Table 4-6, Table 4-7, Table 4-8). Sockeye salmon juveniles were found in two SFK tributaries with average sampling densities of 0.28 and 3.26 fish/100m^2 (1,076 ft^2) in SFK 1.240 and SFK 1.260 respectively (Table 4-8).

In the UT, juvenile sockeye salmon were found from river km 16.8 to 59.1. Juvenile fish were collected from April through September, indicating rearing of class 0+ fish within the UT Creek drainage, and later out-migration timing for at least some individuals (PLP 2011). In mainstream habitats, average sample densities ranged from 0.39 to 2.28 fish/100m^2 (1,076 ft^2) (Table 4-6). Juvenile sockeye salmon were sampled in two UT tributaries in 2008 with average densities of 0.31 and 0.34 for UT 1.380 and UT 1.390, respectively (Table 4-8).

Along the transportation corridor, sockeye salmon EFH is present at five of the 15 crossings over EFH. Sockeye salmon spawning EFH has been documented within Amakdedori Creek tributary, Gibraltar Creek and Gibraltar Creek tributary, UT Creek, and the Newhalen River (AWC 2018). During a 2018 site reconnaissance visit, an Alaska Department of Fish and Game (ADF&G) habitat biologist observed spawning sockeye salmon at the crossing location on an unnamed tributary to Gibraltar Creek (Stream crossing ID 225, Table 4-9; Crossing ADF&G Trip Report, 2018). Juvenile sockeye salmon rearing EFH is located within Gibraltar Creek, UT Creek, and the Newhalen River (AWC 2018, R2 2018). Bridges are planned for all sockeye salmon EFH crossings. This includes single span bridge designs over the Amakdedori Creek tributary crossing, UT Creek crossing, and the Gibraltar Creek tributary (crossing A029). In addition, two multi-span bridge designs would cross Gibraltar Creek and the Newhalen River. All stream crossings of sockeye salmon EFH are depicted in Figure 4-6 and Figure 4-7.

4.1.4 Chum Salmon

Chum salmon typically begin their spawning migration from June to July with spawning taking place from July to August. Females typically deposit up to 4,000 eggs. Chum salmon fry emerge from April through May the following year and immediately begin moving downstream to the sea, usually shortly after ice breaks up from their natal rivers. The duration of this migration depends on the total distance traveled and water velocities encountered. In most cases, the downstream migration takes a few hours to a few days. Little or no feeding occurs in streams during the downstream migration, and feeding may not occur until smolts reach estuarine or salt water habitats at river mouths, thus making marine food resources important for juveniles from late May through July. Once in the estuary, juveniles form schools and normally remain close to shorelines for several months to feed and grow prior to moving into the high seas. Salo (1991) describes chum salmon juveniles as depending on a detritus-based food web in the estuarine habitat. By late summer, juvenile chum salmon move to offshore waters. By their first winter, chum salmon have moved into the GOA and spend 3 to 4 years in the ocean before returning to natal streams (NPFMC 2012).

EFH within the Action Area by life stage for chum salmon:

Eggs: 90,425 LF (27,561 LM) of freshwater stream habitat.

Larvae: 90,425 LF (27,561 LM) of freshwater stream habitat.

Early Juveniles: 81,429 LF (24,820 LM) of freshwater stream habitat; 11,187 ac (4,527 ha) of lake habitat (in Iliamna Lake).

Late Juveniles: 103,205 ac (41,766 ha) of marine habitat (in Cook Inlet).

Adults: 90,425 LF (27,561 LM) of freshwater stream habitat; 11,187 ac (4,527 ha) of lake habitat (in Iliamna Lake); 103,205 ac (41,766 ha) of marine habitat (in Cook Inlet).

All marine/estuarine life stages of chum salmon have designated EFH within Cook Inlet. Juvenile chum salmon were one of three species that dominated the estuarine surveys from 2004-2012 (PLP 2013) north of the Amakdedori Port. They were also regularly collected at Amakdedori Beach. This pattern of consistent and widespread collections indicates that chum salmon rear throughout the marine habitats along Amakdedori Beach, Ursus Cove, and areas sampled by PLP further north. Chum salmon EFH in freshwater exists within NFK River, SFK River, UT Creek, Iliamna Lake, Gibraltar River, and Amakdedori Creek (Table 4-2; Figure 4-8, Figure 4-9; Johnson and Blossom 2017, PLP 2011). The distribution of this species was considerably more restricted in the Action Area than for Chinook, coho, or sockeye salmon. Distribution of chum salmon in these drainages is generally restricted to low-gradient stream reaches due to poor swimming capabilities compared to other salmon. This is a consistent observation throughout the drainages surveyed.

Chum salmon adult returns were highest in the NFK and SFK rivers and lasted approximately six weeks, from July to mid-August (PLP 2018a). All chum salmon spawning within the NFK River occurred in mainstem habitats, between the SFK River confluence and 36.6 km (22.7 mi) upstream (Table 4-5). Just over 79 percent of chum salmon spawning in this section were observed within a 15.5 km (9.6 mi) reach between river km 21.1 and 36.6 (Table 4-5). No adult chum salmon were observed in tributary NFK 1.190 on the survey with the most widespread adult distribution (Table 4-4). Within the SFK River, most chum salmon spawning occurred in mainstem habitats and downstream of river km 34.3. All spawning observations in the SFK River were within the lower 34.3 km (21.3 mi) of river, with over 64 percent occurring within a 9.4 km (5.8 mi) section between river km 24.9 and 34.3. However, during the survey with the most widespread adult distribution, 3.5 percent of adult chum salmon were observed in tributaries (Table 4-4). Relatively few chum salmon were observed spawning in UT Creek (73 observations) and were distributed between river km 0 and 59.1 and in tributary UT 1.140 (Table 4-4, Table 4-5; PLP 2011, Johnson and Blossom 2017). All documented chum spawning reaches in the AWC and adult counts in 2008 within NFK River, SFK River and UT Creek are depicted in Figure 4-8.

Chum salmon peak daily counts show that the runs of adult chum salmon are of similar size in the NFK and SFK rivers and appeared to be considerably reduced in the UT (Table 4-3). Chum salmon peak counts from aerial surveys in the NFK River ranged from 350 in 2005 to 1,432 in 2008; associated densities ranged from 7.8 fish/km in 2005 to 31.9 fish/km in 2008 (Table 4-3). Peak counts in SFK River ranged from 0 in 2004 to 917 in 2008; associated densities ranged from 0 fish/km in 2004 to 24.2 /km in 2006 (Table 4-3). Numbers of observed adult chum salmon in UT Creek were consistently lower than observations in the NFK and SFK rivers. Overall, peak counts of adult chum salmon within UT Creek ranged from 0 chum salmon in 2004 to 44 in 2008.

Essential fish habitat for early juvenile chum salmon is limited within the Action Area and observations of individuals were low in all three rivers. They were primarily found in mainstem habitats with sample densities less than 0.4 fish/100m^2 (Table 4-6). Newly emerged fry were only found within NFK River during winter surveys (PLP 2011). Juvenile chum salmon are known to have a brief period of stream residence from emergence to out-migration and it is likely that the juvenile population consists of a single age class of out-migrating smolts in all three drainages (PLP 2011).

Along the transportation corridor, chum salmon spawning EFH is present within two stream crossings, Gibraltar Creek and UT Creek. Both crossings are proposed as bridges; multi-span bridge design for the Gibraltar Creek crossing and a single span design for the UT Creek crossing (Table 4-9). Chum salmon spawning EFH is documented as far as the outlet of Gibraltar Lake within Gibraltar Creek (AWC 2018). Within the main channel of UT Creek, chum salmon spawning EFH extends just upstream of the proposed crossing locations (Table 4-6, Table 4-9, Figure 4-8; Johnson and Blossom 2017).

4.1.5 Pink Salmon

Females may deposit 1,500 to 2,000 eggs in a gravel nest in freshwater or, in some areas, in upper intertidal zones. The eggs hatch during winter and the developing fish, or alevins, remain in the gravel using their yolk sacs for nourishment. Fry emerge from the gravel in late winter or early spring and immediately move downstream to marine waters. Time spent in freshwater varies, depending on the distance the juveniles travel and stream velocities encountered. Freshwater residence of a few hours to a few days is typical. Feeding does not normally occur during this downstream migration. In the ocean, juvenile pink salmon feed on plankton and larval fish, and may reach four to six inches in length by their first winter. They spend the next year in the open ocean, returning the following summer to spawn in their natal streams. This life cycle of the Pacific salmon is two years from hatching to spawning; the shortest of all Pacific salmon species. Because pink salmon spawn at two years of age, two separate lines of unrelated fish develop in alternating odd and even year cycles. In some locations one line may be dominant over the other in abundance. In the Cook Inlet region, larger pink salmon runs occur during even years.

EFH within Action Area by life stage for pink salmon:

Eggs: 0 LF (0 LM) of freshwater stream habitat.

Larvae: 0 LF (0 LM) of freshwater stream habitat.

Early Juveniles: 0 LF (0 LM) of freshwater stream habitat; 11,187 ac (4,527 ha) of lake habitat (in Iliamna Lake).

Late Juveniles: 103,205 ac of marine habitat (in Cook Inlet).

Adults: 0 LF (0 LM) of freshwater stream habitat; 11,187 ac (4,527 ha) of lake habitat (in Iliamna Lake); 103,205 ac (41,766 ha) of marine habitat (in Cook Inlet).

All marine/estuarine life stages of pink salmon have designated EFH within Cook Inlet. Juvenile pink salmon were one of three species that dominated the estuarine surveys from 2004 to 2012 north of Amakdedori Port (PLP 2013). They were also regularly collected at Amakdedori Beach and estuaries. This pattern of consistent and widespread collections indicates that pink salmon rear throughout the marine habitats along Amakdedori Beach, Ursus Cove, and areas further north.

Almost no pink salmon EFH exists within the Action Area. EFH is present in UT Creek, Iliamna Lake, Gibraltar Creek, and Amakdedori Creek (Table 4-2; Figure 4-10, Figure 4-11; Johnson and Blossom 2017, R2 2018). EFH within UT Creek and Iliamna Lake is based on presence, while Amakdedori Creek EFH is based on presence and spawning (Johnson and Blossom 2017, PLP 2011). Migrating adults were observed during 2018 fish presence surveys at the Gibraltar Creek crossing location. Fish distribution surveys conducted from 2004 to 2008 within the Mine Site and Transportation Corridor footprint (north of Iliamna Lake) did not record any pink salmon within the NFK River or SFK River and the species was only recorded in UT Creek during aerial surveys in 2006 and 2007. In 2006, there were 336 pink salmon recorded during two aerial surveys: July 26 (n=315) and September 4 (n=21; PLP 2018a). All pink salmon observations occurred in the lower reaches of UT Creek. No juvenile pink salmon were recorded.

4.2 Groundfish and Forage Fishes

The Groundfish FMP includes 43 groundfish species and more than eight forage fish species within the forage fish complex in the Action Area (Table 4-10). EFH distribution data does not exist for all managed species and life stages within this FMP, such as sharks, forage fish complex, squids, and grenadiers (NPFMC 2018b). Thirty-nine groundfish species have designated EFH within the Action Area (Table 4-10). The area of EFH for each species and life stage within the Action Area and the GOA is provided in (Table 4-11). All designated EFH for listed species in the Groundfish FMP, which occurs in the Action Area, is depicted in Figure 4-12 through Figure 4-20.

Table 4-10: Designated EFH for multiple life stages of groundfish within the Action Area.[1]

Group	EFH Species	Egg				Larvae				Juvenile				Adult			
		Amakdedori Port	Lighted Navigation Buoys	Lightering Locations	Natural Gas Pipeline	Amakdedori Port	Lighted Navigation Buoys	Lightering Locations	Natural Gas Pipeline	Amakdedori Port	Lighted Navigation Buoys	Lightering Locations	Natural Gas Pipeline	Amakdedori Port	Lighted Navigation Buoys	Lightering Locations	Natural Gas Pipeline
Atka mackerel	Atka mackerel													✓	✓	✓	✓
Flatfish	Alaska plaice	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓
	Arrowtooth Flounder					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Dover sole	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Flathead sole	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Northern rock sole					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Rex sole	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓
	Southern rock sole					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Yellowfin sole	✓	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓
GOA Skates (Rajidae)	Alaska skate									✓	✓	✓	✓	✓	✓	✓	✓
	Aleutian skate													✓	✓	✓	✓
	Bering skate									✓	✓	✓	✓	✓	✓	✓	✓
Octopus	Octopus													✓	✓	✓	✓
Pacific cod	Pacific cod					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Rockfish (Sebastes)	Black rockfish													✓	✓	✓	✓
	Blackspotted rockfish									✓	✓	✓	✓	✓	✓	✓	✓
	Dark rockfish													✓	✓	✓	✓

Group	EFH Species	Egg				Larvae				Juvenile				Adult			
		Amakdedori Port	Lighted Navigation Buoys	Lightering Locations	Natural Gas Pipeline	Amakdedori Port	Lighted Navigation Buoys	Lightering Locations	Natural Gas Pipeline	Amakdedori Port	Lighted Navigation Buoys	Lightering Locations	Natural Gas Pipeline	Amakdedori Port	Lighted Navigation Buoys	Lightering Locations	Natural Gas Pipeline
	Dusky rockfish									✓	✓	✓	✓	✓	✓	✓	✓
	Greenstriped rockfish													✓	✓	✓	✓
	Harlequin rockfish									✓	✓	✓	✓	✓	✓	✓	✓
	Longspine thornyhead rockfish													✓	✓	✓	✓
	Northern rockfish									✓	✓	✓	✓	✓	✓	✓	✓
	Pacific ocean perch					✓	✓	✓	✓					✓	✓	✓	✓
	Pygmy rockfish													✓	✓	✓	✓
	Quillback rockfish													✓	✓	✓	✓
	Redbanded rockfish													✓	✓	✓	✓
	Redstriped rockfish									✓	✓	✓	✓	✓	✓	✓	✓
	Rosethorn rockfish									✓	✓	✓	✓	✓	✓	✓	✓
	Rougheye rockfish													✓	✓	✓	✓
	Sharpchin rockfish													✓	✓	✓	✓
	Shortraker rockfish									✓	✓	✓	✓	✓	✓	✓	✓
	Shortspine thornyhead rockfish													✓	✓	✓	✓
	Silvergrey rockfish									✓	✓	✓	✓				
	Yelloweye rockfish									✓	✓	✓	✓	✓	✓	✓	✓
Sablefish	Sablefish					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sculpins (Cottidae)	Bigmouth sculpin									✓	✓	✓	✓	✓	✓	✓	✓
	Great sculpin									✓	✓	✓	✓	✓	✓	✓	✓

Group	EFH Species	Egg				Larvae				Juvenile				Adult			
		Amakdedori Port	Lighted Navigation Buoys	Lightering Locations	Natural Gas Pipeline	Amakdedori Port	Lighted Navigation Buoys	Lightering Locations	Natural Gas Pipeline	Amakdedori Port	Lighted Navigation Buoys	Lightering Locations	Natural Gas Pipeline	Amakdedori Port	Lighted Navigation Buoys	Lightering Locations	Natural Gas Pipeline
	Yellow Irish lord									✓	✓	✓	✓	✓	✓	✓	✓
Walleye pollock	Walleye pollock	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sharks		No EFH description determined. Insufficient information available.															
Forage Fish Complex	Eulachon																
	Capelin																
	Sand lance																
	Sand fish																
	Euphausiids																
	Mycotophids																
	Pholids																
	Gnostamatids																
Squids																	
Grenadiers																	

Note:
1 A "✓" indicates presence.

Table 4-11: Designated EFH for multiple life stages of groundfish within the Action Area and the GOA.

Group	EFH Species	Egg		Larvae		Juvenile		Adult	
		Action Area (ac)	GOA (ac)	Action Area (ac)	GOA (ac)	Action Area (ac)	GOA (ac)	Action Area (ac)	GOA (ac)
Atka mackerel		--	--	--	--	--	--	103,080	73,325,998
GOA Skates (Rajidae)	Alaska skate	--	--	--	--	98,560	70,477,514	103,094	74,355,769
	Aleutian skate	--	--	--	--	--	--	101,410	73,914,303
	Bering skate	--	--	--	--	95,373	70,496,970	99,273	70,473,511
Octopus		--	--	--	--	--	--	99,180	74,219,105
Pacific cod		--	--	99,371	78,967,281	102,967	58,838,534	102,979	74,346,347
Sablefish		--	--	85,361	79,052,790	35,393	24,335,810	103,062	73,904,084
Sculpins (Cottidae)	Bigmouth sculpin	--	--	--	--	91,322	70,464,049	97,302	73,694,901
	Great sculpin	--	--	--	--	102,985	70,491,526	103,003	70,479,523
	Yellow Irish lord	--	--	--	--	102,967	70,484,854	103,105	72,780,979
Walleye pollock		95,005	79,004,264	97,699	78,984,996	88,760	67,343,867	95,276	73,619,635
Rockfish (Sebastes)	Black rockfish	--	--	--	--	--	--	100,111	70,450,275
	Blackspotted rockfish	--	--	--	--	18,961	70,501,578	29,379	70,508,455
	Dark rockfish	--	--	--	--	--	--	102,928	70,468,821
	Dusky rockfish	--	--	--	--	103,004	70,466,091	90,715	73,960,770
	Greenstriped rockfish	--	--	--	--	--	--	102,958	70,505,065
	Harlequin rockfish	--	--	--	--	94,227	70,501,211	66,814	70,514,090
	Longspine thornyhead rockfish	--	--	--	--	--	--	103,011	73,670,672
	Northern rockfish	--	--	--	--	93,242	70,478,222	102,951	73,298,286
	Pacific ocean perch	--	--	95,344	79,021,994	--	--	93,537	73,948,125
	Pygmy rockfish	--	--	--	--	--	--	102,927	70,487,259
	Quillback rockfish	--	--	--	--	--	--	84,759	70,473,437
	Redbanded rockfish	--	--	--	--	--	--	83,488	72,590,996
	Redstriped rockfish	--	--	--	--	102,953	70,478,836	86,492	70,483,511
	Rosethorn rockfish	--	--	--	--	102,872	70,487,752	102,967	70,491,170

Group	EFH Species	Egg		Larvae		Juvenile		Adult	
		Action Area (ac)	GOA (ac)	Action Area (ac)	GOA (ac)	Action Area (ac)	GOA (ac)	Action Area (ac)	GOA (ac)
	Rougheye rockfish	--	--	--	--	--	--	95,973	74,405,992
	Sharpchin rockfish	--	--	--	--	--	--	95,977	73,206,339
	Shortraker rockfish	--	--	--	--	77,266	70,533,850	98,246	72,007,065
	Shortspine thornyhead rockfish	--	--	--	--	--	--	92,786	73,664,827
	Silvergrey rockfish	--	--	--	--	84,130	70,485,372	--	--
	Yelloweye rockfish	--	--	--	--	84,125	70,501,411	101,208	73,492,368
Flatfish	Alaska plaice	102,788	78,960,325	101,296	78,979,024	--	--	103,013	70,474,639
	Arrowtooth Flounder	--	--	92,585	79,028,485	57,435	66,900,710	92,696	73,912,214
	Dover sole	84,775	79,054,922	99,437	78,981,853	90,733	63,446,377	103,110	74,117,979
	Flathead sole	95,991	78,980,147	99,975	78,968,963	49,425	61,835,611	84,294	73,876,869
	Northern rock sole	--	--	103,145	78,976,366	71,405	18,917,984	103,066	73,464,040
	Rex sole	97,221	79,031,959	97,552	79,002,616	--	--	93,108	73,505,536
	Southern rock sole	--	--	94,997	78,980,527	42,297	22,477,782	93,623	55,572,850
	Yellowfin sole	91,967	79,020,102	--	--	103,047	70,466,794	103,019	70,473,016
Sharks		No EFH description determined. Insufficient information available							
Forage Fish Complex	Eulachon								
	Capelin								
	Sand lance								
	Sand fish								
	Euphausiids								
	Mycotophids								
	Pholids								
	Gnostamatids								
Squids									
Grenadiers									

Forage fishes are those species that are a food source for marine mammals, seabirds, and other fish species. The forage fish species category was established to enable management of these species in a manner that prevents or strictly manages development of a commercial fishery directed toward forage fish (NPFMC 2014), however EFH descriptions have not been determined for forage fish in the Action Area due to insufficient information available (NPFMC 2018b). Common forage fish species within Cook Inlet include members of Family Osmeridae (eulachon, capelin, and other smelt) and Ammodytidae (Pacific sand lance). Table 4-12 lists caught members of the Forage Fish Complex for GOA Groundfish FMPs.

Table 4-12: Forage fishes of the GOA groundfish FMP identified in Project sampling.

Gulf of Alaska Forage Fish Complex
Osmeridae
Eulachon
Capelin
Other smelts
Gunnels
Lanternfishes (Myctophidae)
Pricklebacks (Stichaeidae)

Sampling in marine habitats between Amakdedori Beach and Iniskin Bay was conducted between 2010 and 2018 (GeoEngineers 2018a, PLP 2013). A variety of gear was used, including beach seine, gill net, trammel net and otter trawl. Fish species in EFH categories for Pacific salmon, targeted groundfish, prohibited species, and forage fish were captured during the sampling (Table 4-12, Table 4-13, Table 4-14). Additional sampling results with similar gear are available for Iliamna Bay and Iniskin Bay from 2004 to 2008 (PLP 2013). Results from the earlier sampling are consistent with the more recent sampling with minor variability in species composition and catch rates, however this sampling was more restricted in the area covered and not near the present proposed dock facility at Amakdedori Beach. Designated EFH does not exist for any forage fish complex species within the Action Area, or in Cook Inlet. However, PLP sampling in the region has identified several species of the forage fish complex and based on their presence in sample data, particularly for surf smelt, EFH for the species listed in Table 4-10 is inferred. Essential fish habitat is briefly described by species and life stage for all species with defined habitat in Cook Inlet, including inferred EFH for forage fish complex species listed above. Essential fish habitat within the Cook Inlet Action area was quantified by species and life stage where data were available and the Cook Inlet-wide quantity of EFH is provided in parenthesis.

Table 4-13: Catch per set by bay during nearshore marine sampling between Cottonwood Bay and Iniskin (2010-2012), and Amakdedori Beach (2018).[1]

		Beach Seine 120 ft (36.6 m)							Beach Seine 30 ft (9.1 m)		Gill Net			Trammel Net		
EFH Category	**Species**	**Amakdedori 2018**	**Rocky Cove**	**Ursus Cove**	**Ursus Lagoon**	**Cottonwood Bay**	**Iliamna Bay**	**Iniskin Bay**	**Ursus Lagoon**	**Iliamna Bay**	**Rocky Cove**	**Ursus Cove**	**Cottonwood Bay**	**Rocky Cove**	**Ursus Cove**	**Cottonwood Bay**
Pacific Salmon																
	Chinook salmon, juvenile	0.13	1.5	1.3		0.1	0.1					0.7	0.3			
	Chum salmon, juvenile									26.2						
	Adult				11.0											
	Juvenile	5.00		2.8		23.4	24.1	13.5								
	Coho salmon, juvenile	0.56				0.3	0.2	0.9		1.0						
	Sockeye salmon															
	Adult	0.06														
	Juvenile	0.81		0.3		0.1	0.3	0.2		1.0						
	Pink salmon, juvenile	25.81	24.0	17.3		7.8	11.2	10.4		0.7						
Groundfish Target Species																
	Walleye pollock (*Theragra chalcogramma*)	0.19				0.1	0.2	0.4								
	Pacific cod (*Gadus macrocephalus*)					0.1	0.1	0.9							0.3	
	Rock sole (*Lepidopsetta bilineata*)						0.1									
	Sand sole (*Psettichthys melanostictus*)														0.3	
	Starry flounder (*Platichthys stellatus*)	2.63	3.0	0.8	5.0	0.6	2.5	0.1	64.0	0.2		0.7	0.3	0.3	3.0	1.0
	Yellowfin sole (*Pleuronectes asper*)															0.5
	Flatfish, unid. (Pleuronectidae)	0.06														
	Great sculpin (*Myoxocephalus polyacanthocephalus*)	0.31		0.3	1.0	1.6	0.2	0.2				0.3				
	Pacific staghorn sculpin (*Leptocottus armatus*)	0.38	5.0	0.5	0.5	0.1	0.4		14.0	2.1					1.3	0.5
	Sculpin, unid. (Cottidae)									0.1						
	Shorthorn sculpin (*Myoxocephalus scorpius*)			0.5												
	Silverspotted sculpin (*Blepsias cirrhosis*)	0.19		0.3			0.1									
	Spiny dogfish (*Squalus acanthias*)											0.3	1.0	0.3	4.3	1.5
Prohibited Species																
	Pacific halibut (*Hippoglossus stenolepis*)														2.0	0.3
	Pacific herring (*Clupea pallasii*)	0.75	77.0	405.5		56.2	555.6	0.3		35.4		2.0	21.7		0.3	0.3
Forage Fish																
	Eulachon (*Thaleichthys pacificus*)							0.1								
	Longfin smelt (*Spirinchus thaleichthys*)					0.3	2.4									
	Surf smelt (*Hypomesus pretiosus*)	1.63		4.5		1.5	3.6	0.2		0.2						
	Surf smelt larvae	23.06														
	Pacific sand lance (*Ammodytes hexapterus*)	0.13				2.3	0.2	28.3								
	Snake prickleback (*Lumpenus sagitta*)					0.4	0.2									

EFH Category	Species	Beach Seine 120 ft (36.6 m)							Beach Seine 30 ft (9.1 m)		Gill Net			Trammel Net		
		Amakdedori 2018	Rocky Cove	Ursus Cove	Ursus Lagoon	Cottonwood Bay	Iliamna Bay	Iniskin Bay	Ursus Lagoon	Iliamna Bay	Rocky Cove	Ursus Cove	Cottonwood Bay	Rocky Cove	Ursus Cove	Cottonwood Bay
Unclassified																
	Dolly Varden (*Salvelinus malma*)	1.69	5.0	1.8	3.5	7.3	3.9	9.7	1.0	1.1	0.3	1.3				
	Tomcod (*Microgadus proximus*)	0.06														
	Kelp greenling (*Hexagrammos decagrammus*)										0.3	0.3		1.7		
	Whitespotted greenling (*Hexagrammos stelleri*)	17.63				0.2	0.2	0.1		0.1		0.3		0.7	1.0	1.8
	Greenling (unid.) (*Hexagrammos* sp.)					0.3	0.2									
	Threespine stickleback (*Gasterosteus aculeatus*)	0.38					0.4	0.1		206.7						
	Tubesnout (*Aulorhynchus flavidus*)	0.06					0.5									
	Tubenose poacher (*Pallasina barbata*)	0.06		4.3		0.1	0.1									
	Larval fish, unid.	0.69					0.0									
	Number of Species	**19**	**6**	**13**	**5**	**19**	**24**	**15**	**3**	**12**	**2**	**8**	**4**	**4**	**8**	**7**
	Number of Sets	**16**	**2**	**4**	**2**	**16**	**38**	**15**	**10**	**10**	**3**	**3**	**3**	**3**	**3**	**4**

Note:
1 GeoEngineers 2018a, PLP 2013

Table 4-14: Catch per set for fish captured by otter trawl between Rocky Cove and Iniskin Bay, 2010-2012.[1]

EFH Category	Species	Rocky Cove	Ursus Cove	Cottonwood Bay	Iliamna Bay	Iniskin Bay
Groundfish Target Species						
	Walleye pollock (*Theragra chalcogramma*)			0.8	3.0	3.4
	Pacific cod (*Gadus macrocephalus*)		14.0		0.4	2.0
	Alaska plaice (*Pleuronectes quadrituberculatus*)				0.1	
	Arrowtooth flounder (*Atheresthes stomias*)			0.3	0.1	0.1
	English Sole (Pleuronectes vetulus)			0.3		
	Rock sole (*Lepidopsetta bilineata*)			0.5	0.5	
	Sand sole (*Psettichthys melanostictus*)	1.0	0.3	0.3	0.5	0.2
	Starry flounder (*Platichthys stellatus*)		0.7	1.8	8.3	0.2
	Yellowfin sole (*Pleuronectes asper*)		2.7	5.3	4.8	1.0
	Flatfish, unid. (Pleuronectidae)				0.1	
	Armorhead Sculpin (*Gymnocanthus galeatus*)	1.0				
	Great sculpin (*Myoxocephalus polyacanthocephalus*)				0.5	0.7
	Pacific staghorn sculpin (*Leptocottus armatus*)				1.3	
	Padded sculpin (*Artedius fenestralis*)				0.2	0.2
	Threaded sculpin (*Gymnocanthus pistilliger*)					0.2
	Yellow Irish Lord (*Hemilepidotus jordani*)					0.2
	Sculpin, unid. (Cottidae)					0.2
	Spiny dogfish (*Squalus acanthias*)			0.3		
Prohibited Species						
	Pacific halibut (*Hippoglossus stenolepis*)	2.0	2.7	2.8	0.8	0.2
	Pacific herring (*Clupea pallasii*)			2.3	0.7	0.5
Forage Fish						
	Longfin smelt (*Spirinchus thaleichthys*)			1.0	0.7	0.1
	Snake prickleback (*Lumpenus sagitta*)		7.7	10.8	2.7	0.9
Unclassified						
	Kelp greenling (*Hexagrammos decagrammus*)				0.1	
	Whitespotted greenling (*Hexagrammos stelleri*)	1.0	3.3	1.0	0.7	0.2
	Lingcod (*Ophiodon elongatus*)		0.7			
	Tubesnout (*Aulorhynchus flavidus*)		0.7		0.4	
	Bering poacher (*Occela dodecaedron*)				0.1	
	Sturgeon poacher (*Podothecus acipenserinus*)			1.0	0.7	0.1
	Tubenose poacher (*Pallasina barbata*)		0.7		0.5	
	Variegated snailfish (*Liparis gibbus*)				0.1	0.5
	Lumpsucker (Liparis sp.)			0.3		
	Larval fish, unid.			0.5		
Number of Species		**4**	**10**	**16**	**23**	**18**
Number of Sets		**1**	**3**	**4**	**11**	**13**

Note:
1 PLP 2013.

In 2018, soft- and hard-bottomed habitats not associated with reefs were sampled using a 10-ft otter trawl to help determine how the fish community and productivity of these habitats differed from those of the reefs. Total fish captured across all sites and effort was 178, which equates to an average catch per unit of effort (CPUE) of 4.5 fish/set, within the range obtained for the other survey areas. Average CPUE (fish/set) ranged from 2.8 at Amakdedori, 6.9 for Iliamna/Iniskin Estuary and 8.4 for Ursus Cove, over the same time period. In 2013, average CPUE from trawl net surveys was similarly low for Amakdedori at 2.2 fish/set. In 2018 the trawl catches were dominated by whitespotted greenling and Pacific cod, whereas in 2013 Pacific herring and juvenile flatfish were dominant.

4.2.1 Atka Mackerel

Atka mackerel are widely distributed from the GOA to the Kamchatka Peninsula to the GOA. EFH for Atka mackerel has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11; Figure 4-12). Adult Atka mackerel occur in large localized aggregations and generally over rough, rocky, and uneven bottom near areas where tidal currents are swift (NPFMC 2018b). Adults are semi-demersal, displaying strong diel behavior with vertical movements away from the bottom occurring almost exclusively during the daylight hours, presumably for feeding, and little to no movement at night. Spawning is demersal in moderately shallow waters down to 470 ft (144 m) and peaks in June through September but may occur intermittently throughout the year (NPFMC 2018b). Female Atka mackerel deposit eggs in nests built and guarded by males on rocky substrates or on kelp in shallow water. Eggs develop and hatch at depth in 40 to 45 days, releasing planktonic larvae that have been found up to a mile (800 km) from shore. Little is known of the distribution of young Atka mackerel before their appearance in trawl surveys and the fishery at about age 2 to 3 years (NPFMC 2018b). Young age at maturity (approximately 50 percent are mature at age 3.6) and experience fast growth rates and high natural mortality (mortality equals 0.3). Young average and maximum ages are about 5 and 14 years, respectively. Females have relatively low fecundity (only about 30,000 eggs/female/year) with large egg diameters and male nest-guarding behavior (NPFMC 2018b).

Eggs: Adhesive eggs are deposited in nests built and guarded by males on rocky substrates or on kelp in moderately shallow water (NPFMC 2018b).

Larvae: Planktonic larvae have been found up to one mile (800 km) from shore, usually in the upper water column, but little is known of their distribution (NPFMC 2018b).

Juveniles: Little is known of juvenile Atka mackerel distribution until age 2, when they have appeared in the fishery and surveys (NPFMC 2018b).

Adults: Adults occur in localized aggregations usually at depths less than 656 ft (200 m) and generally over rough, rocky, and uneven bottom near areas where tidal currents are swift. Adults are semi-demersal/pelagic during much of the year, but the males become demersal during spawning; females move between nesting and offshore feeding areas (NPFMC 2018b).

4.2.2 Flatfish

4.2.2.1 Alaska Plaice

Alaska plaice are distributed across the continental shelf waters of the North Pacific ranging from the GOA to the Bering and Chukchi Seas (Pertseva-Ostroumova 1961, Quast and Hall 1972). EFH for Alaska plaice has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11). EFH for flatfish managed species is depicted in Figure 4-13. Adults are benthic and caught in near shore areas along the Alaska Peninsula and Kodiak Island in summer resource assessment surveys (Fadeev 1965, NPFMC 2018b). Alaska plaice over-winter near the shelf margins and adults begin a migration onto the central and northern shelf of the eastern Bering Sea, primarily at depths of less than 300 ft (100 m), although it is unknown if this behavior is also consistent with the GOA (NPFMC 2018b). Spawning usually occurs in March and April on hard sandy ground (Zhang 1987). The eggs and larvae are pelagic and transparent and have been found in ichthyoplankton sampling in late spring and early summer over a widespread area of the continental shelf (NPFMC 2018b).

Eggs: No EFH description determined – insufficient information is available.

Larvae: Alaska plaice larvae are planktonic for up to three months until metamorphosis occurs in shallow water (NPFMC 2018b).

Juveniles: No EFH description determined – insufficient information is available.

Adults: Alaska plaice feed in the summer on sandy substrates of the eastern Bering Sea shelf. They are widely distributed on the middle, northern portion of the shelf and feed on polychaete, amphipods and echiurids. During the winter fish migrate to deeper waters of the shelf margin to avoid extreme cold-water temperatures. Feeding diminishes until spring after spawning (NPFMC 2018b).

4.2.2.2 Arrowtooth Flounder

Arrowtooth flounder are distributed in North American waters from central California to the eastern Bering Sea on the continental shelf and upper slope. EFH for arrowtooth flounder has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11). Adults exhibit a benthic lifestyle and occupy separate winter and summer distributions on the eastern Bering Sea shelf. Arrowtooth flounder overwinter near the shelf margins and upper slope areas and begin a migration onto the middle and inner shelf in April or early May each year with the onset of warmer water temperatures (NPFMC 2018b). A protracted and variable spawning period may range from as early as September through March (Hosie 1976, Rickey 1994). Little is known of the fecundity of arrowtooth flounder (NPFMC 2018b). Larvae have been found from ichthyoplankton sampling over a widespread area of the eastern Bering Sea shelf in April and May and on the continental shelf east of Kodiak Island during winter and spring (Kendall and Dunn 1985, Waldron and Vinter 1978). Nearshore sampling in the Kodiak Island area indicates that newly settled larvae are in the 1.6 in – 2.4 in (40 mm – 60 mm) size range (Norcross et al. 1996). Juveniles are separate from the adult population, remaining in shallow areas until they reach the 4 in – 6 in (10 cm – 15 cm) range (Martin and Clausen 1995, NPFMC 2018b). The estimated length at 50 percent maturity is 11 in (28 cm) for males (4 years) and 14.6 in (37 cm) for females (5 years), from samples collected off the Washington coast (Rickey 1994); and, 18.5 in (47 cm) for GOA females (Zimmerman 1997). The natural mortality rate used in stock assessments differs by sex with females estimated at 0.2 and males estimated at 0.35 (Turnock et al. 2009, Wilderbuer et al. 2009). Arrowtooth flounder were caught during otter trawl surveys between Cottonwood Bay and Iniskin Bay (PLP 2013).

For each arrowtooth flounder life stage information is available, two EFH values are provided: EFH within the Action Area and EFH within Cook Inlet.

Eggs: No EFH description determined – insufficient information is available.

Larvae: EFH for larval arrowtooth flounder is the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 ft – 656 ft (0 m – 200 m)), and slope (656 ft – 9,843 ft (200 m – 3,000 m)) throughout the GOA (NPFMC 2018b).

Juveniles: EFH for late juvenile arrowtooth flounder is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 ft – 164 ft (0 m – 50 m)), middle (164 ft – 328 ft (50 m – 100 m)), and outer (328 ft – 656 ft (100 m – 200 m)) shelf and upper slope (656 ft – 1,640 ft (200 m –500 m)) throughout the GOA wherever substrates consist of gravel, sand, and mud (NPFMC 2018b).

Adults: EFH for adult arrowtooth flounder is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 ft 0 – 164 ft (0 m – 50 m)), middle (164 ft – 328 ft (50 m – 100 m)), and outer (328 ft – 656 ft (100 m – 200 m)) shelf and upper slope (656 ft – 1,640 ft (200 m –500 m)) throughout the GOA wherever there are softer substrates consisting of gravel, sand, and mud (NPFMC 2018b).

4.2.2.1 Dover Sole

Dover sole are widely distributed throughout the GOA. EFH for dover sole has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11). Adults are demersal and are mostly found in water deeper than 980 ft (300 m) in the winter but occur in highest biomass in the 330 ft – 650 ft (100 m - 200 m) depth range during summer in the GOA (Turnock et al. 2002). They gradually move into deeper water as they grow and reach sexual maturity (Jacobson and Hunter 1993, Vetter et al. 1994, Hunter et al. 1990). For mature adults, most of the biomass may inhabit the oxygen minimum zone in deep waters. Spawning in the GOA has been observed from January through August, with a peak period in May (Hirschberger and Smith 1983, NPFMC 2018b), although a more recent study found spawning limited to February through May (Abookire and Macewicz 2003). Eggs have been collected in neuston and bongo nets in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown (NPFMC 2018b). Larvae were captured in bongo nets only in summer over mid-shelf and slope areas (Kendall and Dunn 1985). The age or size at metamorphosis is unknown, but the pelagic larval period is known to be protracted and may last as long as 2 years (Markle et al. 1992). Pelagic post-larvae as large as 2 in (48 mm) have been reported, and the young may still be pelagic at 4 in (10 cm) (Hart 1973, NPFMC 2018b). Dover sole are batch spawners, and Hunter et al. (1992) concluded that the average 2.2-pound (lb) (1 kilogram [kg]) female spawns its 83,000 advanced yolked oocytes in about nine batches. A comparison of maturity studies from Oregon and the GOA indicates that females mature at similar age in both areas (6 - 7 years), but GOA females are much larger 17 in (44 cm) than their southern counterparts 13 in (33 cm) at 50 percent maturity (Abookire and Macewicz 2003). Juveniles less than 10 in (25 cm) are rarely found with the adult population from bottom trawl surveys (Martin and Clausen 1995). The natural mortality rate used in recent stock assessments is 0.085 yr^{-1} based on a maximum observed age in the GOA of 54 years (Stockhausen et al. 2007, NPFMC 2018b).

Eggs: No EFH description determined – insufficient information is available.

Larvae: Dover sole are planktonic larvae for up to 2 years until metamorphosis occurs (NPFMC 2018b).

Juveniles: No EFH description determined – insufficient information is available.

Adults: Dover sole are winter and spring spawners, and summer feeding occurs on soft substrates (combination of sand and mud) of the continental shelf and upper slope. Shallower summer distribution occurs mainly on the middle to outer portion of the shelf and upper slope. Dover sole commonly feed on brittle stars, polychaetes, and other miscellaneous worms (Aydin et al. 2007; Buckley et al. 1999, NPFMC 2018b).

4.2.2.2 Flathead Sole

Flathead sole are distributed from northern California and throughout the GOA (Hart 1973). EFH for flathead sole has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11). Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions in the GOA. From over-winter grounds near the shelf margins, adults begin a migration onto the mid- and outer continental shelf in April or May each year for feeding (NPFMC 2018b). In the GOA, the spawning period may start as early as March but is known to occur in April through June, primarily in deeper waters near the margins of the continental shelf. Eggs are large, 0.1 in – 0.15 in (2.75 - 3.75 mm), and females have egg counts ranging from about 72,000 (8 in (20 cm) fish) to almost 600,000 (15 in (38 cm) fish) (NPFMC 2018b). Eggs hatch in 9 - 20 days depending on incubation temperatures within the range of 36.3 °F – 49.6 °F (2.4 - 9.8 °C) and have been found in ichthyoplankton sampling on the western portion of the GOA shelf in April through June (Porter 2004, NPFMC 2018b). Porter (2004) found that egg density increased late in development such that mid-stage eggs were found near the surface but eggs about to hatch were found at depth (410 ft – 650 ft (125 - 200 m)). Larvae absorb the yolk sac in 6 to 17 days, but the extent of their distribution is unknown (NPFMC 2018b). Nearshore sampling indicates that newly settled larvae are in the 1.2 in – 1.9 in (30 mm - 50 mm) size range (Norcross et al. 1996, Abookire et al. 2001). Flathead sole females in the GOA become 50 percent mature at 8.7 years or about 13 in (33 cm) (Stark 2004). Juveniles less than age 2 have not been found with the adult population and remain in shallow areas (NPFMC 2018b). The natural mortality rate used in recent stock assessments is 0.2 (Stockhausen et al. 2007).

Eggs: No EFH description determined – insufficient information is available.

Larvae: Flathead sole larvae are planktonic larvae for 3 - 5 months until metamorphosis occurs (NPFMC 2018b).

Juveniles: Juveniles usually inhabit shallow areas less than 330 ft (100 m), preferring muddy substrates (NPFMC 2018b).

Adults: Adults spawn in the spring and feed in the summer on sand and mud substrates of the continental shelf. They are widely distributed on the middle and outer portion of the shelf, feeding mainly on pandalid shrimp and brittle stars (NPFMC 2018b).

4.2.2.3 Northern Rock Sole

Northern rock sole are distributed from Puget Sound the GOA (Orr and Matarese 2000). EFH for northern rock sole has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11). Centers of abundance occur in the central GOA (Alton and Sample 1976, NPFMC 2018b). Northern rock sole exhibit a benthic lifestyle and spawn during the winter through early spring period of December through March (NPFMC 2018b). Soviet investigations in the early 1960s established two spawning concentrations: an eastern concentration north of Unimak Island at the mouth of Bristol Bay and a western concentration eastward of the Pribilof Islands between 55°30' and 55°0' N. and approximately 165°2' W (NPFMC 2018b, Shubnikov and Lisovenko 1964). Northern rock sole spawning in the GOA has been found to occur at depths of 140 ft – 200 ft (43 - 61 m) (Stark and Somerton 2002). Spawning females deposit a mass of eggs that are demersal and adhesive (Alton and Sample 1976). Fertilization is believed to be Incubation time is temperature dependent and may range from 6.4 days at 52 ºF (11 ºC) to about 25 days at 52 ºF (2.9 ºC) (Forrester 1964). Newly hatched larvae are pelagic and have occurred sporadically in eastern Bering Sea plankton surveys ((NPFMC 2018b, Waldron and Vinter 1978). Forrester and Thompson (1969) report that by age 1, larvae are found with adults on the continental shelf during summer. In the springtime, after spawning, northern rock sole begin actively feeding and exhibit a widespread distribution throughout the shallow waters of the GOA (NPFMC 2018b). Summertime trawl surveys indicate most of the population can be found at depths from 122 ft – 212 ft (50 m - 100 m) (Armistead and Nichol 1993). The movement from winter/spring to summer grounds is in response to warmer temperatures in the shallow waters and the distribution of prey on the shelf seafloor (Shvetsov 1978). In September, with the onset of cooling in the northern latitudes, northern rock sole begin the return migration to the deeper wintering grounds (NPFMC 2018b). Fecundity varies with size and was reported to be 450,000 eggs for fish 138 in (42 cm) long. Larvae are pelagic, but their occurrence in plankton surveys in the eastern Bering Sea is rare (Musienko 1963). Juveniles are separate from the adult population, remaining in shallow areas until they reach age 1 (Forrester 1964). The estimated age of 50 percent maturity is 7 years for northern rock sole females (approximately 108 in (33 cm)) (NPFMC 2018b). The natural mortality rate is believed to range from 0.18 to 0.20 (Turnock et al. 2002).

Eggs: No EFH description determined – insufficient information is available.

Larvae: Larvae are planktonic for at least 2 - 3 months until metamorphosis occurs (NPFMC 2018b).

Juveniles: Juveniles inhabit shallow areas at least until age 1 (NPFMC 2018b).

Adults: Adults feed on primarily sandy substrates of the eastern Bering Sea shelf and GOA. They are widely distributed on the middle and inner portion of the shelf, feeding on bivalves, polychaetes, amphipods, and miscellaneous crustaceans. During the winter, northern rock sole migrate to deeper waters of the shelf margin for spawning and to avoid extreme cold-water temperatures (NPFMC 2018b).

4.2.2.4 Rex Sole

Rex sole are distributed from Baja California to the GOA (Hart 1973, Miller and Lea 1972). EFH for rex sole has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11). They are most abundant at depths between 330 ft – 656 ft (100 m - 200 m) and are found uniformly throughout the GOA outside the spawning season (NPFMC 2018b). The spawning period off Oregon is reported to range from January through June with a peak in March and April (Hosie and Horton 1977). Using data from research surveys, Hirschberger and Smith (1983) found that spawning in the GOA occurred from February through July, with a peak period in April and May, although they had few, if any, observations from October to February.

More recently, Abookire (2006) found evidence for spawning starting in October and ending in June, based on one year's worth of monthly histological sampling (October through July) that included both research survey and fishery samples. Actual spawning season may extend from October to July (NPFMC 2018b). Fecundity estimates from samples collected off the Oregon coast ranged from 3,900 to 238,100 ova for fish 9 in – 23 in (24 cm - 59 cm) (Hosie and Horton 1977). During the spawning season, adult rex sole concentrate along the continental slope, but also appear on the outer shelf (Abookire and Bailey 2007, NPFMC 2018b). Eggs are fertilized near the sea bed, become pelagic, and probably require a few weeks to hatch (Hosie and Horton 1977). Although maturity studies from Oregon indicate that females are 50 percent mature at 9 in (24 cm), females in the GOA achieve 50 percent maturity at larger size (13.8 in (35.2 cm)) and grow faster such that they achieve 50 percent maturity at about the same age (5.1 years) as off Oregon (Abookire 2006). Juveniles less than 6 in (15 cm) are rarely found with the adult population. The natural mortality rate used in recent stock assessments is 0.17 (Stockhausen et al. 2007).

Eggs: No EFH description determined – insufficient information is available.

Larvae: Larvae are planktonic for at least 2 - 3 months until metamorphosis occurs (NPFMC 2018b).

Juveniles: No EFH description determined – insufficient information is available.

Adults: Adults spawn in the spring and feed during the summer on a combination of sand, mud, and gravel substrates of the continental shelf. They are widely distributed on the middle and outer portion of the shelf, feeding mainly on polychaetes, euphausiids, and miscellaneous worms (NPFMC 2018b).

4.2.2.5 Southern Rock Sole

Southern rock sole are distributed from Baja California waters north into the GOA. EFH for southern rock sole has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11). Centers of abundance occur in the central GOA (Alton and Sample 1976, Orr and Matarese 2000). Adults exhibit a benthic lifestyle and occupy separate winter (spawning) and summertime feeding distributions on the continental shelf (NPFMC 2018b). Southern rock sole spawn during the summer in the GOA (Stark and Somerton 2002). Southern rock sole spawning in the GOA was found to occur at depths of 115 ft – 394 ft (35 m - 120 m) (NPFMC 2018b). Spawning females deposit a mass of eggs that are demersal and adhesive (Alton and Sample 1976). Fertilization is believed to be external (NPFMC 2018b). Incubation time is temperature dependent and may range from 6.4 days at 52 ºF (11 ºC) to about 25 days at 37 ºF (2.9 ºC) (Forrester 1964). Newly hatched larvae are pelagic (Waldron and Vinter 1978) and have been captured on all sides of Kodiak Island and along the Alaska Peninsula (Orr and Matarese 2000). Forrester and Thompson (1969) report that age 1 fish are found with adults on the continental shelf during summer. In the springtime southern rock sole begin actively feeding and commence a migration to the shallow waters of the continental shelf to spawn in summer (NPFMC 2018b). Summertime trawl surveys indicate most of the population can be found at depths from 164 ft – 330 ft (50 m - 100 m) (Armistead and Nichol 1993). The movement from winter/spring to summer grounds may be a response to warmer temperatures in the shallow waters and the distribution of prey on the shelf seafloor (Shvetsov 1978). In September, with the onset of cooling in the northern latitudes, southern rock sole begin the return migration to the deeper wintering grounds. Fecundity varies with size and was reported to be 450,000 eggs for fish 16 in (42 cm) long (NPFMC 2018b). Larvae are pelagic and settlement occurs in September and October (NPFMC 2018b). The age or size at metamorphosis is unknown. Juveniles are separate from the adult population, remaining in shallow areas until they reach age 1 (Forrester 1964). The estimated age of 50 percent maturity is 9 years for southern rock sole females at approximately 14 in (35 cm) length (Stark and Somerton 2002). The natural mortality rate is believed to range from 0.18 to 0.20 (Turnock et al. 2002).

Eggs: No EFH description determined – insufficient information is available (NPFMC 2018b).

Larvae: Larvae are planktonic for at least 2 - 3 months until metamorphosis occurs (NPFMC 2018b).

Juveniles: Juveniles inhabit shallow areas at least until age 1 (NPFMC 2018b).

Adults: Adults spawn in the spring and feed during the summer on a combination of sand, mud, and gravel substrates of the continental shelf. They are widely distributed on the middle and outer portion of the shelf, feeding mainly on polychaetes, euphausiids, and miscellaneous worms (NPFMC 2018b).

4.2.2.6 Yellowfin Sole

Yellowfin sole are distributed in North American waters from British Columbia, Canada to the GOA. EFH for yellowfin sole has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11). Adults exhibit a benthic lifestyle and are consistently caught in shallow areas along the Alaska Peninsula and around Kodiak Island during resource assessment surveys in the GOA (NPFMC 2018b). From over-winter grounds near the shelf margins, adults begin a migration onto the inner shelf in April or early May each year for spawning and feeding. A protracted and variable spawning period may range from as early as late May through August occurring primarily in shallow water (NPFMC 2018b). Fecundity varies with size and was reported to range from 1.3 to 3.3 million eggs for fish 10 in - 18 in (25 cm - 45 cm) long (NPFMC 2018b). Larvae have primarily been captured in shallow shelf areas in the Kodiak Island area and have been measured at 0.1 in – 0.2 in (2.2 mm - 5.5 mm) in July and 0.1 in – 0.5 in (2.5 mm - 12.3 mm) in late August and early September. The age or size at metamorphosis is unknown (NPFMC 2018b). Juveniles are separate from the adult population, remaining in shallow areas until they reach approximately 6 in (15 cm). The estimated age of 50 percent maturity is 10.5 years (approximately 11 in (29 cm)) for females based on samples collected in 1992 and 1993. Natural mortality rate is believed to range from 0.12 to 0.16 (NPFMC 2018b).

Eggs: No EFH description determined – insufficient information is available.

Larvae: Larvae are planktonic for at least 2 - 3 months until metamorphosis occurs (NPFMC 2018b).

Juveniles: No EFH description determined – insufficient information is available.

Adults: Adults spawn in the spring and feed during the summer on a combination of sand, mud, and gravel substrates of the continental shelf. They are widely distributed on the middle and outer portion of the shelf, feeding mainly on polychaetes, euphausiids, and miscellaneous worms (NPFMC 2018b).

4.2.3 GOA Skates (Rajidae)

Skates (Rajidae) that occur in the GOA are grouped into two genera: *Bathyraja* sp., or soft- nosed species (rostral cartilage slender and snout soft and flexible), and *Raja* sp., or hard-nosed species (rostral cartilage is thick making the snout rigid). Skates are oviparous; fertilization is internal, and eggs (one to five or more in each case) are deposited in horny cases for incubation. Adults and juveniles are demersal and feed on bottom invertebrates and fish. Big skates (*Raja binoculata*) and longnose skates (*Raja rhina*) are the most abundant skates in the GOA (NPFMC 2018b). Most of the biomass for these two species is in the Central GOA (NPFMC 2018b). Depth distributions from surveys show that big skates are found primarily from 0 ft – 328 ft (0 m – 100 m); longnose skates are found primarily from 328 ft to 656 ft (100 m – 200 m), although they are found at all depths shallower than 984 ft (300 m). Below 656 ft (200 m) depth, *Bathyraja* sp. skates are dominant. Little is known of their habitat requirements for growth or reproduction, nor of any seasonal movements (NPFMC 2018b). The BSAI skate biomass estimate more than doubled between 1982 and 1996 from bottom trawl surveys; it may have decreased in the GOA and remained stable in the Aleutian Islands in the 1980s (NPFMC 2018b). EFH for three species of skates described below has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11; Figure 4-14).

The three skate species with defined EFH in the Action Area are:

- Alaska skate (*Bathyraja parmifera*)
- Aleutian skate (*Bathyraja aleutica*)
- Bering skate (*Bathyraja interrupta*)

Eggs: Skates deposit eggs in horny cases on shelf and slope (NPFMC 2018b).

Larvae: No EFH description determined – insufficient information is available.

Juveniles: After hatching, juveniles probably remain in shelf and slope waters, but distribution is unknown (NPFMC 2018b).

Adults: Adults are distributed across wide areas of shelf and slope. Surveys have found most skates at depths less than 1640 ft (500 m) in the GOA and eastern Bering Sea, but greater than 1640 ft (500 m) in the Aleutian Islands. In the GOA, most skates are found between 39 °F – 45 °F (4 °C - 7 °C), but data are limited (NPFMC 2018b).

4.2.4 Octopuses

In the GOA, there are at least seven species of octopuses currently identified. Several species are found primarily in subtidal waters to deep areas near the outer slope (NPFMC 2018b). EFH for octopus has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11; Figure 4-15). Known species include *Enteroctopus dofleini*, *Octopus californicus*, *Octopus sp. A*, *Benthoctopus leioderma*, *Opisthoteuthis californiana*, *Japetella diaphana* and *Vampyroteuthis infernalis* (NPFMC 2018b). *Octopus sp. A* is the one of the seven species that has not yet been fully described (Conners and Jorgensen 2008). The most abundant species at depths less than 656 ft (200 m) is the giant Pacific octopus *Enteroctopus dofleini* (NPFMC 2018b). The highest overall diversity of octopus can be found along the shelf break region of the GOA. Species such as *Japetella diaphana* and bathypelagic finned species *Vampyroteuthis infernalis* are found in pelagic waters of the GOA (NPFMC 2018b). Extensive data has been collected on *Enteroctopus dofleini* in British Columbia and Japan and is used as the primary indicator for assemblage (NPFMC 2018b). Preliminary evidence indicates that this species is taken as incidental catch in groundfish fisheries (NPFMC 2018b). Identification of octopus species in the Bering Sea and GOA is still developing and at its current status is very limited.

Generally, octopus lifespan can range anywhere from 1 to 5 years depending on species. Reproductive seasons, age/size at maturity and other general life histories of octopuses in Alaskan waters are largely unknown but inferred from what is known about other members of the genus. *Enteroctopus dofleini* are sexually mature after approximately 3 year however that time can vary based on location (NPFMC 2018b). On average 50,000 eggs are laid and hatchlings emerge at approximately 3.5 mm in size. It is estimated that mortality is highest in the larval stage and that ocean conditions have the largest effect of rate of survival (NPFMC 2018b). Little is known about *Octopus californicus.* It is believed to spawn 100 to 500 eggs and the hatchlings are likely benthic (NPFMC 2018b). Females likely brood the eggs and then die after hatching. *Octopus sp. A* has only recently been identified in the GOA and its full taxonomy has not been determined (NPFMC 2018b). It is thought that this species is likely a terminal spawner with a life span of 12 to 18 months. Females have approximately 80 to 90 eggs (NPFMC 2018b). The eggs are thought to be large, as the benthic larvae are often large and could take up to six months to hatch. The life span of *Benthoctopus leioderma* is unknown (NPFMC 2018b). The eggs are brooded by the female, but mating and spawning is unknown, however they are thought to spawn under rock ledges and crevices and their hatchlings are benthic (NPFMC 2018b). *Opisthoteuthis californiana* is a cirrate octopus as it has fins and cirri on the arms and is common in the GOA likely found over the abyssal plain. Details of its life history are unknown. *Japetella diaphana* is a small pelagic octopus but little is known about members of this family. This is not a common octopus in the GOA (NPFMC 2018b). *Vampyroteuthis infernalis* is a bathypelagic species that lives well below the thermocline most commonly found at 2,297 to 4,921 ft (700 to 1,500 m). Eggs are large and hatchlings resemble adults but with a difference fin arrangement. Little more is known about their life history (NPFMC 2018b).

Eggs: Spawning and embryotic information for Alaskan octopus species is limited, however based on other species, spawning likely occurs on the shelf in strings of eggs in caves, dens, or in boulders and rubble. Eggs are guarded by the female until hatching. The exact habitat needs and preferences for denning are unknown (NPFMC 2018b).

Larvae: Larvae for Alaskan octopus species are likely both pelagic and possibly demersal, however information is limited (NPFMC 2018b).

Juveniles: Juveniles are likely semi-demersal and are widely dispersed on the shelf and upper slope (NPFMC 2018b).

Adults: Adults are demersal and prefer rocks, cobble, and sand/mud habitats (NPFMC 2018b).

4.2.5 Pacific Cod

Pacific cod in the eastern Pacific Ocean are found from central California to the Bering Sea with unconfirmed reports in the Chukchi Sea. Pacific cod are distributed throughout Southcentral Alaska and are found primarily in benthic habitats in water depths ranging from 49 ft to 1,804 ft (15 m - 550 m) (NPFMC 2018b). EFH for Pacific cod has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11; Figure 4-16). Pacific cod was one of the most abundant species captured during sampling in Kachemak Bay (Abookire et al. 2001). EFH for groundfish, including Pacific cod, has been defined within Cook Inlet (Figure 4-16). Pacific cod feed on other fish including walleye pollock, flatfishes, Pacific sand lance, and Pacific herring, as well as on crabs and shrimp (NPFMC 2018b). They may reach 47 in (120 cm) in length but the average length in trawl catches is 27.5 in – 29.5 in (70 cm – 75 cm) (Mecklenburg et al. 2002). Pacific cod usually spawn in relatively deep water during the winter and move to shallower waters to feed (NPFMC 2018b). Males become sexually mature at age 2 and females at age 3 (NPFMC 2018b). Breeding occurs annually, and fecundity increases with increasing size of female fish. Eggs develop on the ocean floor and development is affected by temperature (NPFMC 2018b). Optimal temperatures for egg development are around 38.3 °F – 39.2 °F (3.5 °C – 4 °C). Larvae are moved by ocean currents and have been found in Cook Inlet from May to July. Larvae feed on copepods and other plankton (NPFMC 2018b). Young Pacific cod are often found in shallow coastal waters and move to deeper water with age. Pacific cod were also captured in PLP marine fish surveys between Rocky Cove and Iniskin Bay (PLP 2013).

Eggs: Eggs sink to the bottom after fertilization and are somewhat adhesive. Optimal temperature for incubation is 37 °F – 43 °F (3 °C - 6 °C), optimal salinity is 13 - 23 parts per thousand (ppt), and optimal oxygen concentration is from 2 - 3 ppm to saturation. Little is known about the optimal substrate type for egg incubation (NPFMC 2018b).

Larvae: Larvae are epipelagic, occurring primarily in the upper 148 ft (45 m) of the water column shortly after hatching, moving downward in the water column as they grow (NPFMC 2018b).

Juveniles: Juveniles occur mostly over the inner continental shelf at depths of 197 ft – 492 ft (60 m - 150 m) (NPFMC 2018b).

Adults: Adults occur in depths from the shoreline to 1640 ft (500 m). Average depth of occurrence tends to vary directly with age for at least the first few years of life, with mature fish concentrated on the outer continental shelf. Preferred substrate is soft sediment, from mud and clay to sand (NPFMC 2018b).

4.2.6 Rockfish

4.2.6.1 Rougheye and Blackspotted Rockfish

The presence of two species, rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*S. melanostictus*) were once considered a single variable species with light and dark color morphs (NPFMC 2018b). In 2008 the two species were differentiated, and their distribution and morphological characteristics were described for each (NPFMC 2018b, Orr and Hawkins 2008). Rougheye rockfish is typically pale with spots absent from the dorsal fin and possible mottling on the body (NPFMC 2018b). Blackspotted rockfish is darker with spotting almost always present on the dorsal fin and body (NPFMC 2018b). Both species inhabit the outer continental shelf and upper continental slope of the northeastern Pacific (NPFMC 2018b). Their distribution extends around the arc of the North Pacific from Japan to Point Conception, California, and includes the Bering Sea (Kramer and O’Connell 1988). The center of abundance appears to be Alaskan waters, particularly the eastern GOA (NPFMC 2018b). Adults in the GOA inhabit a narrow band along the upper continental slope at depths of 984 ft - 1,640 ft (300 m - 500 m). Outside of this depth interval, abundance decreases considerably (Ito 1999). Ongoing research in this area may distinguish specific habitat preferences that might be useful for separating the species and determine whether the two species have significantly different life history traits (NPFMC 2018b). Until such information is available, it will be difficult to undertake distinct population assessments (NPFMC 2018b). In the stock assessment, rougheye and blackspotted rockfish are referred together as the rougheye rockfish complex. EFH for both rougheye rockfish and blackspotted rockfish has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11; Figure 4-17).

Though relatively little is known about their biology and life history, rougheye and blackspotted rockfish appear to be K-selected with late maturation, slow growth, extreme longevity, and low natural mortality (NPFMC 2018b). Age and size at 50 percent maturity for female rougheye rockfish is estimated at 19 years and 17 in (44 cm), respectively (McDermott 1994). There is no information on male size at maturity or on maximum size of juvenile males (NPFMC 2018b). Rougheye is considered the oldest of the *Sebastes* spp. with a maximum age of 205 years (Chilton and Beamish 1982, Munk 2001). It is also considered one of the larger rockfish attaining sizes of up to 38 in (98 cm) (Mecklenburg et al. 2002). Natural mortality is low, estimated to be on the order of 0.004 to 0.07 (Archibald et al. 1981, McDermott 1994, Nelson and Quinn 1987, Clausen et al. 2003, Shotwell et al. 2007).

Eggs: Rougheye and blackspotted rockfish are presumed to be viviparous, where fertilization and incubation of eggs is internal, and embryos receive at least some maternal nourishment (NPFMC 2018b). There have been no studies on fecundity of rougheye in Alaska (NPFMC 2018b). One study on their reproductive biology indicated that rougheye had protracted reproductive periods, and that parturition (larval release) may take place in December through April (McDermott 1994). There is no information as to when males inseminate females or if migrations for spawning/breeding occur (NPFMC 2018b).

Larvae: Information on larval rougheye and blackspotted rockfish is very limited. The larval stage is pelagic, but larval studies are hindered because the larvae at present can only be positively identified by genetic analysis, which is both expensive and labor-intensive. The post-larvae and early young-of-the-year stages also appear to be pelagic (Matarese et al. 1989, Kondzela et al. 2007). Genetic techniques have been used recently to identify a few post-larval rougheye rockfish from samples collected in epipelagic waters far offshore in the GOA (Kondzela et al. 2007), which is the only documentation of habitat preference for this life stage (NPFMC 2018b).

Juveniles: There is no information on when juvenile fish become demersal (NPFMC 2018b). Juvenile rougheye rockfish 6 - 16 in (15 - 40 cm) have been frequently taken in GOA bottom trawl surveys, implying the use of low relief, trawlable bottom substrates (Clausen et al. 2003). They are generally found at shallower, more inshore areas than adults and have been taken in a variety of locations, ranging from inshore fiords to offshore waters of the continental shelf (NPFMC 2018b). Studies using manned submersibles have found that large numbers of small, juvenile rockfish are frequently associated with rocky habitat on both the shallow and deep shelf of the GOA (Carlson and Straty 1981).

Adults: Adult rougheye and blackspotted rockfish are demersal and known to inhabit particularly steep, rocky areas of the continental slope, with highest catch rates generally at depths of 984 ft - 1,312 ft (300 m - 400 m) in longline surveys (Zenger and Sigler 1992) and at depths of 984 ft - 1,640 ft (300 - 500 m) in bottom trawl surveys and in the commercial trawl fishery (Ito 1999). Observations from a manned submersible in this habitat indicate that the fish prefer steep slopes and are often associated with boulders and sometimes with *Primnoa* spp. coral (Krieger and Ito 1999, Krieger and Wing

2002). Within this habitat, rougheye rockfish tend to have a relatively even distribution when compared with the highly aggregated and patchy distribution of other rockfish such as Pacific ocean perch (*Sebastes alutus*) (Clausen and Fujioka 2007).

4.2.6.2 Dusky Rockfish and Dark Rockfish

Previously it was thought that there were two varieties of dusky rockfish, a dark colored variety inhabiting inshore, shallow waters, and a lighter colored variety inhabiting deeper water offshore. In 2004 these two varieties were designated as distinct species (NPFMC 2018b). The dark colored variety is now recognized as dark rockfish (*Sebastes ciliatus*) and the lighter colored variety is recognized as dusky rockfish (*Sebastes variabilis*) (Orr and Blackburn 2004). Life history and general distribution descriptions for dark rockfish are unavailable, however EFH for both dusky rockfish and dark rockfish has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11).

Dusky rockfish range from central Oregon through the North Pacific Ocean and Bering Sea in Alaska, with the center of abundance in the GOA (Reuter 1999). Adult dusky rockfish are patchily distributed and are usually found in large aggregations at specific localities of the outer continental shelf (NPFMC 2018b). Dusky rockfish are presumed to be demersal and possibly pelagic, however there is no specific evidence of pelagic behavior (NPFMC 2018b). Most of what is known about dusky rockfish is based on data collected during the summer months from the commercial fishery or in research surveys (NPFMC 2018b). Consequently, there is little information on seasonal movements or changes in distribution (NPFMC 2018b). Life history information on dusky rockfish is extremely sparse. The fish are assumed to be viviparous, as are other *Sebastes*, with internal fertilization and incubation of eggs. Observations during research surveys in the GOA suggest that parturition (larval release) occurs in the spring and is probably completed by summer (NPFMC 2018b). Length of the larval stage, and whether a pelagic juvenile stage occurs, are unknown (NPFMC 2018b). There is no information on habitat and abundance of young juveniles, less than 10 in (25 cm), as catches of these have been virtually nil in research surveys. Even the occurrence of older juveniles has been very uncommon in surveys (NPFMC 2018b).

Dusky rockfish is a slow growing species, with a low rate of natural mortality estimated at 0.09. However, it appears to be faster growing than many other rockfish species (NPFMC 2018b). Maximum age is 51 to 59 years. Estimated age at 50 percent maturity for females is 11.3 years. No information on fecundity is available. The approximate upper size limit of juvenile fish is approximately18 in (47 cm) for females (size at 50 percent maturity is 17 in (43 cm) (NPFMC 2018b).

Eggs: No information is known, except that parturition probably occurs in the spring, and may extend into summer (NPFMC 2018b).

Larvae: No EFH description determined – insufficient information is available.

Juveniles: No information is known for juveniles less than approximately 10 in (25 cm). Larger juveniles have been taken infrequently in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds (NPFMC 2018b).

Adults: Adult dusky rockfish are demersal and primarily found on offshore banks of the outer continental shelf at depths of 328 ft - 1640 ft (100 m - 200 m) in presumably rocky habitats. During submersible dives on the outer shelf 131 ft - 164 ft (40 m - 50 m) in the eastern Gulf, adult dusky rockfish were observed in association with rocky habitats and in areas with extensive sponge beds where the fish were observed resting in large vase sponges (V. O'Connell, ADFG, personal communication). Dusky rockfish are the most highly aggregated of the rockfish species caught in GOA trawl surveys. Outside of these aggregations, the fish are sparsely distributed. There is no information on seasonal migrations (NPFMC 2018b).

4.2.6.3 Shortspine Thornyhead Rockfish and Longspine Thornyhead Rockfish

Longspine thornyhead is not common in the GOA, while the shortspine thornyhead is a demersal species which inhabits deep waters from 56 ft – 5000 ft (17 m - 1,524 m) along the Pacific rim and is common throughout the GOA (NPFMC 2018b). EFH for both shortspine thornyhead rockfish and longspine thornyhead rockfish has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11). Both species are slow-growing and long-lived with maximum age in excess of 50 years and maximum size greater than 30 in (75 cm) and 4 lb (2 kg) (NPFMC 2018b). Shortspine thornyhead spawning, and likely longspine thornyhead, occurs in the late spring and early summer, between April and July in the GOA (NPFMC 2018b). Both species spawn a bi-lobed mass of fertilized eggs which floats in the water column. Juvenile shortspine thornyhead rockfish have an extended pelagic period of about 14 to 15 months and settle out at about 0.9 in – 1.0 in (22 mm - 27 mm) into relatively shallow benthic habitats between 328 ft – 1968 ft (100 m - 600 m) and then migrate deeper as they grow. Fifty percent of female shortspine thornyhead rockfish are sexually mature at about 8.5 in (21.5 cm) (NPFMC 2018b).

Shortspine thornyhead rockfish prey mainly on epibenthic shrimp and fish in the GOA (Yang 1993 and 1996), whereas, cottids were the most important prey item in the Aleutian Islands region. Shortspine thornyhead rockfish are consumed by a variety of piscivores, including arrowtooth flounder, sablefish, "toothed whales" (sperm whales), and sharks. Juvenile shortspine thornyhead rockfish are thought to be consumed almost exclusively by adult thornyhead rockfish (NPFMC 2018b).

Eggs: Eggs float in masses of various sizes and shapes. Frequently the masses are bilobed with the lobes 6 in - 24 in (15 cm - 61 cm) in length, consisting of hollow conical sheaths containing a single layer of eggs in a gelatinous matrix (NPFMC 2018b). The masses are transparent and not readily observed in the daylight. Eggs are 0.3 in – 0.5 in (1.2 mm - 1.4 mm) in diameter with a > 0.01 in (0.2 mm) oil globule and move freely in the matrix. Complete hatching time is unknown but likely greater than ten days (NPFMC 2018b).

Larvae: Three-day-old larvae are about 0.1 in (3 mm) long and float to the surface (NPFMC 2018b).

Juveniles: Juvenile shortspine thornyhead rockfish have an extended pelagic period of about 14 to 15 months and settle out at about 0.9 in – 1.0 in (22 mm - 27 mm) into relatively shallow benthic habitats between 328 ft – 1968 ft (100 m - 600 m) and migrate deeper as they grow (NPFMC 2018b).

Adults: Adults are demersal and can be found at depths ranging from about 295 ft – 4921 ft (90 m - 1,500 m) and are associated with muddy substrates, sometimes near rocks or gravel (NPFMC 2018b). They distribute themselves evenly across this habitat, appearing to prefer minimal interactions with individuals of the same species. They have very sedentary habits and are most often observed resting on the bottom in small depressions (NPFMC 2018b).

4.2.6.4 Northern Rockfish

Northern rockfish range from northern British Columbia through the GOA and Aleutian Islands to eastern Kamchatka and the Kuril Islands, including the Bering Sea (Mecklenburg et al. 2002). The species is most abundant from about Portlock Bank in the central GOA (NPFMC 2018b). EFH for northern rockfish has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11). In the GOA, adult fish appear to be concentrated at discrete, relatively shallow offshore banks of the outer continental shelf (Clausen and Heifetz 2002). Typically, these banks are separated from land by an intervening stretch of deeper water (NPFMC 2018b). The preferred depth range is approximately 246 ft - 492 ft (75 m - 150 m) in the GOA. Information available at present suggests the fish are mostly demersal, as very few have been caught off-bottom or in pelagic trawls (Clausen and Heifetz 2002). In common with many other rockfish species, northern rockfish tend to have a localized, patchy distribution, even within their preferred habitat, and most of the population occurs in aggregations (NPFMC 2018b). Most of what is known about northern rockfish is based on data collected during the summer months from the commercial fishery or in research surveys (NPFMC 2018b). Consequently, there is little information on seasonal movements or changes in distribution for this species.

Life history information on northern rockfish is extremely sparse. The fish are assumed to be viviparous, as other *Sebastes* appear to be, with internal fertilization and incubation of eggs (NPFMC 2018b). Observations during research surveys in the GOA suggest that parturition (larval release) occurs in the spring and is mostly completed by summer (NPFMC 2018b). Pre-extrusion larvae have been described (Kendall 1989), but field-collected larvae cannot be unequivocally identified to species at present, even using genetic techniques (Li et al. 2006). Length of the larval stage is unknown, but the fish apparently metamorphose to a pelagic juvenile stage, which also has been described (Matarese et al. 1989). However, similar to the larvae, smaller-sized post-larval northern rockfish cannot be positively identified at present, even with genetic methods (Kondzela et al. 2007). There is no information on when the juveniles become benthic or habitat occupancy (NPFMC 2018b). Older juveniles are found on the continental shelf, generally at locations inshore of the adult habitat (Clausen and Heifetz 2002). Northern rockfish is a slow growing species, with a low rate of natural mortality (estimated at 0.06), a relatively old age at 50 percent maturity (12.8 years for females in the GOA), and an old maximum age of 67 years in the GOA (Heifetz et al. 2007). Size at 50 percent maturity for females has been estimated to be 14 in (36 cm) and unknown for males. No information on fecundity is available (NPFMC 2018b).

Eggs: No EFH description determined – insufficient information is available.

Larvae: No EFH description determined – insufficient information is available.

Juveniles: No information known for small juveniles (less than 8 in (20 cm)), except that post-larval fish apparently undergo a pelagic phase immediately after metamorphosis from the larval stage. The duration of the pelagic stage is unknown. How long the pelagic stage lasts, and when juveniles assume a demersal existence, is unknown. Observations from manned submersibles in offshore waters of the GOA (e.g., Krieger 1993; Freese and Wing 2003) have consistently indicated that small juvenile rockfish are associated with benthic living and non-living structure and appear to use this structure as refuge. The living structure includes corals and sponges. Large juvenile northern rockfish have been taken in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds (Clausen and Heifetz 2002). Substrate preference of these larger juveniles is unknown (NPFMC 2018b).

Adults: Commercial fishery and research survey data have consistently indicated that adult northern rockfish in the GOA are primarily found on offshore banks of the outer continental shelf at depths of 246 ft - 492 ft (75 m - 150 m). Preferred substrate, habitat type, and migration patterns is unknown. Generally, the fish appear to be demersal, and most of the population occurs in large aggregations (NPFMC 2018b).

4.2.6.5 Pacific Ocean Perch

Pacific ocean perch (*Sebastes alutus*) are widely distributed in the North Pacific from southern California around the Pacific rim to the GOA, and the Aleutian Islands (Allen and Smith 1988). EFH for northern rockfish has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11). Adults are found primarily offshore on the outer continental shelf and the upper continental slope in depths from 492 ft – 1378 ft (150 m - 420 m) (NPFMC 2018b). In the summer, adults inhabit shallower depths, especially those between 492 ft – 984 ft (150 m - 300 m). In the fall, the fish apparently migrate farther offshore to depths from approximately 984 ft - 1378 ft (300 m - 420 m) (NPFMC 2018b). They reside in these deeper depths until May, then return to their shallower summer distribution (Love et al. 2002). Although small numbers of Pacific ocean perch are dispersed throughout their preferred depth range on the continental shelf and slope, most of the population occurs in patchy, localized aggregations (Hanselman et al. 2001). Pacific ocean perch are generally considered to be semi-demersal, but there can be a significant pelagic component to their distribution (NPFMC 2018b). Pacific ocean perch often move off-bottom at night to feed, apparently following diel euphausiid migrations. Commercial fishing data in the GOA since 1995 show that pelagic trawls fished off-bottom have accounted for as much as 20 percent of the annual harvest of this species (NPFMC 2018b).

There is much uncertainty about the life history of Pacific ocean perch, although generally more is known than for other rockfish species (Kendall and Lenarz 1986). The species appears to be viviparous (the eggs develop internally and receive at least some nourishment from the mother), with internal fertilization and the release of live young (NPFMC 2018b). Insemination occurs in the fall, and sperm are retained within the female until fertilization takes place approximately 2 months later (NPFMC 2018b). The eggs hatch internally, and parturition (release of larvae) occurs in April and May. Information on early life history is very sparse, especially for the first year of life. Pacific ocean perch larvae are thought to be pelagic and drift with the current. Oceanic conditions may sometimes cause advection to suboptimal areas (Ainley et al. 1993), resulting in high recruitment variability. Post-larval and early young-of-the-year Pacific ocean perch have been positively identified in offshore, surface waters of the GOA (Gharrett et al. 2002), which suggests this may be the preferred habitat of this life stage. Transformation to a demersal existence may take place within the first year (Carlson and Haight 1976). Small juveniles probably reside inshore in very rocky, high relief areas and begin to migrate to deeper offshore waters of the continental shelf by age 3 (Carlson and Straty 1981). As they grow, they continue to migrate deeper, eventually reaching the continental slope, where they attain adulthood (NPFMC 2018b).

Pacific ocean perch is a slow growing species, with a low rate of natural mortality (estimated at 0.06), a relatively old age at 50 percent maturity (10.5 years for females in the GOA), and a very old maximum age of 98 years in Alaska (84 years maximum age in the GOA) (Hanselman et al. 2007a). Age at 50 percent recruitment to the commercial fishery has been estimated to be between 7 and 8 years in the GOA (NPFMC 2018b). Despite their viviparous nature, the fish is relatively fecund with number of eggs per female in Alaska ranging from 10,000 to 300,000, depending upon size of the fish (Leaman 1991).

Eggs: Little information is known. Insemination is thought to occur after adults move to deeper offshore waters in the fall. Parturition is reported to occur from 66 ft – 98 ft (20 m - 30 m) off the bottom at depths from 1,181 ft – 1,312 (360 m - 400 m) (NPFMC 2018b).

Larvae: Little information is known. Earlier information suggested that after parturition, larvae rise quickly to near surface, where they become part of the plankton (NPFMC 2018b). More recent data from British Columbia indicates that larvae may remain at depths of 574 ft (175 m) for some period of time (perhaps 2 months), after which they slowly migrate upward in the water column (NPFMC 2018b).

Juveniles: A recent, preliminary study has identified Pacific ocean perch in these life stages from samples collected in epipelagic waters far offshore in the GOA (Gharrett et al. 2002). It is unknown how long young-of-the-year remain in a pelagic stage before eventually becoming demersal. At ages 1 to 3, the fish probably live in very rocky inshore areas. Afterward, they move to progressively deeper waters of the continental shelf. Older juveniles are often found together with adults at shallower locations of the continental slope in the summer months (NPFMC 2018b).

Adults: Commercial fishery and research data have consistently indicated that adult Pacific ocean perch are found in aggregations over reasonably smooth, trawlable bottom of the outer continental shelf and upper continental slope (Westrheim 1970; Matthews et al. 1989; Krieger 1993). Observations from a manned submersible in Southeast Alaska found adult Pacific ocean perch associated with pebble substrate on flat or low-relief bottom (Krieger 1993). Pacific ocean perch have been observed in association with sea whips in both the GOA (Krieger 1993) and the Bering Sea (Brodeur 2001). The fish can at times also be found off-bottom in the pelagic environment, especially at night when they may move up in the water column to feed (NPFMC 2018b).

4.2.6.6 Shortraker Rockfish

Shortraker rockfish are found around the arc of the north Pacific from southern California to northern Japan, including the Bering Sea and the Sea of Okhotsk and on seamounts in the GOA (Maloney 2003 and 2004). EFH for shortraker rockfish has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11). Except for the adult stage, information on the life history of shortraker rockfish is extremely limited (NPFMC 2018b). Similar to other *Sebastes*, the fish appear to be viviparous; fertilization is internal, and the developing eggs receive at least some nourishment from the mother (NPFMC 2018b). Parturition (release of larvae) may occur from February through August (McDermott 1994). Little is known about juvenile shortraker rockfish in the GOA; only a few specimens less than 35-cm fork length have ever been caught by fishing gear in this region (NPFMC 2018b). Juveniles have been caught in somewhat larger numbers in bottom trawl surveys of the Aleutian Islands (e.g., Harrison 1993), but these data have not been analyzed to determine patterns of distribution or habitat preference. As adults, shortraker rockfish are demersal and inhabit depths from 328 ft - 3,937 ft (100 m - 1,200 m) (Mecklenburg et al. 2002). However, survey and commercial fishery data indicate that the fish are most abundant along a narrow band of the continental slope at depths of 984 ft - 1,640 ft (300 m - 500 m) (Ito 1999), where they often co-occur with rougheye and blackspotted rockfish (NPFMC 2018b).

Though relatively little is known about its biology and life history, shortraker rockfish appears to be a K-selected species with late maturation, slow growth, extreme longevity, and low natural mortality (NPFMC 2018b). Age of 50 percent maturity for female shortraker rockfish has been estimated to be 21.4 years for the GOA, with a maximum age of 116 years (Hutchinson 2004). Both these values are very old relative to other fish species (NPFMC 2018b). Another study reported an even older maximum age of 157 years (Munk 2001). Female length of 50 percent maturity has been estimated to be 18 in (44.9 cm) (McDermott 1994). There is no information on age or length of maturity for males (NPFMC 2018b). Shortraker rockfish attains the largest size of any species in the genus *Sebastes*, with a maximum length of up to 47 in (120 cm) (Mecklenburg et al. 2002). Estimates of natural mortality for shortraker rockfish range between 0.027 and 0.042 (McDermott 1994), and a mortality of 0.03 has been used in recent stock assessments to determine values of acceptable biological catch and overfishing for the GOA (Clausen 2007).

Eggs: The timing of reproductive events is apparently protracted. Similar to all *Sebastes*, egg development for shortraker rockfish is completely internal. There is no information as to when males inseminate females or if migrations occur for spawning/breeding (NPFMC 2018b).

Larvae: Information on larval shortraker rockfish is very limited. Larval shortraker rockfish have been identified in pelagic plankton tows in coastal Southeast Alaska (Gray et al. 2006). Larval studies are hindered because the larvae at present can be positively identified only by genetic analysis, which is both expensive and labor-intensive (NPFMC 2018b).

Juveniles: Information is negligible regarding the habitat and biological associations of juvenile shortraker rockfish. One study used genetics to identify two specimens of post-larval shortraker rockfish from samples collected in epipelagic waters far offshore in the GOA beyond the continental slope (Kondzela et al. 2007). This limited information is the only documentation of habitat preference for this life stage. Only a few specimens less than 14 in (35 cm) length have ever been caught in the GOA (NPFMC 2018b). The habitat is presumably demersal, as all specimens caught in the GOA as well others caught in the Aleutian Islands (Harrison 1993) and off Russia (Orlov 2001) have been taken by bottom trawls.

Adults: Adult shortraker rockfish are demersal and in the GOA are concentrated at depths of 984 ft - 1,640 ft (300 m - 500 m) along the continental slope. Much is this area is generally considered by fishermen to be steep and difficult to trawl (NPFMC 2018b). Observations from a manned submersible indicated that shortraker rockfish occurred over a wide range of habitats, but soft substrates of sand or mud usually had the highest densities of fish (Krieger 1992). However, this study also showed that habitats with steep slopes and frequent boulders were used at a higher rate than habitats with gradual slopes and few boulders (NPFMC 2018b).

4.2.6.7 Yelloweye Rockfish, Quillback Rockfish, and Rosethorn Rockfish

Yelloweye rockfish, quillback rockfish, and rosethorn rockfish are distributed from Ensenada, in northern Baja California, to Umnak Island and Unalaska Island, of the Aleutian Islands, in depths from 60 ft - 1800 ft (18 m – 549 m) but commonly in 300 ft - 600 ft (91 m – 183 m) in rocky, rugged habitat (Allen and Smith

1988, Eschmeyer et al. 1983). EFH for these species of rockfish has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11). Little is known about the young of the year and settlement. Young juveniles between 1 in – 4 in (2.5 cm - 10 cm) have been observed in areas of high and steep relief in depths deeper than 49 ft (15 m) (NPFMC 2018b). Subadult and adult fish are generally solitary, occurring in rocky areas and high relief with refuge space, particularly overhangs, caves, and crevices (O'Connell and Carlile 1993). Yelloweye are ovoviviparous (NPFMC 2018b). Parturition occurs in southeast Alaska between April and July with a peak in May (O'Connell 1987). Fecundity ranges from 1,200,000 to 2,700,000 eggs per season (Hart 1942, O'Connell, ADFG, personal communication). Yelloweye rockfish feed on a variety of prey, primarily fishes (including other rockfishes, herring, and sand lance) as well as caridean shrimp and small crabs. Yelloweye rockfish are a K-selected species with late maturation, slow growth, extreme longevity, and low natural mortality. They reach a maximum length of about 36 in (91 cm) and growth slows considerably after age 30 years. Approximately 50 percent of females are mature at 18 in (45 cm) and 22 years (NPFMC 2018b). Age of 50 percent maturity for males is 18 years and length is 17 in (43 cm). Natural mortality is estimated to be 0.02, and maximum age published is 118 years (O'Connell and Fujioka 1991, O'Connell and Funk 1987). However, a 121-year-old specimen was harvested in the commercial fishery off Southeast Alaska in 2000 (NPFMC 2018b).

Eggs: No EFH description determined – insufficient information is available.

Larvae: No EFH description determined – insufficient information is available.

Juveniles: Young juveniles between 1 in (2.5 cm) and 4 in (10 cm) have been observed in areas of high relief. This relief can be provided by the geology of an area such as vertical walls, fjord-like areas, and pinnacles, or by large invertebrates such as cloud sponges, *Farrea occa*, *Metridium farcimen*, and *Primnoa* coral (NPFMC 2018b).

Adults: Adult fish are generally solitary, occurring in rocky areas and high relief with refuge spaces particularly overhangs, caves and crevices (O'Connell and Carlile 1993), and can co-occur with gorgonian corals (Krieger and Wing 2002). Not infrequently an adult yelloweye rockfish will cohabitate a cave or refuge space with a tiger rockfish. Habitat specific density data shows an increasing density with increasing habitat complexity: deep water boulder fields consisting of very large boulders have significantly higher densities than other rock habitats (O'Connell and Carlile 1993, O'Connell et al. 2007). Although yelloweye rockfish do occur over cobble and sand bottoms, generally this is when foraging and often these areas directly interface with a rock wall or outcrop (NPFMC 2018b).

4.2.6.8 Other Rockfish

Black rockfish, greenstriped rockfish, harlequin rockfish, pygmy rockfish, redbanded rockfish, redstriped rockfish, sharpchin rockfish and silvergrey rockfish are distributed throughout the GOA, however all lack individual EFH descriptions (NPFMC 2018b). EFH for all of these species has been defined in Cook Inlet and GOA and is shown for individual species in Table 4-10 and Table 4-11.

Eggs: EFH for other rockfish eggs is the general distribution area for this life stage, located in the lower portion of the water column along the shelf 0 ft - 656 ft (0 m to 200 m) and upper slope 656 ft – 1,640 ft (200 m to 500 m) (NPFMC 2018b).

Larvae: No EFH description determined – insufficient information is available.

Juveniles: EFH for early juvenile other rockfish is the general distribution area for this life stage, based on all rockfish species combined, located in the lower portion of the water column along the middle164 ft - 328 ft (50 m to 100 m) and outer shelf 328 ft - 656 ft (100 m to 200 m) throughout the GOA.

Adults: EFH for adult other rockfish is the general distribution area for this life stage, located in the lower portion of the water column along the shelf 0 ft - 656 ft (0 m to 200 m) and upper slope 656 ft – 1,640 ft (200 m to 500 m).

4.2.7 Sablefish

Sablefish are distributed from Mexico through the GOA to the Aleutian Chain, Bering Sea, along the Asian coast from Sagami Bay, and along the Pacific sides of Honshu and Hokkaido Islands and the Kamchatka Peninsula (NPFMC 2018b). EFH for sablefish has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11; Figure 4-18). Adult sablefish are assumed to be demersal and can be found along the continental slope, shelf gullies, and in deep fjords at depths generally greater than 656 ft (200 m) (NPFMC 2018b). Spawning occurs in late winter or early spring along the continental slope where eggs are released near the bottom where they incubate. Larvae are oceanic through the spring and by late summer can be found along the outer coast of Southeast Alaska where they move in to shallower waters to over winter (NPFMC 2018b). Juvenile distribution is unknown to be highly specific or if it appears that way because sampling is highly inefficient and sparse (NPFMC 2018b). Larvae are oceanic through the spring and by late summer, small pelagic juveniles 4 in – 6 in (10 cm - 15 cm) have been observed along the outer coasts of Southeast Alaska, where they apparently move into shallow waters to spend their first winter. During most years, there are only a few places where juveniles have been found during their first winter and second summer (NPFMC 2018b). It is not clear if the juvenile distribution is highly specific or appears so because sampling is highly inefficient and sparse (NPFMC 2018b). During the occasional times of large year-classes, the juveniles are easily found in many inshore areas during their second summer. They are typically 12 in – 16 in (30 cm - 40 cm) long during their second summer, after which they apparently leave the nearshore bays. One or two years later, they begin appearing on the continental shelf and move to their adult distribution as they mature (NPFMC 2018b).

Pelagic ocean conditions appear to determine when strong young-of-the-year survival occurs (NPFMC 2018b). Water mass movements and temperature appear to be related to recruitment success (Sigler et al. 2001). Above-average young of the year survival was somewhat more likely with northerly winter currents and much less likely for years when the drift was southerly (NPFMC 2018b). Recruitment success also appeared related to water temperature (NPFMC 2018b). While pelagic oceanic conditions determine the egg, larval, and juvenile survival through their first summer, juvenile sablefish spend 3 to 4 years in demersal habitat along the shorelines and continental shelf before they recruit to their adult habitat, primarily along the upper continental slope, outer continental shelf, and deep gullies (NPFMC 2018b).

The estimated productivity and sustainable yield of the combined GOA, Bering Sea, and Aleutian Islands sablefish stock have declined steadily since the late 1970s (NPFMC 2018b). This is demonstrated by a decreasing trend in recruitment and subsequent estimates of biomass reference points and the inability of the stock to rebuild to the target biomass levels despite the decreasing level of the targets and fishing rates below the target fishing rate (NPFMC 2018b).

Eggs: Spawning and very ripe sablefish are observed in late winter or early spring along the continental slope. Eggs are apparently released near the bottom where they incubate (NPFMC 2018b).

Larvae: After hatching and yolk adsorption, the larvae rise to the surface and are oceanic through the spring to late summer (NPFMC 2018b).

Juveniles: Small pelagic juveniles 4 in – 6 in (10 cm - 15 cm) have been observed along the outer coasts of Southeast Alaska, where they apparently move into shallow waters to spend their first winter. They are typically 12 in – 16 in (30 cm - 40 cm) long during their second summer, after which they apparently leave the nearshore bays (NPFMC 2018b). One or two years later, they begin appearing on the continental shelf and move to their adult distribution as they mature (NPFMC 2018b).

Adults: Adult sablefish are assumed to be demersal and can be found along the continental slope, shelf gullies, and in deep fjords at depths generally greater than 656 ft (200 m) (NPFMC 2018b).

4.2.8 Sculpins (Cottidae)

Cottidae (sculpins) is a large circumboreal family of demersal fishes inhabiting a wide range of habitats in the north Pacific Ocean and Bering Sea. Most species live in shallow water or in tidepools, but some inhabit the deeper waters (up to 3,280 ft (1,000 m)) of the continental shelf and slope (NPFMC 2018b). Most species do not attain a large size (generally 3.9 in - 6 in (10 cm - 15 cm)), but those that live on the continental shelf and are caught by fisheries can be 11.8 in - 19.7 in (30 cm - 50 cm) (NPFMC 2018b). Most sculpins spawn in the winter. All species lay eggs, but in some genera, fertilization is internal. The female commonly lays eggs amongst rocks where they are guarded by males (NPFMC 2018b). Egg incubation duration is unknown; larvae were found across broad areas of the shelf and slope all year-round in ichthyoplankton collections from the southeast Bering Sea and GOA (NPFMC 2018b). Larvae exhibit diel vertical migration (near surface at night and at depth during the day). Sculpins generally eat small invertebrates (e.g., crabs, barnacles, mussels), but fish are included in the diet of larger species; larvae eat copepods. The approximate upper size limit of juvenile fish is unknown (NPFMC 2018b).

EFH for three species of sculpin has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11; Figure 4-19) and are described below.

- Yellow Irish lord (Hemilepidotus jordani)
- Bigmouth sculpin (*Hemitripterus bolini*)
- Great sculpin (*Myoxocephalus polyaphalus*)

Eggs: Most sculpin species lay demersal eggs in nests that are guarded by males in rocky shallow waters near shore (NPFMC 2018b).

Larvae: Sculpin are distributed pelagically and in neuston across broad areas of shelf and slope, but predominantly on inner and middle shelf (NPFMC 2018b).

Juveniles: No EFH description determined – insufficient information is available.

Adults: Adult sculpins are demersal and live in a broad range of habitats from rocky intertidal pools to muddy bottoms of the continental shelf and in rocky, upper slope areas. Most commercial bycatch occurs on middle and outer shelf areas used by bottom trawlers for Pacific cod and flatfish (NPFMC 2018b).

4.2.9 Walleye Pollock

Walleye pollock is an abundant species in the GOA and is also found in Cook Inlet. Pollock range from the Chukchi Sea south through the Bering Sea and Pacific Ocean to central California and Japan (NPFMC 2018b). EFH for walleye pollock has been defined in Cook Inlet and GOA (Table 4-10 and Table 4-11;Figure 4-20). Pollock reach 36 in (91 cm) in length and are an important species in commercial fisheries (NPFMC 2018b). Walleye pollock are demersal and may occur at depths to 3,117 ft (950 m) but are also pelagic and occur in schools near the surface and in mid-water habitats (Mecklenburg et al. 2002). Small pollock feed on copepods and other zooplankton and larger pollock feed on fish (NPFMC 2018b). Although walleye pollock is grouped with groundfish, young pollock are the dominant forage fish consumed by larger fish, including adult pollock, and many marine bird and mammal species (Schumacher et al. 2003). Walleye pollock consistently spawn in the Shelikof Strait area and were the second most abundant groundfish species captured during small-mesh trawl sampling in Kachemak Bay in 2000 (Gustafson and Bechtol 2005). They were also regularly captured in PLP marine fish surveys at Amakdedori Beach and estuary areas further north (GeoEngineers 2018a, PLP 2013).

Eggs: Walleye pollock eggs are pelagic and occur on the outer continental shelf generally over 238 ft – 656 ft (100 to 200 m) depth in Bering Sea and on continental shelf in the GOA (NPFMC 2018b).

Larvae: Larvae are pelagic and occur in the outer to mid-shelf region in the Bering Sea and throughout the continental shelf within the top 131 ft (40 m) in the GOA (NPFMC 2018b).

Juveniles: Age 0, age 2, and age 3 walleye pollock appear to be pelagic and demersal, with a widespread distribution and no known benthic habitat preference (NPFMC 2018b).

Adults: EFH for adult walleye pollock occur depths greater than 230 ft (70 m), both pelagically and demersally, on the outer and mid-continental shelf of the GOA and Aleutian Islands (NPFMC 2018b).

4.2.10 Sharks, Forage Fish Complex, Squids, and Grenadiers

Sharks, forage fish complex (eulachon, capelin, sand lance, sand fish, euphausiids, myctophids, pholids, gonostromatids, etc.), squids, and grenadiers are included in the GOA groundfish FMP, however no EFH description is determined due to insufficient information (NMFMP 2018a). Six species from the forage fish complex, including Pacific herring, were captured during sampling between Amakdedori Beach and Iniskin Bay inferring EFH within the Action Area (Table 4-12, Table 4-13).

4.2.10.1 Surf Smelt

Surf smelt range from Long Beach, California to Chignik Lagoon, Alaska. They are an abundant schooling forage fish that can be found in the ocean, estuaries and occasionally freshwater. Surf smelt feed on animals in the water column and on the bottom, consuming crustaceans, polychaetes, larvaceans, insects and occasionally small fishes. They are preyed upon by Chinook salmon and coho salmon, bald eagles, common murres, rhinoceros auklets, various terns and seals (WDFW 2015). Surf smelt in northwest Washington spawn year-round, with no particular spawning season more dominant than another. Eggs, about 1 millimeter (mm) in diameter, are deposited in the upper intertidal zone on mixed sand and gravel beaches. After spawning, the eggs are dispersed across the beach by wave activity, so more of the beach is used for incubation than is used for actual spawning (Moulton and Penttila 2001).

The life history of the surf smelt is intimately linked to nearshore geophysical processes. The critical element of surf smelt spawning habitat is the availability of a suitable amount of appropriately textured spawning substrate at a certain tidal elevation along the shoreline. Their potential spawning/spawn incubation zone spans the uppermost one-third of the tidal range. Spawning substrate grain size is generally a sand-gravel mix, with the bulk of the material in the 0.04 to 0.28 in (1 to 7 mm) diameter range. Within a typical sediment drift cell, surf smelt spawning habitat may be limited at the erosional beginning of the drift cell, where beaches tend to be overly coarse in sediment texture. Surf smelt may also be limited at the depositional end of a drift cell, where the upper beach may be overly sandy in character. Most spawning beaches are used on an annual basis, although there are "outlier" sites that may be used only during periods of high local stock abundance (Penttila 2007).

Surf smelt spawning may occur at irregular, short intervals at any particular site. Spawning takes place in just a few inches of water just below the waterline during high tides. Spawning events a few days apart are commonly superimposed on each other, and it is not uncommon for an area to contain two to five individual broods of eggs. Once a spawning season begins, the rate of new egg deposition coupled with hatchings will likely provide the site with a continuous deposit of eggs for several months (Penttila 2007).

Surf smelt were abundant during 2004-2008 sampling in Iliamna and Iniskin bays (PLP 2013). Adults and larvae were found at Amakdedori Beach during 2018 (Table 4-11), which indicates that spawning areas were likely close. Eggs were not detected in sampling conducted at Amakdedori Beach, Iniskin Bay and Nordyke Island from April to June 2018 (GeoEngineers 2018a).

Eggs: No EFH description determined – insufficient information is available.

Larvae: No EFH description determined – insufficient information is available.

Juveniles: No EFH description determined – insufficient information is available.

Adults: No EFH description determined – insufficient information is available.

4.2.10.2 Capelin

Capelin are abundant in coastal areas of Alaska; however, stocks have undergone dramatic declines since the 1970s. These declines are attributed to various threats including ecosystem shifts due to climate change, incidental bycatch and contamination/destruction of spawning habitat (e.g., oil spills) (ADF&G 2005). Spawning occurs from mid-May through July when adults (2 - 3 years) move inshore to spawn on coarse gravel and/or sand beaches. Eggs incubate in the substrate hatching 15 - 30 days later with larvae being subjected to the tides (Doyle et al. 2002).

Capelin are a high-energy forage fish that play a key role in the overall marine food web. These fishes are a common food source, especially during and after spawning events. They are utilized by numerous predators such as sea birds, salmon, and marine mammals – including pinnipeds and cetaceans.

Three capelin were caught during beach seine and otter trawl sampling from 2004 to 2018 between Amakdedori Beach and Iniskin Bay, however capelin spawn was documented on No Name Reef in 2018 (GeoEngineers 2018a). The eggs found in 2018 were predominantly attached to *Fucus distichus* (rockweed) rather than being within beach substrates as described above.

Eggs: No EFH description determined – insufficient information is available.

Larvae: No EFH description determined – insufficient information is available.

Juveniles: No EFH description determined – insufficient information is available.

Adults: No EFH description determined – insufficient information is available.

4.2.10.3 Gunnels

The gunnels are a family, Pholidae, of marine fishes in the order Perciformes. They are elongated, somewhat eel-like fishes that range from the intertidal zone to depths of 660 ft (200 m), though the majority are found in shallow waters. Most are restricted to the North Pacific, ranging as far south as Baja California and East China. They typically reach a maximum length of 20 cm – 30 cm (8 in – 12 in), but *Apodichthys flavidus* reaches 46 cm (18 in). They eat small crustaceans and molluscs.

Gunnels are included as a forage fish in the GOA FMP, however EFH has not been defined for this species complex. They were encountered during PLP marine fish surveys at Iliamna and Iniskin bays during 2004-2008 sampling (PLP 2013).

Eggs: No EFH description determined – insufficient information is available.

Larvae: No EFH description determined – insufficient information is available.

Juveniles: No EFH description determined – insufficient information is available.

Adults: No EFH description determined – insufficient information is available.

4.2.10.4 Pricklebacks (Stichaeidae)

Pricklebacks (family Stichaeidae) are a species complex that includes pricklebacks, warbonnets, eelblennys, cockscombs, and shannys and are included in the forage fish complex of the GOA FMP. These species typically reside in shallow water and provide a forage base for numerous predatory species. Snake prickleback were commonly encountered during beach seine and trawl sampling at Amakdedori Beach and estuary areas further north (PLP 2013).

Eggs: No EFH description determined – insufficient information is available.

Larvae: No EFH description determined – insufficient information is available.

Juveniles: No EFH description determined – insufficient information is available.

Adults: No EFH description determined – insufficient information is available.

4.3 Weathervane Scallop

Weathervane scallops are distributed from Point Reyes, California, to the Pribilof Islands, Alaska and are covered in the Alaska region by the Scallop FMP. The highest known densities in Alaska occur in the Bering Strait, off Kodiak Island, and along the eastern gulf coast from Cape Spencer to Cape St. Elias. Weathervane scallop EFH within Cook Inlet is shown on Figure 4-21. Weathervane scallops are found from intertidal waters to depths of 984 ft (300 m), but abundance tends to be greatest between depths of 131 ft and 427 ft (40 m – 130 m) on beds of mud, clay, sand, and gravel. Beds tend to be elongated along the direction of current flow. A combination of large-scale (overall spawning population size and oceanographic conditions) and small-scale (site suitability for settlement) processes influence recruitment of scallops to these beds. Sexes are separate and mature male and female scallops are distinguishable based on gonad color. Although spawning time varies with latitude and depth, weathervane scallops in Alaska spawn from May to July depending on location. Eggs and spermatozoa are released into the water, where the eggs become fertilized. After a few days, eggs hatch, and larvae rise into the water column and drift with ocean currents. Larvae are pelagic and drift for about one month until metamorphosis to the juvenile stage when they settle to the bottom.

Eggs: No EFH description determined – insufficient information is available.

Larvae: No EFH description determined – insufficient information is available.

Early Juveniles: No EFH description determined – insufficient information is available.

Late Juveniles: EFH for late juvenile weathervane scallops is the general distribution area for this life stage, located in the sea floor along the inner (3.3 ft – 164 ft (1 m – 50 m)), middle (164 ft – 328 ft (50 m – 100 m)), and outer (328 ft – 656 ft (100 m – 200 m)) shelf in concentrated areas of the GOA where there are substrates of clay, mud, sand, and gravel that are generally elongated in the direction of current flow.

Adults: EFH for adult weathervane scallops is the general distribution area for this life stage, located in the sea floor along the inner (3.3 ft – 164 ft (1 m – 50 m)) , middle (164 ft – 328 ft (50 m – 100 m)) and outer (328 ft – 656 ft (100 m – 200 m)) shelf in concentrated areas of the GOA where there are substrates of clay, mud, sand, and gravel that are generally elongated in the direction of current flow.

4.4 Habitat Areas of Particular Concern

There are no Habitat Areas of Particular Concern within the Action Area.

4.5 Amakdedori Port Habitat Mapping

The proposed Amakdedori Port is located approximately 1.4 mi (2.3 km) north of Amakdedori Creek, on a high energy gravel/sand beach referred to as Amakdedori Beach. The beach extends approximately 4.8 mi

(7.7 km) north and 5 mi (8 km) south of the mouth of Amakdedori Creek. PLP mapped approximately 137,047 ac (55,461.2 ha) of Amakdedori Beach and adjoining marine habitat (44,708 ac [18,129.2 ha] of nearshore habitat, and 92,340 ac [37,368.8] of offshore habitat). Nearshore habitat included 4,820 ac (1,950 ha; 4 percent) of beach complex and 14,190 ac (5,742.5 ha; 10 percent) of subtidal mixed gravel. The complete acreage and percentage of habitat mapped is provided in Table 4-15.

Table 4-15: Nearshore and offshore habitat mapped by PLP at Amakdedori Beach.[1]

Type	Sub-Type	Substrate	Acres	Percent
Nearshore	Beach Complex	Beach Complex	4,820	4
	Beach Complex Total		**4,820**	**4**
	Intertidal	Reef	8,559	6
	Intertidal Total		**8,559**	**6**
	Subtidal	Mixed Gravel	14,190	10
		Reef	15,337	11
		Sand/Fine	1,802	1
	Subtidal Total		**31,328**	**23**
Nearshore Total			**44,708**	**33**
Offshore	Intertidal	Reef	4,824	4
	Intertidal Total		**4,824**	**4**
	Subtidal	Mixed Fine	65,640	48
		Mixed Gravel	12,838	9
		Reef	8,324	6
		Sand/Fine	714	1
	Subtidal Total		**87,516**	**64**
Offshore Total			**92,340**	**67**
Grand Total			**137,047**	**100**

Note:
1 GeoEngineers 2018b

The backshore of Amakdedori Beach is composed of a storm berm formed by large woody debris with a broad flat riparian upland composed principally of dune grass transitioning to low/dwarf shrub vegetation. Along the periphery of the beach (north, south, and offshore) lie extensive intertidal and subtidal reefs that extend as much as 8 mi (12.9 km) offshore, with gaps of deeper subtidal habitat mostly less than 30 ft (9.1 m) deep between them. These reef habitats support dense marine macrovegetation dominated by rockweed, red algae, and kelps. Subtidal habitats are composed primarily of sand, cobbles, boulders and bedrock (GeoEngineers 2018a and 2018b).

5 EVALUATION OF POTENTIAL EFFECTS ON EFH

This assessment considers the potential effects of the Pebble Project's proposed actions on the quantity and quality of EFH for all life stages of Pacific salmon, groundfish, and scallops (managed species) including: discharges of dredged or fill material into waters of the U.S., including wetlands; work or structures in marine waters; and construction of bridge crossings over navigable waters of the U.S, including wetlands, that require federal authorization. These actions could result in habitat removal or disturbance, water quality degradation, wetland and riparian buffer removal, streamflow changes, stream temperature changes, and stream sedimentation. The *Impacts to Essential Fish Habitat from Non-fishing Activities in Alaska* (Limpinsel et al. 2017) identifies potential impacts associated with mining, port and road construction, and pipeline installation, along with recommended conservation measures. The following terminology is used in this evaluation of potential effects on EFH:

This EFH analysis considers four categories of duration: temporary, short-term, long-term, and permanent.

- Temporary – days to weeks
- Short-term – < 3 years
- Long-term – > 3 years to < 20 years
- Permanent – > 20 years or no recovery

This EFH analysis defines three degrees of potential impact: low, moderate, and high.

- *Low Degree of Impact*: the effect may cause temporary to short-term degradation of EFH including interruptions of spawning, feeding, or growth to maturity, but EFH characteristics would be likely to return to normal after the activity ceases. If EFH is removed, the effect can be reversed in the short-term, or may result in minor functional changes (i.e., culverts).
- *Moderate Degree of Impact*: the effect may permanently remove EFH in areas of low density use by managed species.
- *High Degree of Impact*: the effect may permanently remove EFH in areas of high or higher quality EFH as determined by high density of use by managed species.

The terms "no impact" or "negligible impacts" are used where impacts are not expected or, if they occur, are expected to be so minimal as to be unmeasurable.

The evaluation of potential effects to EFH is divided between freshwater (Section 5.1) and marine (Section 5.2) ecosystems. Within each ecosystem, the evaluation is divided by project component including mine site, transportation corridor, and natural gas pipeline as relevant.

5.1 Freshwater Ecosystems

The freshwater ecosystem for this project is defined as all rivers, streams, tributaries, ponds, lakes, bogs and marshes designated as EFH that exist in the project Action Area (Figure 3-10, Figure 3-11, and Figure 3-12), generally extending from the mine site to Amakdedori Beach, in Kamishak Bay.

5.1.1 Mine Site

Potential effects to freshwater EFH caused by mine site construction (Figure 3-2) are discussed below. Mine site impacts are summarized in Section 5.1.1.7.

Mine site construction activities would occur year-round:

- Major Site Earthworks September Y2 – May Y4
- Mill & Infrastructure Construction May Y3 – October Y4
- Pit Pre-production Mining September Y3 – October Y4

5.1.1.1 Loss of Habitat

Construction at the mine site would discharge fill material into 46,836 LF (14,276 LM) of EFH catalogued as anadromous streams in the AWC and/or identified by PLP research as EFH. These anadromous stream reaches support primarily low levels of use by rearing Chinook salmon and rearing and spawning coho salmon. Mortality of managed species would most likely occur in streams removed during Project construction (Table 5-1) of the TSFs and main water management pond. The magnitude of the potential mortality to Pacific salmon in streams directly impacted by construction activities will depend on construction timing and presence of Pacific salmon life stages, including eggs, juveniles, and adults. Juveniles and embryonic life stages would be more susceptible to mortality than adult Pacific salmon. The NFK and SFK reaches that would be removed have a low Pacific salmon presence compared to downstream reaches indicating that these habitats are of lower quality EFH or not limited in abundance in the remainder of each drainage. Construction timing will be determined during detailed project design and in consultation with the ADF&G to minimize impacts to habitat during critical species life stages. PLP will develop a plan to prevent fish passage into habitats proposed for removal prior to construction that would substantially reduce the potential for fish mortality.

Construction of the mine site (September Y2 – October Y4) would remove 46,836 LF (14,277 LM) (13.6 percent of EFH within Action Area) of designated EFH within the NFK and SFK tributaries of the Koktuli River; no EFH would be removed in UT Creek (Table 5-1). The total loss of EFH represents a 3 percent loss of the 1,573,510 LF (479,606 LM) of EFH in the Koktuli River drainage (Table 5-1). Primary EFH losses would result from construction of the bulk and pyritic tailings TSF within the headwater drainage NFK 1.190, with some additional loss from construction of the main water management pond within headwater tributary NFK 1.200. Construction of facilities within NFK River would permanently remove 42,917 LF (13,081 LM) or 11.3 percent of EFH tributaries out of a total documented 383,856 LF (116,999 LM) of EFH in NFK River and 22.2 percent of the 193,408 LF (58,951 LM) of EFH in the Action Area within NFK River. The proposed mine pit is also situated within the headwaters of the SFK River, 1.5 mi (2.4 km) north of Frying Pan Lake (Figure 3-2). Approximately 3,920 LF (1,194.8 LM) or about 1 percent of the 367,112 LF (111,896 LM) of EFH in SFK River would be removed in the headwaters of SFK River (SFK 1.0) upstream from Frying Pan Lake. Approximately 3,920 LF (1,195 LM) or about 1 percent of the 367,112 LF (111,896 LM) of EFH in SFK River would be removed in the headwaters of SFK River (SFK 1.0) upstream from Frying Pan Lake. Approximately 2.6 percent of the 151,531 LF (46,187 LM) of EFH in the Action Area would be removed.

Approximately 39,524 LF (12,047 LM) of NFK-C, primarily within NFK 1.190, would be removed, 22,938 LF (6,992 LM) of which are documented as low-use spawning habitat for coho salmon (Table 4-4, Table 5-1, , Figure 4-4). Aerial survey counts in 2008 on the day of peak distribution within the drainage found 27 out of the 1,746 spawning coho salmon were in NFK 1.190, representing 1.5 percent of adult coho salmon in NFK River. Spawning has not been detected in the tributary for any other EFH species. The 39,524 LF (12,065 LM) of NFK C, and its smaller tributaries that would be removed are also used by rearing coho and Chinook salmon (Table 4-6, Table 4-7, Table 4-8). Compared to the NFK-wide juvenile densities, overall densities and distribution of juvenile Chinook salmon are low within NFK 1.190 and its tributaries with mean sample densities of 0.11 fish/100m^2 in 2008 and 2018 sampling as compared to 4.88 fish/100m^2 at NFK1.0 in the same years (Table 4-8). Rearing coho salmon within NFK 1.190 and its tributaries were found at much lower densities as compared to mainstem NFK River sites in 2008 and 2018 sampling, with mean densities of 1.24 fish/100m^2 in NFK 1.190 and 25.33 fish/100m^2 at NFK 1.0, in combination, indicating overall lower EFH quality or adequate habitat quantity and quality in other areas of the drainage. An additional 3,393 LF (1,034 LM) of NFK River EFH in NFK-D would be removed from headwater tributary NFK 1.200 during construction of the main WMP. Fish sampling in NFK1.200 in 2018 found mean Chinook salmon densities of 0.08 fish/100m^2 and 2.24 fish/100m^2 for coho salmon (Table 4-8, Figure 4-1, Figure 4-2, Figure 4-4).

Developing the mine pit would eliminate 3,920 LF (1,195 LM) of low density coho and sockeye salmon rearing EFH in the headwaters of SFK River in reach SFK-E, upstream from Frying Pan Lake (Table 5-10; Figure 4-1, Figure 4-4, Figure 4-6). No Adult Pacific salmon were observed within the headwater reach of SFK River that would be removed during any of the aerial surveys flown from 2004 through 2008 to document the distribution of adult salmon. Habitats that would be removed exhibited some of the lowest density use by both coho and sockeye salmon juveniles within the SFK drainage, suggesting low overall quality EFH or abundance of quality habitat in unaffected areas. Surveys conducted from 2004 through 2008 in mainstem habitats in SFK River found that juvenile salmon densities generally decreased with distance from the confluence with NFK River with mean coho salmon densities of 37.40 fish/100m^2 in SFK-A, 6.88 fish/100m^2 in SFK-B, 0.64 fish/100m^2 in SFK-C, 2.52 fish/100m^2 in SFK-D and 0.70 fish/100m^2 in SFK-E, while sockeye salmon juvenile densities were much lower in mainstem habitats with mean densities of 1.96 fish/100m^2 in SFK-A, 0.62 fish/100m^2 in SFK-B, no juvenile sockeye salmon in SFK-C or SFK-D, and 0.02 fish/100m^2 in SFK-E (Table 4-6). Baseline studies found rearing Pacific salmon were rare upstream from Frying Pan Lake in SFK (Figure 4-1, Figure 4-4, Figure 4-6; PLP2018a, PLP 2011). Loss of 3,920 LF (1,195 LM) of upper SFK River EFH would represent a 1 percent loss of SFK River EFH and a 2.6 per cent loss of EFH in the SFK Action Area. The physical loss of habitat would be low overall and juvenile salmon densities observed within the reach to be eliminated indicate the loss would have negligible consequences to managed species.

Direct impacts of EFH removal would be permanent. However, considering the low use of EFH to be removed (based on densities of juvenile Chinook, coho and sockeye salmon captured within these habitats), the lack of spawning in SFK-E reaches to be removed and the low level of spawning in the NFK 1.190 tributary to be removed, indicates that drainage-wide impacts to Pacific salmon populations from these direct habitat losses would be unlikely.

The Koktuli River and the Upper Talarik Creek drainages include 2,033,856 LF (619,919 LM) of stream EFH. In total, 46,836 LF (14,276 LM) of stream EFH within the Koktuli River drainage would be lost, all within headwater streams of the NFK and SFK rivers within the Action Area around the mine footprint. This EFH loss amounts to approximately 2.3 percent of the total EFH in these drainages and 13.4 percent of EFH in the Action Area (Table 5-1). The 46,836 LF (14,276 LM) loss of headwater streams is permanent, but the impacts in the context of available EFH in NFK River, SFK River, and UT Creek drainages are localized and minimal. The larger, downstream reaches documented to be more heavily used by Pacific salmon for spawning and rearing would not be directly impacted, although reductions in downstream flows due to mine operations could affect EFH in downstream reaches. Indirect effects, such as alterations to water flow and nutrient transport, could have further indirect impacts in downstream reaches of NFK River and SFK River in designated EFH for Chinook (Figure 4-1, Figure 4-2), coho (Figure 4-1, Figure 4-4), sockeye (Figure 4-1, Figure 4-6), and chum (Figure 4-1, Figure 4-8) salmon, and are discussed in Section 5.1.1.3. Overall, the degree of habitat loss impact is moderate: EFH for rearing Chinook and coho salmon, and spawning and developing embryonic coho salmon would be permanently removed in areas with low densities of managed species and impacts could be detectable in the short-term, but population level effects within the context of the NFK River, SFK River, and UT Creek are not anticipated.

Table 5-1: Summary of EFH directly removed during mine site development.

Drainage Reach	Stream Code	Total EFH Stream LF	EFH Stream LF Removed (% of Total EFH Stream)	EFH Stream LF In Action Area (% Removed)
Total Koktuli River		**1,573,510**	**46,836 (3)**	**344,939 (13.6)**
Total North Fork Koktuli River		**383,856**	**42,917 (11.3)**	**193,408 (22.2)**
Total NFK-C		**163,645**	**39,524 (24.2)**	133,879 (29.5)
	NFK 1.190	23,566	22,938 (95.6)	23,566 (100)
	NFK 1.190.10	8,011	8,011 (100)	25,047 (31.9)
	NFK 1.190.10.03	246	246 (100)	246 (100)
	NFK 1.190.30	2,731	2,731 (100)	2,731 (100)
	NFK 1.190.40	4,924	4,924 (100)	4,924 (100)
Total NFK-D		**90,315**	**3,393 (3.5)**	11,424 (30)
	NFK 1.200	5,351	3,393 (60)	5,352 (63)
Total South Fork Koktuli River		**367,112**	**3,920 (1)**	151,531 (2.6)
Total SFK-E		**40,836**	**3,920 (9.1)**	22,451 (17.5)
	SFK 1.0	22,451	3,920 (16.3)	22,451 (17.5)
Total Upper Talarik Creek		**460,416**	**0 (0)**	4,224 (0)
Grand Total (Koktuli River[1] and UT Creek)		**2,033,856**	**46,836 (2.3)**	**349,163 (13.4)**

Note:
1 Koktuli River including all its tributaries

5.1.1.2 Blasting

Blasting will be necessary to construct the open pit, material sites, and other structures. Blasting would occur as needed (infrequently) during construction of the project from September Y2 to October Y4.

Mortality of Pacific salmon including eggs, juveniles and adults is possible during blasting if in-water overpressures exceed thresholds set by regulatory agencies. In the mine site Action Area, only lower quality/low use rearing habitats in upper UT, NFK- D and upper SFK could be affected by blasting and the majority of those habitats (in NFK and SFK), which include low quality/low use coho salmon spawning habitat, would be permanently removed during construction therefore eliminating effects of blasting.

Occasionally, blasting could occur within the Action Area near fish-bearing waters along EFH tributaries of NFK River and the headwaters of SFK River north of Frying Pan Lake (Figure 3-10). The use of explosives near occupied fish habitat can produce in-water overpressures and in-gravel particle velocities that could injure or result in mortality to fish and fish eggs in spawning gravels.

In a review of research on the effects of various overpressures and particle velocities on fish and fish eggs, Kolden and Aimones-Martin (2013) found that the slowest LD10[1] particle velocity in Chinook salmon eggs occurred at 5.8 inches per second (in/s). Other Pacific salmon species tolerated considerably faster particle velocities, with an LD10 occurring at 9.1 in/s in coho, 16.4 in/s in chum, 24.5 in/s in pink, and 33.0 in/s in sockeye salmon. Their review also found that the lowest sound pressure level (SPL) to injure fish was 10.0 psi. The report ultimately recommended that blast-related overpressures and peak particle velocities in fish-bearing waters should be set below thresholds known to injure fish or result in egg mortality. In 2013, the ADF&G adopted revised blasting standards (Timothy 2013) to be applied to projects where the impacts of blasting on fish and embryos in fish-bearing waterbodies could not be avoided or mitigated. The revised standards limit in-water instantaneous pressure rise in the water column in rearing habitat and migration corridors to no more than 7.3 psi where and when fish are present and specified peak particle velocities in spawning gravels are limited to no more than 2.0 in/s during early stages of embryo incubation before epiboly is complete (Timothy 2013).

The estimated pressure and vibration forces that could be generated from the Project blasting activities have not been calculated, pending development of blasting plans. Blasting in areas near fish habitat would be reviewed and planned in consultation with the ADF&G and in accordance with the guidelines and BMPs outlined in the publication “Alaska Blasting Standard for the Proper Protection of Fish, Alaska Department of Fish and Game, Technical Report No. 13-03” (Timothy 2013). If necessary, blasting activities will be scheduled when the fewest species/least vulnerable life stages of federally managed species will be present, consistent with permit stipulations. The Project will comply with regulatory requirements and collaborate with agency staff to ensure overpressures and particle velocities do not exceed levels that have been shown to cause injury or mortality to salmonids and salmonid embryos. Blasting can cause in-water overpressures and particle velocities lethal to fish and developing embryos despite efforts to maintain sub-lethal thresholds. Such occurrences are anticipated to be rare but result in low levels of mortality within the immediate vicinity of blasting adjacent to fish bearing waters. Overall, blasting effects are anticipated to be limited to levels that could cause temporary avoidance of blast areas. Within the Action Area, fish are expected to return to the site of blasting and habitat conditions to return to a usable state once blasting is complete, with the exception of those areas permanently removed during construction. The degree of impact

[1] ‘Lethal Dose 10’- is the level that results in mortality of approximately 10 percent in exposed fish.

is low: the effect may cause temporary degradation of EFH (rearing Chinook, coho, and sockeye salmon) including interruptions to feeding or growth to maturity, but EFH characteristics would be likely to return to normal after the activity ceases. The effects may disturb or displace managed species, but mortalities are unlikely and EFH will likely return to normal after the activity ceases.

5.1.1.3 Water Flow

Management of surface runoff and groundwater at the mine site (September Y2 through October Y4) would result in streamflow changes to the NFK River, the SFK River, and UT Creek, that could affect habitat quantity, water temperature (Section 5.1.1.4), and water quality (Section 5.1.1.5). Changes in baseflow can alter channel morphology and hydrogeomorphic processes that maintain and regulate EFH quantity and quality, including groundwater upwellings for spawning and wintering and productive feeding habitats. In addition, attenuation of peak and channel forming flows can have beneficial or adverse effects on channel stability and form, and therefore habitat quantity and quality.

Water collected within the mine site that is not required for the Project (surplus water) will be treated at two water treatment plants and discharged into the NFK River, the SFK River, and UT Creek. The combined mean annual discharge from both water treatment plants is estimated to be 29 cfs (1.1 m^3/s) (Knight Piésold 2018b). Treated water discharge is an integral part of the mine plan and would commence during construction. Modelling results for estimated mean annual flows for surface and groundwater at several stations in the NFK River, the SFK River, and UT Creek, for both pre-mining and end-of-mine conditions that includes treated water discharges (Knight Piésold 2018b) are presented in Table 5-2.

While the specific changes in flow by stream reaches to certain habitats are predicted throughout this section, the potential impacts to stream morphology are not directly predicted. However, detailed baseline studies on the fluvial geomorphology of the streams in the mine Action Area suggest that all three major drainages are consistent with typical fluvial geomorphic characteristics of gravel bed streams and that channel forms are predominantly consistent with linear flow regressions (PLP 2013). The primary processes defining the character of each stream are related to the physiographic and planform features of each drainage, hydraulic geometry and sediment characteristics from upstream to downstream in each drainage, ice processes, beaver activity and sediment sources. While changes in flow outlined below could lead to changes in the fluvial geomorphic character of some stream reaches, consistent with their reduction of flow, ice processes that help form stream character would likely remain similar post construction with upper, steeper reaches of each drainage and their smaller tributaries exhibiting bed-fast ice conditions and lower reaches exhibiting floating ice conditions all of which can be drivers of bank erosion rates, channel widths and bankfull depths. It is uncertain what role ice processes play specifically in channel morphology within the streams of the NFK, SFK and UT Creek, however, evidence of ice jam related channel avulsion, sediment deposition and localized erosion have been documented. Similarly, beaver activity is common in upper portions of each drainage and within tributaries while in main stem reaches further downstream, beaver activity is restricted to off-channel habitat areas. Beaver dams also play a role in stream morphology by affecting localized sedimentation by retaining and depositing fines and reducing downstream transport of all substrates until the dams' experience failure leading to rapid redistribution of fines and erosion. Ice and beaver effects to stream morphology would likely minimize the potential effects to channel morphology as specifically related to potential changes attributable to the reductions in flow.

Changes in mean annual stream flow are predicted to exceed 2 percent in 193,408 LF (58,951 LM) of EFH in the NFK drainage, primarily as result of the removal of all flows from NFK 1.190 and NFK1.200, while 151,531 LF (46,187 LM) of EFH would see flow reductions in excess of 2 percent in mean annual flow in the SFK River. Mean annual flows in UT Creek would remain within about 1 percent of pre-mine flows. Detailed modelling results indicate that most of the streamflow impacts would occur from changes to surface waters while reductions to the groundwater contribution to streamflow would be negligible. This suggests that the distribution of spawning and wintering habitats potentially related to groundwater inputs within the Action Area should remain largely unaffected. The largest streamflow reductions are expected in the NFK River, primarily at flow station NK119A (100 percent; Figure 4-1), resulting from the removal of NFK 1.190 and tributaries during construction. Surface flow reductions within the NFK River downstream from NFK 1.190 show a 7 percent reduction in mean annual flow at NK100C, and a 7 percent reduction closer to the confluence with SFK River at site NK100A. The highest magnitude changes would occur within habitats of NFK 1.190 and NFK 1.200 that would be removed during construction. NFK 1.190 is documented as low-density spawning habitat for coho salmon with 2008 aerial adult surveys showing 27 adults accounting for 1.5 percent of adult coho salmon within NFK River within the tributary on the day of peak adult distribution. No other adult salmon have been identified within NFK 1.190. No adult salmon were observed in NFK 1.200 during surveys of adult salmon distribution in NFK River. Both NFK 1.190 and NFK 1.200 provide rearing habitat for coho and Chinook salmon. Sampling for juvenile salmon in NFK 1.190 and tributaries in 2008 and 2018 found mean sample densities of 0.11 fish/100m^2 for Chinook salmon and 1.24 fish/100m^2 for coho salmon, while sampling in NFK 1.200 and tributaries found mean sample densities of 0.08 fish/100m^2 for Chinook salmon and 2.24 fish/100m^2 for coho salmon (Table 4-8). The impacts of habitat removal in NFK 1.190 and NFK 1.200 were fully addressed under habitat loss, Section 5.1.1.1.

Mean monthly flows modelled for flow sites within the Action Area within NFK River showing mean annual flow reductions in excess of 2 percent suggest that while mean annual flows will be lower, the overall distribution of flow is expected to be similar throughout the year, with the exception of NK119A, which would be eliminated during construction (Figure 5-1). While NK100C mean annual surface flow would be reduced by approximately 7 percent, peak monthly flows in May and June would be within 5 and 3 percent of pre-mining flows with the largest reductions occurring during the winter between November and April when flows would range between 6 to 9 percent lower. At modelling site NK100A, the mean annual discharge would also decrease by about 7 percent with May and June peak monthly flows showing reductions of about 7 and 10 percent. Winter average monthly flows in the late winter months between February and April are predicted to be between about 3 and 7 percent higher than pre-mining. Overall, the post construction flow regime should be relatively similar to pre-mine conditions with modest reductions in channel-forming base surface flows, which would be further minimized by the nearly unchanged groundwater flows predicted.

The next highest reduction of flows would occur in the SFK River where mean annual surface water flow reductions are predicted to range from 7 percent to 2 percent among the six modeled flow stations within SFK River (Table 5-2). The highest predicted flow reductions of 7 percent are for site SK119A within the tributary SFK 1.190. Aerial surveys conducted in 2008 to determine the distribution of Pacific salmon documented 28 chum salmon (2.9 percent) and 50 coho salmon (3.2 percent) of SFK-wide counts on the days of peak distribution. Furthermore, aerial spawning surveys in 2008 found 1,178 chum salmon and

5,647 coho salmon, each accounting for over 99 percent, in the lower SFK River A and B reaches identified in the AWC as spawning habitat (Table 4-4). Juvenile coho salmon and Chinook salmon within SFK1.190 and its tributaries were found at relatively low densities. Sampling in SFK 1.190 and tributaries in 2008 and 2018 found mean Chinook salmon densities of 0.05 fish/100m^2 and 2.38 fish/100m^2 for coho salmon, while coho salmon densities in SFK 1.240 were 10.25 fish/100m^2. Juvenile sockeye salmon were documented at three sites, with densities highest at SFK 1.260 with 3.26 fish/100m^2 and lowest at SFK 1.0 (km 54.7-64.2) with 0.02 fish/100m^2. Reaches of the SFK River upstream of SFK 1.190, including tributary SFK 1.240, are predicted to have reduced mean annual surface flows of up to 4 percent while sites downstream from the confluence with SFK 1.190 are predicted to have reduced mean annual surface flows of up to 2 percent. Aerial survey counts of adult Pacific salmon conducted in 2008 on the day of peak distribution observed no Chinook or sockeye salmon adults in mainstem SFK reaches upstream from the confluence with SFK 1.190. The same surveys found 7 (0.7 percent) adult chum salmon and 24 (1.5 percent) adult coho salmon upstream from SFK 1.190. Pacific salmon spawning has not been detected in SFK River upstream from Frying Pan Lake or within SFK 1.240.

Mean monthly flows modelled for flow sites within the Action Area within SFK River showing mean annual flow reductions in excess of 2 percent suggest that while mean annual flows will be lower, the overall distribution of flow is expected to be similar throughout the year (Figure 5-1). While SK119A mean annual surface flow would be reduced by approximately 7 percent, peak monthly flows in May and June would be within about 6 percent of pre-mining flows with the largest reductions occurring during the winter between November and April, ranging from about 8 to 11 percent lower. At modelling site SK124A, mean annual discharge would decrease by about 4 percent with May and June peak monthly flows showing reductions of about 2 and 4 percent. Winter average monthly flows in winter between November and April are predicted to be between about 0 and 9 percent lower than pre-mining. At modelling site SK100F, mean annual flows would drop approximately 4 percent, however late winter flows in March and April would increase by around 27 and 83 percent, while peak flows in June and again in September would be reduced by about 12 and 6 percent. At site SK100C, the furthest downstream modelling in the SFK River that is predicted to exceed 2 percent mean annual flow reduction, monthly average peak flows in May and June would be reduced by about 2 to 5 percent while winter flows between November and March would range from around 4 to 8 percent lower. April modelled monthly flows would about 1.5 percent higher than pre-mining April flows. Overall, the flow regime should be generally maintained with modest reductions in surface flows, which would be further minimized by the nearly unchanged groundwater flows predicted.

Mine infrastructure within the UT Creek drainage would be limited to roads and water treatment plant discharge facilities. Changes to mean annual surface water flows in UT Creek could be affected by pit dewatering activities, however the net result of pit dewatering and treated water discharge from water treatment would be an estimated increase of 1 percent at site UT100D, nearest the discharge facilities. Mean annual surface water flows for sites downstream from UT100D are predicted to remain the same as pre-mine flows (Table 5-2).

Changes in streamflow described above can affect EFH quantity and quality, however, because net reductions in flow are relatively small, changes in available Pacific salmon spawning and rearing habitat are expected to be equally small. Potential impacts to spawning and rearing habitats for Pacific salmon were modelled for wet, dry and average precipitation years post-construction with treated water discharge. A hybrid habitat simulation analysis model (HABSYN) was utilized to synthesize habitat-flow relationships (R2 2018d). This simulation accounted for predicted stream flow reductions and treated surplus water discharges from the mine water treatment plants. This modeling approach incorporated a "habitat-mapping" component that enabled predictions of habitat-flow relationships for each habitat unit within a given reach. The predictions are based on physical habitat simulation system (PHABSIM) modeling at measured transects. The PHABSIM methodology consists of both a hydraulic and habitat model which provides a means of estimating fish habitat as a function of streamflow. Within PHABSIM, the physical and hydraulic characteristics of a stream at different streamflow levels are combined with a set of habitat suitability criteria (HSC) or indices that describe the suitability or preferences of the physical and hydraulic conditions. Each target fish species and life stage combination have a unique set of HSC for variables such as, velocity, depth, and substrate. The suitability of each variable is expressed as a value between 0 and 1, where 0 is not at all suitable and 1 is highly suitable. Thus, for each specific location, the hydraulic model described the physical habitat conditions, while the HSC described how suitable those conditions are for a specific fish species and life stage. When combined, these model components allow the calculation of a habitat-flow relationship which is expressed as Weighted Usable Area (WUA). WUA is an index of the amount of habitat present under a given range of flows. The WUA increases or decreases with increasing flow as a function of both the hydraulic and habitat models. In the hydraulic model, while substrate would likely remain constant over a range of flows, velocity and depth typically increase with an increase in flow. In the habitat model, substrate would once again remain constant with changing flow; however, as depth and velocity change in response to flow, the suitability of depth or velocity will also change, and the direction and degree of that change will vary by species and life stage. For example, coho salmon fry in the NFK have a suitability of 1 for velocities less than 0.1 ft/s, but a suitability of 0 for velocities greater than 2.5 ft/s. Thus, the habitat suitability increases as velocities move from 0 to 0.1 ft/s but would decrease with any additional flow. As the suitability of velocity conditions decrease, the amount of available habitat also decreases. Therefore, changes in hydraulics as flows change, combined with the associated change in habitat suitability of both the depth and velocity are combined to determine how the habitat-flow relationship changes for specific species and habitats. In this manner, some habitats by species can either increase or decrease from pre-mining conditions as the reduced flow regime produces more or less suitable habitat. Using this methodology, total available spawning and rearing habitat was predicted (in acres) by species in reaches of the NFK River, the SFK River, the UT Creek and the mainstem Koktuli River, under pre-mine and after treated water release conditions for wet, average, and dry precipitation years (Table 5-3, Figure 5-2).

Table 5-2: Preliminary watershed model results; estimated pre-mine and post-mine streamflow reductions at end-of-mine life.[1]

Station	Pre-mine Annual Flow (cfs)			End-of-Mine Mean Flow (cfs)			Change in Mean Annual Flow (cfs)				Mean Annual Discharge from WTPs (cfs)
	Surface Water	Ground-water	Total	Surface Water	Ground-water	Total	Surface Water	Ground-water	Total	% Change of Surface Water	
North Fork Koktuli River											
NK100C	50	10.9	60.9	46.4	10.9	57.3	-3.6	0	-3.6	-7%	
NK119A	25.2	0.8	26	0	0	0	-25.2	-0.8	-26	-100%	
NK100A	258.9	2.6	261.5	241.3	2.6	243.9	-17.6	0	-17.6	-7%	21.6
South Fork Koktuli River											
SK119A	36.9	2.3	39.2	34.3	2.3	36.6	-2.6	0	-2.6	-7%	
SK124A	19.7	9.5	29.3	19	9.5	28.5	-0.7	0	-0.8	-4%	
SK100F	30	1	31	28.8	1	29.7	-1.3	0	-1.3	-4%	
SK100C	50.3	63.1	113.4	48.3	63.1	111.4	-2	0	-2	-4%	
SK100B	188	11.6	199.6	183.4	11.6	195	-4.6	0	-4.6	-2%	
SK100A	266.9	17.9	284.9	262.3	17.9	280.3	-4.6	0	-4.6	-2%	6.6
Upper Talarik Creek											
UT100D	28.6	0.4	29.1	28.9	0.4	29.4	0.3	0	0.3	1%	
UT119A	28.3	1.1	29.3	28.2	1.1	29.3	0	0	0	0%	
UT100B	228.5	2.7	231.2	228.7	2.7	231.4	0.2	0	0.2	0%	0.8
Total Mean Annual Discharge from WTP (cfs)											29

Note:
1 Knight Piesold 2018b. Memorandum: RFI 019 Part 2 Streamflow Reductions at End of Mine Life.

The HABSYN predicted the greatest habitat reductions are expected for spawning adult Pacific salmon during dry years. Spawning habitat reductions are typically predicted to be less than or around 5 percent during dry years, and less than 5 percent in wet years. There are many instances of modest increases in spawning habitat. Notable changes in the NFK include a 12.8 percent loss of Chinook salmon spawning habitat in dry years, and 10 percent increases in sockeye salmon spawning habitat in NFK-A and NFK-C in wet years. Similarly, rearing habitats were predicted to change most during dry precipitation years. Most losses predicted are small and primarily in SFK River, with the greatest loss of 1.5 percent of rearing habitat for Chinook salmon, primarily within low density reaches of the SFK River. Most other reductions within SFK River are predicted to be within 1 percent of pre-mine flow conditions, while sockeye salmon rearing habitat is predicted to increase in SFK River in all but wet years.

Chinook salmon spawning habitat changes ranged from a loss of 12.8 percent in dry years to a loss of 4.7 percent in wet years in the NFK, with highest magnitude changes predicted in reaches nearest the mine where spawning densities were lowest during baseline studies. In terms of actual acreages of change, model predictions showed changes of up to 2 ac of total NFK Chinook salmon spawning habitat in average precipitation years and less in dry and wet years. In SFK River, Chinook salmon spawning habitat reductions are predicted to range from a loss of 4.9 percent in dry years to 2.8 percent in average years with a predicted 0.2 percent increase in wet years. Koktuli River Chinook salmon spawning habitats are predicted to increase by 2 and 3 percent in average and wet years while a 3 percent reduction is predicted in dry years. Chinook salmon spawning habitats in the UT Creek are predicted to remain at pre-mine levels in all precipitation scenarios.

Coho salmon spawning habitats in the NFK River were predicted to decrease by around 5 percent in dry years, less than 5 percent in average years and remain at pre-mining levels in wet years. Coho salmon spawning habitats in the SFK river would be reduced in all precipitation scenarios, however all reductions were small ranging from 3.5 to 1 percent. In contrast, modelled habitats in the Koktuli River showed a modest increase (0.6 to 2.4 percent) in available coho salmon spawning habitat in all precipitation scenarios, while Upper Talarik Creek spawning habitats would consistently remain at pre-mining levels.

Gains in sockeye salmon spawning habitats were predicted for all precipitation scenarios and in all rivers (Table 5-3); however, there were also some losses evident, primarily within the SFK River during average (1.3 percent reduction) and dry (3.9 percent reduction) precipitation years. NFK River was predicted to lose 2.1 percent of sockeye salmon spawning habitat in dry years but showed increases of 4.4 and 10 percent during average and wet years. Sockeye salmon spawning habitats are predicted to remain approximately at pre-mining levels in Upper Talarik Creek which is the largest producer of sockeye salmon among the drainages near the mine site (Table 5-3).

Chum salmon spawning habitat acreage would increase or remain at pre-mining levels in all rivers during wet and average years. Habitat reductions of around 2.5 percent were predicted in dry years for NFK and SFK rivers and of 0.1 percent in average years for SFK.

Table 5-3: Pacific salmon spawning and juvenile rearing habitat[1] (acres) modeled for wet, average, and dry precipitation years; pre-mine and after release of treated surplus water.

Species	Wet Year				Average Year				Dry Year			
	Spawning		Juvenile		Spawning		Juvenile		Spawning		Juvenile	
Stream Reach	Pre-Mine (ac)	With Treated Water Discharge (ac) (% change)	Pre-Mine (ac)	With Treated Water Discharge (ac) (% change)	Pre-Mine (ac)	With Treated Water Discharge (ac) (% change)	Pre-Mine (ac)	With Treated Water Discharge (ac) (% change)	Pre-Mine (ac)	With Treated Water Discharge (ac) (% change)	Pre-Mine (ac)	With Treated Water Discharge (ac) (% change)
Chinook salmon												
NFK Total	**26.96**	**25.68 (-4.7)**	**14.96**	**15.1 (+0.9)**	**24.67**	**22.67 (-8.1)**	**14.17**	**14.32 (+1.1)**	**12.24**	**10.67 (-12.8)**	**13.84**	**14.1 (+1.9)**
NFK-A	12.49	12.24	4.81	4.92	11.66	11.29	4.71	4.79	7.38	6.96	4.73	4.86
NFK-B	6.13	5.82	4.76	4.66	6.39	6.09	4.15	4.10	1.99	1.53	3.86	3.85
NFK-C	8.31	7.62	5.34	5.51	6.61	5.29	5.26	5.43	2.87	2.17	5.21	5.38
NFK-190	0.03	0.00	0.05	0.01	0.02	0.00	0.05	0.01	0.00	0.00	0.05	0.01
SFK Total	**36.57**	**36.66 (+0.2)**	**21.71**	**21.57 (-0.7)**	**37.03**	**36.01 (-2.8)**	**21.41**	**21.21 (-0.9)**	**24.38**	**23.19 (-4.9)**	**16.95**	**16.69 (-1.5)**
SFK-A	21.82	21.97	9.35	9.33	24.63	24.62	9.12	9.09	19.88	19.45	7.73	7.68
SFK-B	6.94	7.12	4.60	4.59	6.35	6.10	4.61	4.62	2.42	2.09	3.65	3.57
SFK-C	4.74	4.90	6.14	6.19	4.00	3.75	6.34	6.32	1.61	1.35	4.55	4.59
SFK-190	3.06	2.67	1.63	1.45	2.05	1.54	1.35	1.18	0.48	0.30	1.02	0.86
KR	**11.51**	**11.86 (3.0)**	**15.84**	**15.84 (0)**	**15.02**	**15.34 (2.1)**	**15.18**	**15.17 (3.4)**	**16.32**	**15.81 (-3.1)**	**14.78**	**14.80 (0.1)**
UT	**19.60**	**19.6 (0)**	**21.22**	**21.22 (0)**	**20.83**	**20.83 (0)**	**21.87**	**21.87 (0)**	**17.37**	**17.39 (0.1)**	**22.51**	**22.51 (0)**
Sum	**94.64**	**93.8 (-0.9)**	**73.73**	**73.72 (0)**	**97.56**	**94.85 (-2.8)**	**72.62**	**72.57 (-0.1)**	**70.31**	**67.05 (-4.6)**	**68.08**	**68.11 (0)**
Coho salmon												
NFK Total	**35.27**	**35.25 (0)**	**19.19**	**19.5 (+1.7)**	**34.14**	**32.28 (-5.5)**	**18.69**	**18.93 (+1.3)**	**26.81**	**25.3 (-5.6)**	**18.24**	**18.67 (+2.4)**
NFK-A	15.89	15.76	6.12	6.24	14.45	13.73	6.08	6.16	10.85	10.35	5.97	6.10
NFK-B	5.97	6.13	6.09	6.02	6.88	6.86	5.48	5.44	5.98	5.71	5.02	5.07
NFK-C	13.39	13.36	6.91	7.22	12.80	11.68	7.06	7.32	9.98	9.24	7.18	7.50
NFK-190	0.02	0.00	0.07	0.02	0.01	0.00	0.07	0.02	0.00	0.00	0.07	0.01
SFK Total	**36.90**	**36.53 (-1)**	**15.05**	**15.04 (-0.1)**	**34.37**	**33.55 (-2.4)**	**14.87**	**14.77 (-0.7)**	**24.92**	**24.04 (-3.5)**	**14.65**	**14.62 (-0.2)**
SFK-A	20.49	20.50	5.62	5.62	20.43	20.36	5.44	5.45	18.34	18.12	5.64	5.63
SFK-B	5.28	5.36	3.08	3.07	4.66	4.52	2.96	2.96	2.33	2.15	3.07	3.05
SFK-C	6.94	7.14	5.02	5.10	7.08	6.95	5.21	5.20	3.34	3.15	4.85	4.96
SFK-190	4.18	3.54	1.33	1.24	2.21	1.72	1.26	1.16	0.90	0.61	1.09	0.98
KR	**28.14**	**28.45 (+1.1)**	**13.58**	**13.51 (-0.5)**	**33.15**	**33.95 (+2.4)**	**12.12**	**12.00 (-1.0)**	**40.13**	**40.38 (+0.6)**	**11.39**	**11.30 (-0.8)**
UT	**33.88**	**33.88 (0)**	**21.82**	**21.8 (-0.1)**	**37.04**	**37.04 (0)**	**21.91**	**21.89 (-0.1)**	**32.97**	**32.97 (0)**	**23.11**	**23.11 (0)**
Sum	**134.18**	**134.12 (0)**	**69.63**	**69.85 (+0.3)**	**138.70**	**136.82 (-1.4)**	**67.59**	**67.58 (0)**	**124.83**	**122.69 (-1.7)**	**67.39**	**67.7 (+0.4)**

Species	Wet Year				Average Year				Dry Year			
	Spawning		Juvenile		Spawning		Juvenile		Spawning		Juvenile	
Stream Reach	Pre-Mine (ac)	With Treated Water Discharge (ac) (% change)	Pre-Mine (ac)	With Treated Water Discharge (ac) (% change)	Pre-Mine (ac)	With Treated Water Discharge (ac) (% change)	Pre-Mine (ac)	With Treated Water Discharge (ac) (% change)	Pre-Mine (ac)	With Treated Water Discharge (ac) (% change)	Pre-Mine (ac)	With Treated Water Discharge (ac) (% change)
Sockeye salmon												
NFK Total	**28.04**	**30.83 (+10)**	**14.87**	**14.92 (+0.3)**	**32.69**	**34.11 (+4.4)**	**14.98**	**15.01 (+0.2)**	**31.16**	**30.51 (-2.1)**	**15.01**	**15.69 (+4.5)**
NFK-A	12.55	13.22	4.72	4.75	14.18	14.18	4.52	4.59	11.75	11.44	4.61	4.70
NFK-B	4.56	5.16	6.34	6.31	5.92	6.30	6.57	6.36	6.72	6.78	5.73	5.75
NFK-C	10.89	12.45	3.78	3.83	12.56	13.63	3.85	4.04	12.68	12.29	4.64	5.22
NFK-190	0.03	0.00	0.03	0.02	0.02	0.00	0.04	0.02	0.01	0.00	0.03	0.01
SFK Total	**51.59**	**51.8 (+0.4)**	**15.17**	**15.12 (-0.3)**	**55.25**	**54.56 (-1.3)**	**10.23**	**10.96 (+7.1)**	**46.81**	**44.97 (-3.9)**	**14.33**	**14.8 (+3.3)**
SFK-A	27.83	27.91	6.51	6.49	29.74	29.84	4.87	4.86	32.06	31.82	6.02	6.01
SFK-B	7.92	8.23	3.70	3.68	9.25	9.26	2.98	2.94	5.60	5.21	3.32	3.30
SFK-C	9.47	9.69	4.28	4.27	9.99	9.94	1.73	2.49	5.59	5.33	4.02	4.54
SFK-190	6.36	5.97	0.67	0.68	6.26	5.52	0.65	0.67	3.57	2.62	0.97	0.95
KR	**27.98**	**28.25 (1.0)**	**15.50**	**15.50 (0)**	**31.79**	**32.63 (2.6)**	**15.03**	**14.98 (-0.3)**	**45.16**	**45.49 (0.7)**	**12.25**	**12.15 (-0.8)**
UT	**42.03**	**42.03 (0)**	**16.55**	**16.53 (-0.1)**	**45.07**	**45.07 (0)**	**15.89**	**15.89 (-0.1)**	**44.39**	**44.15 (-0.5)**	**16.11**	**16.1 (-0.1)**
Sum	**149.64**	**152.91 (2.2)**	**62.08**	**62.07 (0)**	**164.79**	**166.36 (1)**	**56.13**	**56.83 (1.2)**	**167.51**	**165.13 (-1.4)**	**57.70**	**58.73 (1.8)**
Chum salmon												
NFK Total	**49.95**	**54.63 (+9.4)**	--[3]	--	**58.72**	**59.74 (+1.7)**	--	--	**55.45**	**54.07 (-2.5)**	--	--
NFK-A	22.64	23.95	--	--	25.56	25.65	--	--	23.22	22.93	--	--
NFK-B	10.70	11.50	--	--	12.61	13.33	--	--	12.56	12.15	--	--
NFK-C	16.53	19.17	--	--	20.47	20.75	--	--	19.62	19.00	--	--
NFK-190	0.08	0.00	--	--	0.08	0.00	--	--	0.04	0.00	--	--
SFK Total	**50.73**	**52 (+2.5)**	--	--	**70.26**	**70.23 (-0.1)**	--	--	**65.57**	**64.06 (-2.3)**	--	--
SFK-A	31.90	32.16	--	--	39.26	39.37	--	--	41.21	41.27	--	--
SFK-B	6.41	6.75	--	--	13.04	13.30	--	--	10.38	9.88	--	--
SFK-C	6.20	6.69	--	--	11.24	11.36	--	--	9.51	9.19	--	--
SFK-190	6.23	6.41	--	--	6.73	6.20	--	--	4.47	3.72	--	--
KR	**24.58**	**25.00 (+1.7)**	--	--	**30.64**	**31.67 (+3.4)**	--	--	**39.33**	**39.22 (-0.3)**	--	--
UT	**40.09**	**40.08 (0)**	--	--	**51.12**	**51.11 (0)**	--	--	**56.96**	**57.02 (+0.1)**	--	--
Sum	**165.35**	**171.71 (+3.8)**	--	--	**210.74**	**212.74 (+0.9)**	--	--	**217.31**	**214.38 (-1.3)**	--	--

Notes:
1 Source: R2 2018d. Response to RFI #48: HABSYN.
2 Habitat estimates are provided in acres. Numbers in parenthesis indicate the percent habitat change from pre-mine conditions.
3 “--" = Not Applicable

Overall, any reduction in water flow into the NFK River and the SFK River drainages could impact Pacific salmon habitat, Pacific salmon spawning, egg survival, and Pacific salmon rearing. However, detailed modelling of Pacific salmon spawning and juvenile rearing habitat changes by species and drainage indicates the effects from flow changes to modelled EFH would range from small to positive for some species. Densities of spawning Pacific salmon are low in all drainages within the mine site Action Area. Based on the low observed densities of adult Pacific salmon and the variability observed in annual numbers of returning adults, it is unlikely that available spawning habitats are saturated by any species during any given year suggesting that modest changes in spawning habitat availability, as predicted by modelling, would have little impact on spawning site selection, spawning success, or fry production. Similarly, juvenile densities across much of the mine site area sampling sites were also low and juveniles were well dispersed. There is no indication from baseline data that rearing habitat availability is limiting juvenile production; predicted modest changes in habitat availability would be unlikely to reduce juvenile Pacific salmon production. On average, considering all drainages modeled and summarized in Table 5-3, project impacts on Pacific salmon spawning and rearing habitats within the mine Action Area would remain within plus or minus 5 percent of pre-mining acreages, with most reductions occurring in lower quality or in existing low Pacific salmon density habitats. Population level effects to the local watersheds are unlikely and population level effects at the Bristol Bay watershed level would be undetectable. Potential low to positive level effects described above for EFH by species and life stage would be permanent. The impacts of flow changes on overall EFH quantity and quality are expected to be low.

5.1.1.4 Water Temperature

Treated water discharges (September Y2 through October Y4) to the NFK River, the SFK River, and the UT Creek have the potential to alter the water temperature of receiving waterbodies. Changes in water temperature could potentially alter spawning timing and egg incubation periods of managed species, alter productivity of receiving water streams, and alter aquatic invertebrate community structure. Treated water discharged at the NFK River, the SFK River, and the UT Creek from the water treatment plants is expected to be 41°F (5°C) from December through April (winter) and 51.8°F (11°C) during May through October (summer). Table 5-4 presents the existing (pre-mine) range of average temperatures (degrees Celsius) recorded at the NFK River, the SFK River, and the UT Creek streams during winter and summer and the expected temperature range with treated water discharges (R2 2018c). NFK River water temperatures would increase in winter from a pre-mining range of 32.4°F to 32.5°F (0.2°C to 0.3˚C) to an average range of 35.6°F to 38.8°F (2.0°C to 3.8°C), while UT Creek winter water temperature would increase from 32.4°F (0.2°C) to a range of 32.9°F to 33.6°F (0.5°C to 0.9°C). Modeling for SFK River at Frying Pan Lake indicated that the treated water would cool as it flows through the lake and effectively reduce downstream water temperatures to pre-mine conditions during most winter months. Only the month of April shows slight increases in temperature from pre-mine conditions of 32.4°F (0.20 °C) up to 33.4°F (0.75°C) increase; pre-mine monthly average winter water temperatures were not available for SFK River (R2 2018c).

Winter water temperature changes could impact eggs and alevins within spawning gravels primarily through increased metabolism, growth, and changes in time of emergence. However, current winter temperatures in NFK and SFK rivers, and UT Creek are below the optimum egg incubation ranges found for Pacific salmon species in the Action Area. Weber-Scannell (1991) reports the following ranges of optimum egg incubation temperatures from the literature: Chinook, 39.2°F to 53.6°F (4.0°C to 12.0°C); coho, 41°F to 51.8°F (5.0°C to 11.0°C); sockeye, 39.9°F to 55.0°F (4.4°C to 12.8°C); chum, 39.9°F to

55.9°F (4.4°C to 13.3°C); and pink salmon, 41.0°F to 57.2°F (5.0°C to 14.0°C). The predicted increased winter discharge water temperatures would not raise river temperatures to the lower limits of optimum egg survival for any species and would therefore be unlikely to negatively affect egg survival, rather there may potential for increased survival of eggs in NFK River. Increases in water temperatures during alevin development can substantially increase development rates and associated yolk conversion rates potentially leading to faster yolk depletion and early emergence from the gravel at overall smaller sizes. Fry could emerge too early at suboptimal periods of the year and experience poor feeding, growth, and survival. Studies reviewed by Weber-Scannell (1991) were conducted at water temperature ranges substantially higher than post-mining temperatures predicted in NFK, SFK or UT Creek. Coho and sockeye salmon length at emergence decreased between 35.6°F and 41.0°F (2.0°C and 5.0°C), while chum and Chinook salmon length at emergence increased between 41.0°F and 46.4°F (5.0°C and 8.0°C), then decreased with higher temperatures (Weber-Scannell 1991). NFK River habitats could warm to near the optimum alevin development temperatures for coho salmon or could be slightly higher. It is unlikely that increases in winter water temperatures will warm adequately to enhance or adversely affect developing alevins in SFK River or UT Creek, and within NFK River, post-mining water temperatures may increase to within the optimal ranges for alevin development or slightly warmer.

Summer monthly average water temperatures in NFK River would be attenuated slightly by treated water discharge as minimum temperatures would increase from 42.6°F (5.9°C) pre-mining to 44.8°F (7.1°C) with treated water discharge, while maximum summer water temperatures would remain the same at 54.9°F (12.7°C) (R2 2018c). SFK River summer average water temperature variability would also be attenuated by treated water discharge with predicted higher minimum and lower maximum average monthly water temperatures. Water temperatures would range from 39.7°F to 56.3°F (4.3°C to 13.5°C) post discharge as opposed to 37.9°F to 57.7°F (3.3°C to 14.3°C) pre-mining. UT Creek summer monthly average water temperatures would remain nearly the same as pre-mining water temperatures but both minimum and maximum water temperatures would increase. Summer water temperatures with treated water discharge would range from 37.9°F to 54.7°F (3.3°C to 12.6°C) while pre-mining summer water temperatures ranged from 37.8°F to 54.5°F (3.2°C to 12.6°C). Optimum temperature ranges for Pacific salmon are generally wide and encompass both pre-mine and post-treated water discharge temperature regimes in NFK River, SFK River, and UT Creek for all species of Pacific salmon (Weber-Scannell 1991). A literature review conducted by Weber-Scannell (1991) found that coho salmon and Chinook salmon fry had optimum temperature ranges of between 53.6°F and 57.2°F (12°C and 14°C), while most studies indicate that for sockeye, chum and pink salmon, optimum ranges were slightly lower from 51.8°F to 57.2°F (11°C to 14°C). Mixed age class ranges of optimum water temperatures for coho salmon were 53.2°F to 58.3°F (11.8°C to 14.6°C), 45.1°F to 61.9°F (7.3°C to 14.6°C) for Chinook salmon, 51.1°F to 61.9°F (10.6°C to 14.6°C) for sockeye salmon, and 42.1°F to 61.9°F (5.6°C to 14.6°C) for pink salmon. Optimum ranges for spawning adult Pacific salmon were generally somewhat higher. Water temperatures predicted during summer post-mine operations all fall within optimum ranges described (Weber-Scannell 1991). In addition, the relatively small summer shifts in water temperature are all within the natural variability observed within all three drainages and would not be anticipated to alter aquatic invertebrate communities.

Table 5-4: Range of average stream water temperatures pre-mine and after release of treated surplus water.[1]

Stream	Winter		Summer	
	Pre-Mine °F (°C)	With Treated Water °F (°C)	Pre-Mine °F (°C)	With Treated Water °F (°C)
NFK River	32.4 - 32.5 (0.2–0.3)	35.6 - 38.8 (2.0–3.8)	42.6–54.9 (5.9–12.7)	44.8–54.9 (7.1–12.7)
SFK River[2]	32.4 (0.2)	33.4 (0.75)	37.9–57.7 (3.3–14.3)	39.7–56.3 (4.3–13.5)
UT Creek	32.4 (0.2)	32.9–33.6 (0.5-0.9)	37.8–54.5 (3.2–12.5)	37.9–54.7 (3.3–12.6)

Note:
1 Source: R2 2018a. Response to request for information #47: Potential mine effects on water temperatures.
2 During winter months, only the month of April shows a slight increase in water temperatures of 0.2 to 0.75 °C as Frying Pan Lake attenuates the thermal input –SFK River winter data is for April only

Water temperatures within the NFK River and SFK River drainages are seasonally variable. and are known to exceed ADEC (2012) values for incubation and spawning (PLP 2011). Despite high natural variability and low winter water temperatures, populations of spawning and rearing Pacific salmon exist within all drainages of the mine area and would continue to do so during mine operations. The highest potential effect would be temperature increases in a dry year in which weather is warmer than average which could lead to water temperatures that exceed published optimum levels for Pacific salmon. These occurrences are expected to be infrequent and could potentially result in impacts that may be detectable temporarily or in the short-term. During other years, summer water temperature effects would be expected to cause negligible impacts to Pacific salmon and their habitat. Winter water temperature effects would be expected to be negligible to potentially positive. The overall degree of impact is low: Expected summer and winter water temperatures post release of treated surplus water would have a negligible or even positive effect on EFH quality (rearing Chinook, coho and sockeye salmon, and spawning Chinook, chum, coho and sockeye salmon), but infrequent dry and warm years could result in temporary or short-term effect; mortalities are unlikely.

5.1.1.5 Water Quality

Spawning substrate selection by Pacific salmon is influenced by chemical and physical characteristics such as instream and hyporheic flow, dissolved gases, nutrient exchange, and temperature, that may be disrupted by construction mining activities through changes in water quality (Lewis-Russ 1997). Naturally occurring minerals and metals can be liberated from rock and soil substrates from construction earthwork activities (September Y2 through October Y4). The introduction of this metal and mineral rich runoff or acid mine drainage (AMD) into the aquatic ecosystem can have adverse impacts on the ecology of entire watersheds. AMD can also lower pH that can negatively impact Pacific salmon populations by acute and chronic exposure. Pacific salmon are vulnerable to low pH when undergoing the physiological changes that occur during smolts' transition from freshwater to salt water and adult spawners' transition from salt water to freshwater (Chambers et al. 2012). AMD is known to be toxic to fish, algae, zooplankton, and aquatic invertebrate populations at the ecosystem, metabolic, and cellular levels (Buhl and Hamilton 1991).

Metal contamination and exposure influences migratory behavior and avoidance mechanisms in fish populations (Goldstein et al. 1999). Numerous studies have shown how exposure to toxic contaminants in surface waters can impact fish olfaction, which is critical for mating, locating prey, and avoiding predators (Tierney et al. 2010). Studies have shown that salmonids exposed to sublethal levels of metals are susceptible to increasing levels of fish pathogens due to stressed immune responses and metabolisms (Jacobson et al. 2003, Spromberg and Meador 2005).

In Alaska, existing water quality regulations promulgated and enforced by federal and state agencies are designed to control and manage water quality changes to avoid, limit, control or offset potential impacts. The Project has developed a water management plan (Knight Piésold 2018a) to manage surface runoff, groundwater, and water produced within the mine site. Water management facilities for the project include: fresh water diversion channels, the open pit water management pond, the main water management pond, the TSFs, seepage collection and recycle ponds, sediment ponds, and two water treatment plants. Surplus water collected within the mine site that is not required for operations will be treated and discharged into nearby NFK River, SFK River and UT Creek, pursuant to an individual APDES permit. Wastewater will be treated prior to discharge to water quality levels that are protective of aquatic life consistent with Alaska water quality standards. Once initiated, water treatment and discharge will be permanent. Treatment of wastewater prior to discharge in compliance with APDES permit stipulations and in coordination with the ADF&G, including required monitoring of discharges, is expected to be effective at maintaining suitable water quality for managed species. Close coordination with ADF&G and ADEC would occur during final process design to ensure that discharge is managed to minimize potential affects to aquatic habitats as practicable. Discharge of water would be permanent but no effects on EFH are anticipated.

5.1.1.6 Contaminant Release

Incidental spills of petroleum lubricants and fuels during construction (September Y2 through October Y4) at the mine site have the potential to affect fish and aquatic resources, including EFH. Incidental spills can be safely controlled at the time of release by the personnel who are present, do not have the potential to become an emergency within a short time, and are of limited quantity, exposure, and potential toxicity. Potential causes of incidental spills include equipment failure, fuel transfers, accidents, and human error. Effects would depend on the season, size of spill, and location. Petroleum lubricants and fuels can cause acute effects on fish proximate to the spill location, which could potentially lead to avoidance of the area by fish.

PLP and their construction contractors must comply with all laws and regulations related to spill prevention and preparedness of petroleum lubricants and fuels, including 40 CFR Part 110. Spill prevention control measures would be included in construction operations; petroleum lubricants and fuel spills would be promptly cleaned up. Given the required spill prevention controls measures it is unlikely that an incidental spill would result in the release of enough petroleum lubricants and fuels to result in any consequential exposure of EFH. Based upon regulatory compliance and implementation of control measures, impacts on EFH from contaminant releases during construction are expected to be negligible.

5.1.1.7 Summary of Mine Site Potential Effects to Freshwater Ecosystem EFH

Discharge of fill materials associated with construction of the mine site would result in direct and indirect physical, chemical, biological, and physical impacts to EFH within the mine site and surrounding areas.

Potential effects to freshwater EFH are discussed in sections 5.1.1.1 through 5.1.1.6. Direct effects are those that occur as a result of the placement of fill into waters of the U.S., including loss of habitat, changes in water quality and potential releases of contaminants. The other effects, including blasting, changes in water flow and water temperature, would be indirect in nature. Table 5-5 summarizes potential impacts to freshwater EFH and their assessed degree of impact.

Table 5-5: Summary of potential impacts to freshwater ecosystem EFH in the mine site area.

Potential Impact			
Type (Source)	**Description**	**Duration**	**Degree**
Direct loss of habitat (Discharges of dredged or fill material into EFH)	- Removal of approx. 46,836 LF (14,277 LM) of EFH within the mine site footprint.	**Permanent**	The degree of impact is **moderate**: - EFH for rearing Chinook and coho salmon, and spawning and developing embryonic coho salmon would be permanently removed in areas with low densities of managed species and impacts could be detectable in the short-term, but population level effects within the context of the NFK River, SFK River, and UT Creek are not anticipated.
Blasting (Blasting for construction of mine facilities, including open pit)	- Potential injury or death of fish or eggs in spawning gravels.	**Temporary**	The degree of impact is **low**: - Blasting activities would adhere to "Alaska Blasting Standard for the Proper Protection of Fish, Technical Report No. 13-03." - Regulatory compliance and collaboration with agency staff will likely result in overpressures and particle velocities below levels that have been shown to cause injury or mortality to salmonids and salmonid embryos.
Water flow (Water management activities)	- Predicted stream flow changes to NKF River, SFK River and UT Creek and resulting EFH losses/gains.	**Permanent**	The degree of impact is **low**: - Overall, changes would be permanent and range from low to slightly positive for some species in terms of both spawning and rearing habitats. - NFK River – up to low level of impact to Chinook salmon EFH quantity and quality. - SFK River – up to low level effect on EFH quantity and quality. -Generally positive effect on sockeye salmon spawning and rearing habitat.

Potential Impact			
Type (Source)	**Description**	**Duration**	**Degree**
Water temperature (Discharges of treated wastewater)	- Potential changes in water temperature from discharges of treated wastewater.	**Permanent**	The degree of impact is **low**: - Water temperatures changes would be permanent. - Summer water temperature effects would be expected to cause negligible impacts to Pacific salmon and their habitat. -Winter water temperature effects would be expected to be negligible to potentially positive. - Infrequent dry, warmer than average years, could lead to water temperatures that exceed published optimum levels for Pacific salmon - Water temperature changes are expected to be within the range of seasonal variability.
Water quality (Discharges of treated wastewater)	- Potential metals increase in water quality as a result of acid mine drainage.	**Long term**	The degree of impact is **low**: - Wastewater would be treated and tested for compliance with federal and state clean water standards prior to discharge to streams.
Contaminant release (Incidental spill of petroleum lubricants and fuels)	- Potential incidental spills of petroleum lubricants and fuels in EFH, which are toxic to fish.	**Not Applicable**	The degree of impact is **negligible**: - Incidental spills of petroleum lubricants and fuels into EFH will be minimized through the implementation of spill prevention plans.

5.1.2 Transportation Corridor

Potential effects to freshwater EFH from the transportation corridor are discussed below. The discussion is divided by transportation infrastructure components including the proposed road and Iliamna Lake ferry terminals. The discussion on potential effects to EFH from the road is grouped by: fish passage and habitat loss, material source development, water use, water quality, contaminant release, blasting, and invasive species. Potential effects from the Iliamna Lake ferry terminals are grouped by: loss of habitat, noise disturbance, blasting, water quality, and contaminant release. Impacts are summarized in Section 5.1.2.3.

The following is a high-level overview of the transportation corridor construction schedule:

- Road construction activity would occur year-round, subject to permit conditions.
    - Construct temporary access Amakdedori-Kokhanok June Y1 – September Y1
    - Construct temporary access North Terminal-Mine Site July Y1 – November Y1
    - Access road construction (south) September Y1 – July Y2
    - Access road construction (north) November Y1 – October Y2
    - Construct major bridges June Y2 – September Y2

- Ferry terminal construction activities onshore would be conducted on a year-round basis. In lake construction at the terminals would occur throughout the ice-free period, subject to permitting conditions.
  - Amakdedori Port & Dock Construction September Y1 – September Y2
  - Construct South Ferry Terminal June Y2 – September Y2
  - Construct North Ferry Terminal June Y2 – September Y2

5.1.2.1 Roads

5.1.2.1.1 Fish Passage and Habitat Loss

Project roads (Figure 3-3) will cross 80 drainages and streams along the 77 mi (123 km) transportation corridor (PLP 2018b), 15 of which are designated EFH for Pacific salmon (Table 5-6). Seven bridges and eight culverts will be designed and installed to provide for fish passage and minimize impacts to Pacific salmon EFH. Conceptual bridge designs and typical culvert designs are included in Appendix A. Bridges would be constructed between June Y2 and September Y2, while culvert installation would take place between July Y1 and October Y2. Culvert design and construction will meet guidelines contained in the ADF&G and the ADOT&PF Fish Passage Memorandum of Agreement (ADF&G and ADOT&PF 2001):

- Five single-span, two-lane bridges, ranging in length from approximately 30 – 120 ft (9.1 – 36.6 m) are proposed for the UT Creek, First Creek, two unnamed streams north of Gibraltar lake, and a tributary of Amakdedori Creek.
- One 575 ft (175.3 m) multi-span, two-lane bridge across the Newhalen River.
- One 470 ft (143.3 m) multi-span, two-lane bridge across the Gibraltar River.
- Culverts ranging from 1-8 ft (0.3 – 2.4 m) in diameter will be installed in designated freshwater EFH in 8 streams (Table 5-6). Culverts will be designed and sized in accordance with ADOT&PF and ADF&G standards for fish passage. Fish passage design standards accommodate anticipated levels of flow, maintain sufficient channel width, and minimize slope changes. Installation of culverts will alter EFH at the immediate location of the culvert, but managed species would continue to use the streams with minor functional changes in habitat.

Bridge and culvert design, stream flows, fish passage requirements, and habitat loss will be reviewed and verified by ADF&G during the permitting process. Permit stipulations may include seasonal restrictions on instream activities to avoid impacts to habitat during species critical life stages (e.g., spawning and egg development). Free passage of Pacific salmon species may be temporarily interrupted but would continue unimpeded after construction is complete. Construction of stream crossings would avoid spawning migration windows as much as possible and where potential in-stream work could obstruct passage of fish for longer than 48 hours, diversion methods could be employed under the guidance of the ADF&G. Juvenile and adult fish passage facilities would be incorporated on all water diversion projects (e.g., fish bypass systems) as required by permit. Natural habitat at the immediate location of culverts would be altered with recovery being short-term; EFH would continue to be used by managed species with minor functional changes in habitat. Habitat disturbance from construction effects would therefore range from temporary to short-term. The degree of impact is low: the effect may cause temporary to short-term degradation of EFH (coho salmon, Chinook salmon, and sockeye salmon spawning and rearing; chum salmon spawning; and pink salmon presence), but EFH characteristics would likely return to normal after the activity ceases. Effects would result in minor EFH functional changes.

Table 5-6: Stream crossings on Pacific salmon EFH streams in the Transportation Corridor.[1]

Stream Crossing ID	AWC Code[2]	Pacific Salmon Species[3] and Life Stage[4]	Access Road Crossing	Road Crossing Details			Pipeline and Fiber Optic Cable Crossing	Pipeline and Fiber Optic Cable Crossing Type
				Type	Bridge Length (ft) (m)	Culvert Diameter /Length (ft) (m)		
Amakdedori Port to South Ferry Terminal								
A001	--	COr	Yes	Culvert	--	6/170 (1.8/51.8)	Yes	Trench or HDD
A002	243-40-10010-2008 (Amakdedori Creek Tributary)	COsr, Ss	Yes	Bridge – Single Span	120 (36.6)	--	Yes	Suspend pipeline beneath bridge
A067	--	COr	Yes	Culvert	--	4/100 (1.2/30.5)	Yes	Trench or HDD
A003	--	COr	Yes	Culvert	--	5/270 (1.5/82.3)	Yes	Trench or HDD
A023	--	COr	Yes	Bridge – Single Span	60 (18.3)	--	Yes	Suspend pipeline beneath bridges
A028	(Gibraltar Creek Tributary)	COr, Ss	Yes	Bridge – Single Span	60 (18.3)	--	Yes	Suspend pipeline beneath bridges
A052	(Gibraltar Creek Tributary)	COr	Yes	Culvert	--	4/120 (1.2/36.6)	Yes	Trench or HDD
A029	(Gibraltar Creek Tributary)	COr	Yes	Culvert	--	5/90 (1.5/27.4)	Yes	Trench or HDD
A030	324-10-10150-2196 (Gibraltar Creek)	COpr, CHs, Pp, Ssr	Yes	Bridge – Multi-span	515 (157)	--	Yes	Suspend pipeline beneath bridges

Stream Crossing ID	AWC Code[2]	Pacific Salmon Species[3] and Life Stage[4]	Access Road Crossing	Road Crossing Details			Pipeline and Fiber Optic Cable Crossing	Pipeline and Fiber Optic Cable Crossing Type
				Type	Bridge Length (ft) (m)	Culvert Diameter /Length (ft) (m)		
North Ferry Terminal to Mine Site								
A035	324-10-10150-2183-3010 (First Creek)	COs	Yes	Bridge-Single Span	40 (12.2)		Yes	Suspend pipeline beneath bridges
A037	324-10-10150-2183-3050 (Mini Creek)	COr	Yes	Culvert	--	1/169 (0.3/51.5)	Yes	Trench or HDD
A038	324-10-10150-2183 (UT Creek)	COsr, Ksr, Ssr, CHs	Yes	Bridge-Single Span	90 (27.4)	--	Yes	Suspend pipeline beneath bridges
A039	324-10-10150-2183-3057 (UT Creek Tributary)	COr	Yes	Culvert	--	8/110 (2.4/33.5)	Yes	Trench or HDD
A044[5]	324-10-10150-2183-3307 (UT Creek Tributary)	COr, Kr	Yes	Culvert-Elliptical	--	8/180 (2.4/54.9)	Yes	Trench or HDD
Iliamna Spur Road								
NS005	324-10-10150-2207 (Newhalen River)	COpr, Kps, Ssr	Yes	Bridge-Multi-span	576 (175.6)	--	No	--

Notes:
1 PLP 2018b RFI 086 Fish/Waterbody Crossings. October 1, 2018.
2 Johnson and Blossom 2017.
3 Pacific salmon codes: CO = coho salmon; S = Sockeye salmon; CH = chum salmon; K = Chinook salmon.
4 Pacific salmon life stages: p = present; s = spawning; r = rearing (Johnson and Blossom 2017).
5 Crossing A044 is located more than 984 ft (300 m) up stream of AWC upper extent in tributary 324-10-10150-2183-3307.

5.1.2.1.2 Material Source Development

Fill material for road and pad construction associated with the transportation facilities will be sourced at 18 newly developed material sites located adjacent to the road (Table 5-7). Material sites would be constructed in parallel to road construction operations from September Y1 – October Y2.

Table 5-7: Proposed material sites for construction of transportation facilities.

Access Road	Material Site ID	Distance to Pacific Salmon EFH
South Access Road	MS-A01	> 2,200 ft (670.6 m)
	MS-A02	> 2,000 ft (609.6 m)
	MS-A03	> 3,800 ft (1,158.3 m)
	MS-A04	> 3,900 ft (1,188.7 m)
	MS-A05	> 2.5 miles (4 km)
	MS-A06	> 3.5 miles (5.6 km)
	MS-A07	> 3,500 ft (1,066.8 m)
	MS-A08	> 2,000 ft (609.6 m)
Iliamna Spur Road	MS-N01	> 1,200 ft (365.8 m)
	MS-N02	> 3,500 ft (1,066.8 m)
	MS-N03	> 1.8 miles (2.9 km)
Mine Access Road	MS-T01	> 1,100 ft (335.3 m)
	MS-T02	> 3,900 ft (1,188.7 m)
	MS-T03	> 200 ft (61.0 m)
	MS-T04	> 550 ft (167.6 m)
	MS-T05	> 800 ft (243.8 m)
	MS-T06	> 900 ft (274.3 m)
	MS-T07	> 3,700 ft (1,127.8 m)

Material sites developed within riverine floodplains can impact Pacific salmon EFH by creating turbidity plumes and re-suspending sediment and nutrients, removing spawning habitat, and altering channel morphology. These impacts can lead to secondary impacts, such as altering Pacific salmon migration patterns, creating physical and thermal barriers to upstream and downstream migration, fluctuations in water temperature, decreased dissolved oxygen, increased mortality of early life stages, increased susceptibility to predation, loss of suitable habitat, decreased nutrients (from loss of floodplain connection and riparian vegetation), and decreased food production (loss of invertebrates) (Limpinsel et al. 2017). Sediments mobilized off site from upland material sites and gravel washing operations are a potential source of turbidity and may potentially affect EFH.

The proposed material sites avoid EFH floodplains and are located at substantial distances from EFH (Table 5-8). However, some material sites are near EFH floodplains or include wetlands that contribute flow and nutrients to EFH. Disturbance of these floodplains and wetlands could temporarily increase turbidity with resulting effects similar to those described above, but to a lesser degree. The implementation and use of appropriate BMPs and SWPPPs (Section 5.1.2.1.4) will minimize potential effects to EFH from material site development. The effects to EFH from material site development and operation are anticipated to be negligible.

5.1.2.1.3 Water Use

Construction activities for the proposed road, natural gas pipeline and fiber optic cable, would require water for construction (dust control, compaction, etc.) and hydrostatic testing between September Y1 and October Y2. Water would be withdrawn from waterbodies adjacent to the construction zone on an as needed basis. At total of 21 temporary water withdrawal sites have been identified along the transportation corridor (Table 5-8). Eleven of the planned water extraction sites will be at Pacific salmon EFH streams or lakes. Water withdrawal can alter natural flow, stream velocity, and channel depth-to-width ratios. Water withdrawal can also change sediment and nutrient transport characteristics (Christie et al. 1993, Fajen and Layzer 1993), increase deposition of sediments, reduce water depth, and accentuate diurnal temperature patterns (Zale et al. 1993). Loss of vegetation along streambanks and shorelines due to fluctuating water levels can decrease the availability of fish cover and food and reduce bank stability. Changes in the quantity and timing of stream flow alters the velocity of streams, which, in turn, affects the composition and abundance of both insect and fish populations (Spence et al. 1996). Water withdrawal can also physically divert, entrap or impinge managed species leading to direct mortality of entrained individuals or indirect mortality from entrapment in dewatered stream reaches or pools.

Water withdrawals from fish bearing streams require authorization from the ADNR and the ADF&G. ADF&G reviews permit applications to ensure that water withdrawals are protective of fish by verifying that adequate fish passage is available, particularly during critical life stages, and water levels are sufficient to avoid stranding juveniles and dewatering redds. Permit conditions would set limits on water withdrawal (typically maximum pumping rate, maximum gallons per day, and total volume withdrawn) necessary to protect fish and their habitat and would require the installation of screens at water intake points to prevent fish entrapment. Compliance with ADF&G permit stipulations would minimize potential impacts to EFH. The degree of impact is low: the effect may cause minor temporary changes to EFH (coho salmon, Chinook salmon, sockeye salmon, spawning and rearing; chum salmon spawning; and pink salmon presence), but EFH characteristics would return to normal after the activity ceases.

Table 5-8: Planned temporary water extraction sites.

Milepost	Name	Designation	Waterbody	Pacific Salmon Species[1] and Life Stage[2]	Use	Facility	Estimated Volume (Mgal)[3]
Amakdedori Port to South Ferry Terminal							
MP-0	WES-01	Amakdedori Creek	Stream	CHp, COp, Pp	Construction & hydrostatic testing	Pipeline, road, & port	5 Mgal
MP-3	WES-02	Amakdedori Trib-A	Stream	COr, Ss	Construction & hydrostatic testing	Pipeline, road, & port	3 Mgal
MP-33	WES-09	Gibraltar Creek	Stream	COp	Construction & hydrostatic testing	Pipeline & road	1 Mgal

Milepost	Name	Designation	Waterbody	Pacific Salmon Species[1] and Life Stage[2]	Use	Facility	Estimated Volume (Mgal)[3]
MP-36.68	WES-10	Iliamna Lake	Lake	Ss	Construction & hydrostatic testing	Pipeline, road, & port	8 Mgal
North Ferry Terminal to Mine Site							
MP-0	WES-11	Iliamna Lake	Lake	CHs, COsr, Ks, Pp, Ssr	Construction & hydrostatic testing	Pipeline, road, & port	8 Mgal
MP-5	WES-12	First Creek_A	Stream	COr	Construction & hydrostatic testing	Pipeline & road	1 Mgal
MP-10	WES-13	First Creek_B	Stream	COr	Construction & hydrostatic testing	Pipeline & road	1 Mgal
MP-14	WES-14	First Creek_C	Stream	COs	Construction & hydrostatic testing	Pipeline & road	1 Mgal
MP-20	WES-16	UT Creek	Stream	COsr, Ksr, Ssr, CHs	Construction & hydrostatic testing	Pipeline & road	1 Mgal
Iliamna Spur Road							
MP-0	WES-21	Bear Creek	Stream	COrp	Construction & hydrostatic testing	Pipeline & road	1 Mgal
MP-2	WES-20	Newhalen River	Stream	Ksp	Construction & hydrostatic testing	Pipeline & road	5 Mgal

Note:
1 Pacific salmon codes: CO = coho salmon; S = silver salmon; CH = chum salmon; K = Chinook salmon; P = pink salmon.
2 Pacific salmon life stages: p = present; s = spawning; r = rearing (Johnson and Blossom 2017).
3 M=million gallons. The volumes reported here are the total expected withdrawals over the construction period September Y1 – October Y2.

5.1.2.1.4 Water Quality

Road construction (July Y1 – October Y2), bridge and culvert installation, could result in direct effects through temporary increases in turbidity from in-water work and indirect effects such as the introduction of heavy metals (e.g., copper, lead, zinc) and other pollutants. Potential consequences include decreased success of incubating Pacific salmon eggs; reduced food sources for rearing juvenile Pacific salmon; modified habitat; degraded EFH; and, in extreme cases, mortality to eggs and rearing fish. The scope of the potential effects to Pacific salmon life stages would depend on the timing and magnitude of impacts.

Suspended solids can injure juvenile Pacific salmon and reduce their ability to sight-feed on surface and near-surface invertebrates at higher concentrations of turbidity (USACE 2008). At lower turbidity juvenile Pacific salmon may use turbid waters as cover to hide from predators. Salmonids can encounter naturally turbid conditions in estuaries and glacial streams, but this does not necessarily mean that salmonids in general can tolerate increases of suspended sediments over time (Bash et al. 2001). Relatively low levels of anthropogenic turbidity may negatively affect salmonid populations that are not naturally exposed to relatively high levels of natural turbidity (Gregory 1992). The feeding efficiency of juvenile salmonids has been shown to be impaired by turbidity levels exceeding 70 NTU, well below typical and persistent levels in fresh waters of the Action Area (Pentec 2005).

A comprehensive list of construction and operational BMPs will be incorporated into the proposed Project. BMPs are expected to be effective in minimizing sediment additions; any alterations of water quality would be localized and temporary. The degree of impact is low: EFH (coho salmon, Chinook salmon, sockeye salmon, spawning and rearing; chum salmon spawning; and pink salmon spawning) may be temporarily degraded, but EFH characteristics will return to normal after the activity ceases.

5.1.2.1.5 Contaminant Release

Incidental spills of petroleum lubricants and fuels during road construction (July Y1 – October Y2) have the potential to affect fish and aquatic resources, including EFH. Potential causes of incidental spills include equipment failure, fuel transfers, accidents, and human error. Effects would depend on the season, size of spill, and location. Petroleum oils and fuels can cause acute effects on fish proximate to the spill location, which could potentially lead to avoidance of the area by fish.

PLP and their construction contractors must comply with all laws and regulations related to spill prevention and preparedness of petroleum lubricants and fuels, including 40 CFR Part 110. Spill prevention control measures would be included in construction operations; petroleum lubricants and fuel spills would be promptly cleaned up. Given the required spill prevention controls measures it is unlikely that an incidental spill would result in the release of enough petroleum lubricants and fuels to result in any consequential exposure of EFH. Based upon regulatory compliance and implementation of control measures, impacts on EFH (coho salmon, Chinook salmon, sockeye salmon, spawning and rearing; chum salmon spawning; and pink salmon spawning) from contaminant releases during construction are expected to be negligible.

5.1.2.1.6 Blasting

Blasting would be required for road and pipeline construction (September Y1 – October Y2). Blasting would occur along approximately 25 mi (40.2 km) of the south access road between Amakdedori Port and the south ferry terminal, 1.4 mi (2.3 km) on the mine access road between the north ferry terminal and the mine site, and 3 mi (4.8 km) on the Newhalen access road. Depending on the blasting location and estimated pressure and vibration forces, blasting could result in: disruption in pre-existing balance of suspended sediment transport and turbidity; direct impacts to fish spawning and nesting habitats (redds), adults, juveniles, and prey items. Additional discussion regarding the potential effects of blasting forces on fish is provided in Section 5.1.1.2. Detailed blasting locations, and estimated pressure and vibration forces generated by blasting have not been calculated, pending future blasting plans. Approximately 15,563 LF (4,744 LM) of Pacific salmon EFH streams occur within 1,000 ft (304.8 m) of potential blasting areas. Blasting in areas near fish habitat would be reviewed and planned in consultation with ADF&G and in accordance with the guidelines and BMPs outlined in "Alaska Blasting Standard for the Proper Protection of Fish, Alaska Department of Fish and Game, Technical Report No. 13-03" (Timothy 2013). If necessary, blasting activities will be scheduled when the fewest species and/or least vulnerable life stages of federally managed species will be present, consistent with permit stipulations. Regulatory compliance and collaboration with agency staff will likely result in overpressures and particle velocities below levels that have been shown to cause injury or mortality to salmonids and salmonid embryos or would be conducted when Pacific salmon are least likely to be present. Blasting impacts would be temporary, and fish are expected to return to the site once blasting is complete. The degree of impact is low: blasting may cause temporary degradation of EFH (coho salmon spawning and rearing; Chinook salmon presence; sockeye salmon spawning; and chum salmon spawning), but EFH characteristics would return to normal after the activity ceases.

5.1.2.1.7 Invasive species

Road construction (July Y1 – October Y2) can serve as a vector for introducing nonnative species to a watershed by creating suitable habitat for invasive species, planting invasive species along roadsides for erosion control, and serving as a route for the accidental introduction from vehicular or other traffic traveling the road system (Trombulak and Frissell 2000). Prior to construction and operations PLP will prepare and implement an invasive species management plan. Reclamation and slope stabilization activities will require use of weed-free native plant seeds certified by the Alaska Plant and Materials Center. The degree of impact to EFH (coho salmon, Chinook salmon, sockeye salmon, spawning and rearing; chum salmon and pink salmon spawning) is negligible.

5.1.2.2 Ferry Terminals

5.1.2.2.1 Loss of Habitat

Proposed facilities to be constructed below the OHWM in Iliamna Lake include: a launch ramp, ferry landing ramp and mooring point, and two mooring buoys with navigation lights for the south ferry terminal (Figure 3-6, Figure 3-7); and, a ferry landing ramp and mooring point, and two mooring buoys with navigation lights for the north ferry terminal (Figure 3-4, Figure 3-5). Discharge of fill material to construct the ferry terminals will cover approximately 0.1 ac (0.04 ha) of shallow lake aquatic habitat, and 185 ft (56.4 m) of shoreline (bank) at the north ferry terminal, and 0.7 ac (0.28 ha) and 738 ft (224.9 m) at the south terminal. The north and south ferry landing ramps would extend 105 ft (32 m) and 155 ft (47.2 m), respectively, into the lake below the OHWM. Construction activities at the ferry terminals would take place from June Y2 to September Y2.

The proposed north ferry terminal location has a sand-gravel beach with patches of cobble and small boulders. The shoreline in this area drops quickly to water depths greater than 15 ft (4.6 m), before flattening out at this depth for 200 ft (61 m) or more from the shoreline. Areas immediately east of the north terminal location are shallow with large boulders.

The proposed south ferry terminal location has a beach of varying substrate size, with large boulders in the eastern portion transitioning to smaller boulders and cobbles with some gravel to the west. The entire south ferry terminal area is backed by 20- to 30-ft-high bluffs. Water depth in this area ranges between 6 ft and 8 ft (1.8 m and 2.4 m) for approximately 100 ft (30.5 m) from shore, and then drops gradually to depths around 15 ft at 250 ft or more from the shoreline.

The proposed ferry terminal locations are designated EFH by the AWC for presence of Chinook, coho, chum, and pink salmon, and spawning and rearing for sockeye salmon.

PLP conducted surveys of the fish communities at the proposed ferry terminal locations in 2013, 2017, and 2018. These surveys consistently found that the fish communities in shoreline and nearshore habitats were overwhelmingly dominated by threespine stickleback (*Gasterosteus aculeatus*), which represented more than 99 percent of all fish collected. Small numbers of sockeye salmon fry, generally 25 or less on any sampling date, were observed at the north ferry terminal location (Hart Crowser 2018a, Hart Crowser 2018b, Paradox NR 2018a). Sockeye salmon fry were more abundant at the south ferry terminal location in May-July 2018, with 150 or more fish sometimes observed, but the species was absent in August and was always much less common than threespine stickleback (Paradox NR 2018a). Other salmonids were regularly caught in low to moderate numbers in the spring months in 2013 at the north ferry terminal (Hart Crowser 2018a) but were rare (< 2-3 observations per date) or not observed at the ferry terminal locations in other months (Hart Crowser 2018b, Paradox NR 2018a).

Aerial surveys to determine if adult sockeye salmon were spawning at or near the terminal locations were conducted in July and August of 2013 and 2018. Adult sockeye salmon were observed along the shore of both the north and south ferry terminal locations (Hart Crowser 2018a, Paradox NR 2018b). Fish were moving along the shore, generally headed toward eastern portions of the lake that have numerous tributaries, mainland beaches, and island beaches that are known to be important spawning areas. No spawning salmon, or pre-spawning behaviors (e.g., male-female pairs, digging of nests) were observed at either the north or south ferry terminal locations (Hart Crowser 2018a, Paradox NR 2018b).

Based on the results of these fish surveys, it appears that the north and south ferry terminal locations are used for rearing by juvenile salmonids in the spring, but are not important locations for sockeye salmon rearing, adult sockeye salmon spawning, or the rearing of other salmonid species at other times of the year. Threespine stickleback are the most common species at the terminal locations.

Discharge of fill material to construct the ferry terminals will permanently remove EFH, however, the fish surveys indicate that the habitat lost receives limited use as rearing habitat by juvenile Pacific salmon and is not used for spawning by Pacific salmon. Fill impacts can modify water circulation by changing the direction or velocity of water flow; alter the location, structure, and dynamics of aquatic communities including prey; and alter shoreline and substrate erosion and deposition rates. The combined loss for the two terminals of 0.8 ac (0.32 ha) and 923 ft (281.3 m) of littoral zone is minimal relative to the approximately 300 miles (482.8 km) of shoreline that will remain undisturbed in Iliamna Lake, particularly given the limited use for salmonid rearing and absence of adult spawning in these locations. The north and south ferry landing ramps are not expected to limit longshore movement of adult and juvenile Pacific salmon. The rip-rap habitat placed around the landing ramp will be similar in size and character to the boulder habitats currently present in both locations and will not represent a novel habitat feature. Rip-rap would be colonized in the short-term and subsequently used by prey organisms and managed species. EFH abutting fill locations may be disturbed or degraded during construction but is expected to recover after construction activities are completed. The degree of impact is moderate: habitat with low densities of managed species (presence of Chinook, coho, chum, and pink salmon, and spawning and rearing for sockeye salmon) would be permanently removed.

5.1.2.2.2 Noise Disturbance

Noise disturbance associated with construction activities (June Y2 – September Y2) can degrade the quality of EFH. Fish may be affected and displaced by noise from construction vessels and construction activity. No pile driving is planned for construction of either the north or south ferry terminals, thus injurious high-amplitude underwater noise is not expected to result from normal construction. Blasting is expected for the south ferry terminal, and this is addressed separately in Section 5.1.2.2.3. The placement of metal rails, rip-rap and/or concrete blocks in the water to construct the ferry ramp would generate relatively low-amplitude noise likely to cause managed species to temporarily move away from the construction site. PLP studies have documented that nearshore lake habitat at the ferry terminals is lightly used by juvenile salmonids and is not used for adult spawning by managed species. (Hart Crowser 2018a, Hart Crowser 2018b, Paradox NR 2018a). The degree of impact is low: effects may temporarily degrade EFH (presence of Chinook, coho, chum, and pink salmon, and spawning and rearing for sockeye salmon) through the introduction of noise, but EFH characteristics would return to normal after the activity ceases.

5.1.2.2.3 Blasting

Construction of the south ferry terminal (June Y2 – September Y2) is expected to require blasting on lands near the shore of Iliamna Lake. Blasting can produce in-water overpressures and in-gravel particle velocities that could injure fish or result in fish and egg mortality in spawning gravels. These impacts could result in mortality of Pacific salmon at each life stage including eggs, juveniles, and adults if present in the area. Depending in the blasting location and estimated pressure and vibration forces, blasting could result in: disruption in pre-existing balance of suspended sediment transport and turbidity; direct impacts to fish spawning and nesting habitats (redds), adults, juveniles, and prey items. Additional discussion regarding the potential effects of blasting forces on fish is provided in Section 5.1.1.2. The estimated pressure and vibration forces generated by blasting have not been calculated, pending future blasting plans. Blasting in areas near fish habitat would be reviewed and planned in consultation with the ADF&G and in accordance with the guidelines and BMPs outlined in "Alaska Blasting Standard for the Proper Protection of Fish, Alaska Department of Fish and Game, Technical Report No. 13-03" (Timothy 2013). If necessary, blasting activities will be scheduled when the fewest species and/or least vulnerable life stages of federally managed species will be present, or consistent with permit stipulations. A blasting program to contain the production of overpressures and particle velocities below levels that have been shown to cause injury or mortality to salmonids and salmonid embryos will be developed in collaboration with agency staff and compliance with permit and regulatory requirements. Blasting effects would be temporary, and fish are expected to return to the site once construction noise has diminished. The degree of impact is low: blasting may cause temporary degradation of EFH (presence of Chinook, coho, chum, and pink salmon, and spawning and rearing for sockeye salmon), but EFH characteristics would return to normal after the activity ceases.

5.1.2.2.4 Water Quality

Construction of the ferry terminal (June Y2 – September Y2) may result in temporary increases in turbidity from in-water work or from construction runoff. Negative effects of increased turbidity at the terminal construction sites could result in decreases in dissolved oxygen, mortality of early life stages, increased susceptibility to predation, loss of suitable habitat, and decreased food production (prey). Surveys in 2013 and 2018 did not observe spawning sockeye salmon adults at or near the proposed north and south ferry terminal locations. Impacts to eggs or fry of this species are not expected.

Impacts to water quality, including release of harmful chemicals, would be minimized through implementation of a SWPPP and BMPs. Impacts to managed species from construction activities could be minimized in various ways including timing work to occur outside of peak juvenile and adult migration periods, in-water isolation of work areas, and/or efficient planning and execution of in-water work to minimize the overall amount of time that EFH and managed species could be encountered. All work would occur in accordance with permit conditions. Impacts to EFH from potential increases in turbidity or contaminant releases at the ferry terminals during construction would be temporary. The degree of impact is low: the effect may cause temporary degradation of EFH (presence of Chinook, coho, chum, and pink salmon, and spawning and rearing for sockeye salmon), but EFH characteristics would be likely to return to normal after the activity ceases.

5.1.2.2.5 Contaminant Release

Construction of the ferry terminals (June Y2 – September Y2) would involve both work aboard vessels and on specialized land-based equipment that has the potential to release contaminants from incidental spills of petroleum lubricants and fuel. Potential spill sources include: equipment failures, fuel transfers, or accidents. Petroleum lubricants and fuels are considered acutely toxic. Mortality of fish, invertebrates, and plants that come in direct contact with a diesel spill may occur.

PLP and their construction contractors must comply with all laws and regulations related to spill prevention and preparedness of petroleum lubricants and fuel, including 40 CFR Part 110, and those related to vessel-to-vessel transfers, including 33 CFR Part 155. PLP and their construction contractors must comply with all laws and regulations related to spill prevention and preparedness of petroleum lubricants and fuels, including 40 CFR Part 110. Spill prevention control measures would be included in construction operations; petroleum lubricants and fuel spills would be promptly cleaned up. Given the required spill prevention controls measures it is unlikely that an incidental spill would result in the release of enough petroleum lubricants and fuels to result in any consequential exposure of EFH. Based upon regulatory compliance and implementation of control measures, impacts on EFH (presence of Chinook, coho, chum, and pink salmon, and spawning and rearing for sockeye salmon) from contaminant releases during construction are expected to be negligible.

5.1.2.3 Summary of Transportation Corridor Potential Effects to Freshwater Ecosystem EFH

Potential effects to freshwater EFH associated with the transportation corridor are discussed in sections 5.1.2.1 and 5.1.2.2. Potential direct effects include loss of habitat, changes in water quality, and potential releases of contaminants from the placement of fill into waters of the U.S. Effects from other activities, such as water use, blasting, and potential introduction of invasive species populations, would be indirect effects. A summary of potential impacts to EFH and their assessed degree of severity is provided in Table 5-9.

Table 5-9: Summary of potential impacts to freshwater ecosystem EFH in the transportation corridor.

Potential Impact			
Impact (Source)	**Description**	**Duration**	**Degree**
Fish passage and habitat loss (Discharges of fill associated with construction of roads; 7 bridges & 8 culverts)	-Removal of habitat. -Potential introduction of Pacific salmon migration barriers during construction only, -Potential changes in stream flow and channel configuration.	- Free passage of Pacific salmon species may be **temporarily** interrupted - Habitat disturbance from construction effects would be **short-term** as disturbed habitat would return to approximate pre-construction conditions within 1 to 3 years.	The degree of impact is **low:** - Bridges and culverts will be designed for fish passage consistent with ADOT&PF and ADF&G standards. - Construction be timed to ensure instream activities avoid impacts to habitat during species critical life stages (e.g., spawning and egg development periods) (Permit stipulations would further enforce timing restrictions). - Free passage of Pacific salmon species may be temporarily interrupted for up to 48 hours or as directed by permit stipulations, but primarily outside of spawning migration periods; stream diversions could be employed during construction to provide for fish passage; fish passage would continue unimpeded after construction is complete. - Habitats altered remain usable by managed species with minor functional changes.
Habitat loss (Discharges of fill associated with construction of the north and south ferry terminals)	- North ferry terminal: Removal of approx. 0.1 ac (0.04 ha)/ 185 -ft (56.4 m) EFH. hábitat. - South ferry terminal: Removal of approx. 0.7 ac (0.28 ha) and 738 -ft (224.9 m) EFH habitat. - Disturbance of habitats abutting fill areas.	- Habitat removed would be **permanent** - Habitat impacts to areas abutting filled areas would be **short-term**	The degree of impact is **moderate:** - Habitat loss is minimal relative to area that will remain undisturbed in Iliamna Lake. - Ferry terminal structures are expected to create new shoreline and nearshore habitats from deposited rip-rap that will be colonized in the short-term. - Habitat lost is of little biological significance for managed species. - EFH abutting fill locations may be disturbed or degraded during construction but is expected to recover after construction activities have ceased.
Water use (Temporary withdrawal of water from 11 EFH water sources)	- Potential changes in quantity of water; fish entrapment.	**Temporary**	The degree of impact is **low:** **-** Appropriate flow velocity and water levels to support continued stream/lake functions will be maintained through compliance with water use authorizations.

Potential Impact			
Impact (Source)	**Description**	**Duration**	**Degree**
Water quality (Stormwater runoff from road and ferry terminal construction)	- Potential increases in turbidity and sedimentation; changes in water temperature; and changes in the concentration and introduction of PAHs, heavy metals, and other pollutants.	**Temporary**	The degree of impact is **low**: - Effects of turbidity, sedimentation, water temperature changes, heavy metals, and other pollutants on EFH will be minimized through implementation of SWPPPs and BMPs.
Material source development (Stormwater runoff from development of material sites in proximity of EFH)	- Potential increases in turbidity and sedimentation.	**Not Applicable**	The degree of impact is **negligible**: - Material sites avoid EFH floodplains and are located at >500 ft (152.4 m) from EFH. - Effects of turbidity and sedimentation on EFH will be minimized through implementation of required SWPPPs and BMPs.
Invasive species (Introduction of invasive species by vehicles and planting of stabilizing vegetation)	- Potential habitat modification and displacement of native species.	**Not Applicable**	The degree of impact is **negligible**: - Use of certified weed free seed for reclamation and bank stabilization, and implementation of an invasive species management plan.
Noise disturbance (Road and ferry terminal construction equipment, trenching, and vessels)	- Potential habitat degradation due to the introduction of noise.	**Temporary**	The degree of impact is **low**: - EFH may be temporarily degraded due to the introduction of noise, but EFH characteristics would return to normal after the activity ceases.

Potential Impact			
Impact (Source)	**Description**	**Duration**	**Degree**
Blasting (Blasting near EFH for construction of the road, south ferry terminal)	- Degradation of EFH through introduction of pressure and vibration forces that can potential injury, or cause mortality of fish or eggs in spawning gravels.	**Temporary**	The degree of impact is **low**: - Blasting activities would adhere to "Alaska Blasting Standard for the Proper Protection of Fish, Technical Report No. 13-03." - Regulatory compliance and collaboration with agency staff will likely result in overpressures and particle velocities below levels that have been shown to cause injury or mortality to salmonids and salmonid embryos.
Contaminant release (Incidental spill of petroleum lubricants and fuels from road and ferry construction)	- Potential incidental spills of petroleum lubricants and fuels in EFH, which are toxic to fish.	**Not Applicable**	The degree of impact is **negligible**: - Compliance with 40 CFR Part 110, and related vessel-to-vessel transfers, including 33 CFR Part 155. - Implementation of spill prevention control measures would be included in construction operations, and petroleum lubricants and fuel spills would be cleaned up promptly.

5.1.3 Natural Gas Pipeline and Fiber Optic Cable

Potential effects to freshwater EFH from construction of the natural gas pipeline (Figure 3-1) and fiber optic cable are discussed below. The discussion is organized by: loss of habitat, water use, water quality, contaminant release, and blasting. Section 5.1.3.6 summarizes gas pipeline and fiber optic cable construction impacts.

Onshore natural gas pipeline and fiber optic cable construction will occur simultaneously with road construction. Trench development would occur in parallel with road development in most areas. Actual placement of the pipe backfill, and testing would be completed through the spring to fall season:

- Anchor Point Compressor Station — June Y3 - August Y3
- Pipeline construction along road segments — November Y1 - October Y2
- Iliamna Lake sub-lake placement — June Y3 – July Y3
- Pipeline Complete — September Y3

5.1.3.1 Loss of Habitat

The natural gas pipeline and fiber optic cable along the main access road segments would be buried adjacent to the road and would cross 15 Pacific salmon EFH streams. Construction would take place November Y1 through October Y2. The pipeline and fiber optic cable would be attached to the proposed bridges at six of the crossings (Table 5-6). For the remaining 8 stream crossings, the pipeline and fiber optic cable would be installed using trenching or Horizontal Directional Drilling (HDD) techniques, depending on geotechnical conditions and practicability at each of the crossing locations. The pipeline and fiber optic cable would also be laid across Iliamna Lake. Construction of the pipeline across Iliamna Lake would occur June Y3 – July Y3. In deep-water areas of the lake, the pipeline and fiber optic would be laid directly on the lake floor. In shallow waters located close to shore at the ferry terminals the pipeline and fiber optic cable would be buried flush with, or below, the lake floor as required to prevent them from being a hazard to navigation and/or to protect them from ice scouring. An extended reach backhoe or suction dredge would be used for trenching in shallow waters. The following discussion addresses potential loss of habitat for the different pipeline water crossing construction techniques:

- Suspend pipeline beneath bridges. This crossing method would place the pipeline and fiber optic cable above the stream, suspended or secured from six bridges; no loss of EFH is expected.
- HDD. This technique would place the pipeline below the stream. HDD typically results in minimal disruption to riparian vegetation adjacent to the stream, and no disturbance to the stream bed. Loss of EFH is not expected.
- Stream trenching. Water would be diverted, and a trench would be excavated using chain excavators, wheel trenchers, and/or backhoes. Side cast material from the excavation of the trench would be temporary stored above the OHWM of the creek, within the abutting 30 ft road construction buffer. The trench would be deep enough to provide the design soil/sediment cover depth over the top of the pipeline and fiber optic cable. Construction and water diversion methods would vary, depending on soil type and stream channel characteristics. Excavators would generally be used in areas of steep slopes, high water tables, soils with cobbles and boulders, or deep trench areas such as river and stream crossings. Temporary and short-term loss of habitat would result from diverting rivers or streams, removing riparian vegetation, and excavating streambed materials (typical trench width is 8 ft [2.4 m]). In addition, trenching would result in temporary increases in turbidity during construction. Water diversions would be temporary. Juvenile and adult fish passage facilities would be incorporated on all water diversion projects (e.g., fish bypass systems) as required by permit. Habitat impacts would be short-term.
- Nearshore Iliamna Lake trenching. Trenching methods will include an extended reach backhoe working from a small barge with spuds to maintain position (effective up to 30 ft [9.1 m] water depth) or a jet sled operated from the lay barge. The area of substrate disturbance for the submerged portions of the natural gas pipeline is a 30-ft (9.1-m) wide corridor that would result from trenching and any areas where trenched material would be temporarily side cast A clam shell crane working from a barge would be used for any excavation/fill required to limit pipeline contact gaps with the lake bed. Loss of EFH would result from removing littoral vegetation, if present, and excavation of lake floor materials. However, these losses would be temporary as disturbed areas are expected to recover in the short-term after construction is complete as littoral vegetation re-establishes, and waves transport sediment along shoreline and through the excavated area. PLP studies have documented that nearshore lake habitat at the ferry terminals is lightly used by juvenile salmonids and is not used for adult spawning by managed species. (Hart Crowser 2018a, Hart Crowser 2018b, Paradox NR 2018a). Nearshore trenching at Iliamna Lake has the potential to temporarily disturb and displace sockeye salmon fry and adults during construction, but fish use is expected to return to normal after the activity ceases.
- Pipeline and fiber optic laying activities. Pipe laying across Iliamna Lake (June Y3 – July Y3) will utilize a combination of a shore pull and lay barge construction. A pipe pull/lay barge would be

utilized for the work. Sections of pipe up to several miles in length would be welded on shore and pulled out into Iliamna Lake along the bottom and/or utilizing floats. Long segments of pipe would be joined utilizing divers and underwater welding. The pulling of pipe along the lake bottom has the potential to harm habitat in areas where the pipe encounters the lake substrate; other areas (e.g., lake substrate depressions and areas where the pipe does not make complete contact with the substrate) would be left relatively intact. Given the water depths, lack of light, and oligotrophic status of Iliamna Lake, impacts to deep-water benthic areas are not expected to be substantial to EFH. For example, pelagic, open-water areas are the dominant habitat used by sockeye salmon juveniles in the lake (Paradox NR 2018c). To the extent these benthic habitats have value to EFH species, the lake habitat under the pipe would be permanently lost, but the pipeline itself will provide areas for colonization of lake organisms in the short-term. Pipe lay operations may result in the temporary EFH disturbance in and near the construction area, but fish habitat adjacent to the pipeline are expected to return to normal after the activity ceases.

Trenching activities may result in short-term EFH losses, but this will be limited to the excavation trench and side cast areas where required. The area of substrate disturbance for the submerged portions of the natural gas pipeline is a 30-ft (9.1-m) wide corridor, while trenching across streams is expected to result in narrower disturbance width of 8 ft (2.4 m) as material extracted would not be stored below the OHWM of streams. EFH area affected will be minimized by completing the crossing perpendicular to the streams. Placement of the pipeline and fiber optic cable on the lake bottom will result in a change of substrate type from a natural to artificial substrate, but the biological value of this habitat is low, and impacts will be at least partially offset by the area made available for colonization with lake organisms in the short-term by the pipeline itself. Effects on EFH can be further minimized through seasonal restrictions on instream and in-water activities to avoid impacts to habitat during species critical life stages (e.g., spawning and egg development periods), and as required by permit stipulations. The degree of impact is low: trenching activities would result in short-term impacts to EFH (coho salmon, Chinook salmon, and sockeye salmon, spawning and rearing; chum salmon spawning; and pink salmon presence). EFH characteristics will likely return to normal after the activity ceases and a minor amount of habitat would be altered with minimal functional changes.

5.1.3.2 Water Use

Potential impacts to EFH from construction of the natural gas pipeline and fiber optic cable could result from the withdrawal of water from local lakes and streams for use during pipeline hydrotesting or construction activities and eventual release back into the environment. Water withdrawals for construction of the road, natural gas pipeline and fiber optic cable are discussed in Section 5.1.2.1.3.

5.1.3.3 Water Quality

In-water activities, including trenching, have the potential to introduce temporary increases in turbidity and sedimentation into EFH. In-water work would be temporary from November Y1 through October Y2, lasting from days to weeks, depending on the activity. Potential increases in turbidity and sediment load in the water column from in-water work are expected to be temporary. Construction runoff has the potential to introduce temporary increases in turbidity and sedimentation into EFH. Discharges of construction stormwater are regulated by the APDES General Permit AKG320000 – Statewide Oil and Gas Pipelines. The Project will require the preparation and implementation of a SWPPP that will include stormwater runoff controls. Potential impacts would be temporary and minor. The degree of impact is low: water quality changes may cause temporary degradation of EFH (coho salmon, Chinook salmon, and sockeye salmon, spawning and rearing; chum salmon and pink salmon spawning), but EFH characteristics would be likely to return to normal after the activity ceases.

5.1.3.4 Contaminant Release

Potential sources of contaminants from pipeline construction activities (November Y1 – October Y2) include hydrostatic testing, HDD, and spills of petroleum lubricants and fuel:

- Hydrostatic testing. Pipeline test methods would include hydrostatic testing. No chemical additives would be added to the water used for hydrostatic testing. Discharges of hydrostatic water are regulated by the APDES General Permit AKG320000 – Statewide Oil and Gas Pipelines. Section 2.6.1.3 of AKG320000 prohibits the use of antifreeze or biocides in pipeline hydrostatic testing. Disposal methods and locations would be developed in accordance with APDES General Permit AKG320000 prior to filing a Notice of Intent (NOI) for coverage. Specific BMPs for test water discharge will be developed as required in the general permit. The discharge BMPs will be designed to prevent erosion at the point of discharge and downstream. The primary control will be energy dissipation at the water discharge point to prevent erosion and consequent sediment loading. Contaminants are not anticipated to be present as the pipeline will not contain liquid hydrocarbons. However, monitoring of discharge water for contaminant parameters listed on the general permit will be conducted to verify contaminant discharge is not occurring.
- HDD. This drilling technique poses some potential for impacts from loss of fluid through subsurface fractures (frac-out), or in unconsolidated gravel or coarse sand. Drilling mud (fluid) used in HDD poses a low risk to waterbodies and wetlands. However, fluid loss may result in a temporary increase in turbidity or siltation that can negatively impact aquatic life by covering spawning/feeding areas and clogging fish gills. After HDD begins, specific monitoring would be conducted to determine whether a subsurface fluid loss occurs. To provide a means to ensure that the pressure on the drilling fluid is set to match the formation, the pressure levels would be set as low as possible and closely monitored. The pressure should not exceed what is needed to penetrate the formation. A significant drop in pressure or drop in mud return could indicate a potential fluid loss and drilling would be halted immediately. Details regarding prevention, detection, and response to a potential frac-out or drilling fluid release would be addressed in the HDD Plan and Spill Prevention Control and Countermeasures (SPCC) Plan. Discharges of drill fluid and drill cutting water are regulated by the APDES General Permit AKG320000 – Statewide Oil and Gas Pipelines.
- Spills of petroleum lubricants and fuels in and out of the water. Potential spill sources include: equipment failures, fuel transfers, accidents or human error. Petroleum lubricants and fuels are considered acutely toxic. Mortality of fish, invertebrates, and plants that come in direct contact with a diesel spill may occur. PLP and their construction contractors must comply with all laws and regulations related to spill prevention and preparedness of petroleum lubricants and fuel, including 40 CFR Part 110, and those related to vessel-to-vessel transfers, including 33 CFR Part 155. Construction operations would implement spill prevention control measures, and in the event of a spill facilitate a rapid response and cleanup operation. While a large release of petroleum lubricants

and fuels would be expected to have short-term effects on EFH, such an event is unlikely considering the control measures that would need to be included in the Project. Small spill events resulting in minimal or unmeasurable effects to EFH are more likely.

Based on the effective implementation of control measures and compliance with regulatory requirements, including APDES General Permit AKG320000, 40 CFR Part 110, and 33 CFR Part 115, impacts to EFH (coho salmon, Chinook salmon, and sockeye salmon, spawning and rearing; chum salmon and pink salmon spawning) would be temporary and negligible.

5.1.3.5 Blasting

Blasting for construction of the natural gas pipeline will occur concurrent with construction of the road. Road construction blasting impacts are discussed in Section 5.1.2.1.6.

5.1.3.6 Summary of Potential Effects to Freshwater EFH for Construction of the Natural Gas Pipeline and Fiber Optic Cable

Potential effects to freshwater EFH associated with the natural gas pipeline and fiber optic cable are discussed in sections 5.1.3.1 through 5.1.3.5. Potential direct effects include the loss of habitat, changes in water quality, and potential releases of contaminants from the placement of fill into waters of the U.S. Effects from other activities, such as water use and blasting, would be indirect effects. A summary of potential impacts to EFH and their assessed degree of severity is included in Table 5-10.

Table 5-10: Summary of potential impacts to freshwater ecosystem EFH for the natural gas pipeline and fiber optic cable.

Potential Impacts			
Type (Source)	**Description**	**Duration**	**Degree**
Loss of habitat (Pipeline and fiber optic cable stream crossings)	- Loss of habitat from trenching through EFH. - Placement of the pipeline on the lake bottom will result in the change of substrate type from a natural to artificial substrate of the pipeline itself.	**Short-term**	The degree of impact is **low:** - Short-term EFH losses limited to the excavation trench (typical trench width is 8 ft [2.4 m]). - Artificial substrate (pipeline) is expected to be recolonized with lake organisms in short-term. - Managed species may be displaced from construction areas but are expected to return to normal after construction activities have ceased or habitats have recovered. - Effects on managed species can be minimized through seasonal restrictions on in-water activities to avoid impacts to habitat during species critical life stages (e.g., spawning and egg development periods), and as required by permit stipulations.

Potential Impacts			
Type (Source)	**Description**	**Duration**	**Degree**
Water use (Temporary withdrawal of water from EFH)	- Degradation of EFH from potential changes in quantity of water; fish entrapment.	**Temporary**	The degree of impact is **low:** **-** Appropriate flow velocity and water levels to support continued stream/lake functions would be maintained through compliance with water use authorizations.
Water quality (Stormwater runoff from pipeline construction)	- Degradation of EFH from potential increases in turbidity and sedimentation.	**Temporary**	The degree of impact is **low:** - Discharges of hydrostatic water are regulated by the APDES General Permit AKG320000 – Statewide Oil and Gas Pipelines. - Effects of sedimentation on fish habitat would be minimized through implementation of required stormwater management plans and BMPs. - Temporarily degraded EFH habitat may avoided by managed species, but EFH characteristic would return to normal after the activity ceases.
Contaminant release (Hydrostatic testing, HDD, and spills of petroleum lubricants and fuels)	- Hydrostatic testing - Potential spills of petroleum lubricants and fuels in EFH which are toxic to fish. - Potential temporary increase in turbidity or siltation from frac-out that could negatively impact aquatic life.	**Not Applicable**	The degree of impact is **negligible**: - Compliance with APDES General Permit AKG320000, 40 CFR Part 110, and related vessel-to-vessel transfers, including 33 CFR Part 155. - Implementation of spill prevention control measures would be included in construction operations. - Petroleum lubricants and fuel spills would be promptly cleaned up. - Implementation of HDD plan**.**
Blasting (Blasting near EFH for pipeline trench development as required)	- Degradation of EFH through introduction of pressure and vibration forces that can potential injury, or cause mortality of fish or eggs in spawning gravels.	**Temporary**	The degree of impact is **low**: - Blasting activities would adhere to "Alaska Blasting Standard for the Proper Protection of Fish, Technical Report No. 13-03." - Regulatory compliance and collaboration with agency staff would likely result in overpressures and particle velocities below levels that have been shown to cause injury or mortality to salmonids and salmonid embryos.

5.2 Marine Ecosystem

The marine ecosystem for the project is comprised of estuarine and marine EFH within the Action Area in Cook Inlet

5.2.1 Amakdedori Port

Potential effects to EFH from construction of the Amakdedori Port facilities (Figure 3-8, Figure 3-9) are discussed below and organized by: loss of habitat, noise disturbance, water quality, contaminant release, and invasive species. A summary of impacts is included in Section 5.2.1.6.

Construction schedule for Amakdedori Port includes:

- Amakdedori Port site capture (land by barge) — May Y1
- Amakdedori Port & Dock Construction — September Y1 - September Y2

5.2.1.1 Loss of Habitat

The proposed construction of Amakdedori Port, lighted navigation buoys, and two spread anchor mooring system in Kamishak Bay would include placement and removal of fill in shoreline habitat, installation of sheet pile, and installation of permanent anchors.

5.2.1.1.1 Amakdedori Port

The proposed Amakdedori Port facility includes a causeway (truck route and causeway), sheet pile wharf structure (Figure 3-8), and associated land-side structures. Construction activities at Amakdedori Port below the high tide line would take place between September Y1 and September Y2; construction of the causeway and related infrastructure would continue as long as weather and icing conditions allow and recommence as soon as practicable in the spring, subject to permitting conditions. Construction would remove and/or fill 11 ac (4.5 ha) of nearshore EFH habitat including 2.2 ac (0.9 ha) of beach complex and 8.8 ac (3.6 ha) of subtidal mixed gravel habitat. Fill material, sourced at material sites along the road, would be placed directly on the seafloor to build the causeway. Fill materials will be tested and be within the neutral range of 7.5 to 8.4 pH. In marine waters, this pH range will maximize colonization of marine organisms. Excessively alkaline or acidic fill material will not be used. Only clean fill will be used. The wharf would be located at the outer end of the causeway and is a sheet pile wall design. The area behind the sheet pile would be filled with competent fill material and rock to solidify the structure. The port would include two lighted navigation buoys located on the reefs framing the entrance to the Amakdedori Port. The buoys would be 3 ft (0.9 m) in diameter and anchored to the reef using screw anchors or 3 by 3 by 3 ft (0.9 x 0.9 x 09 m) concrete block anchors, with an anchoring design that prevents excessive anchor chain drag or swing.

PLP conducted fish surveys at Amakdedori Beach near the proposed Amakdedori Port location in 2013, 2017, and 2018. Intertidal fish communities were dominated by juvenile salmonids, with the number captured peaking in early-May, coinciding with the Pacific salmon smolt migration from freshwater to marine habitats. Juvenile pink and chum salmon were consistently abundant, with some showing of juvenile sockeye salmon. Surf smelt larvae and adults were found at Amakdedori Beach, but whether surf smelt spawn in this area remains unconfirmed. Spawning surveys for forage species conducted near the proposed

Amakdedori Port did not detect forage fish eggs in any of the sediment samples; however, sampling occurred from late April into June and may have missed the spawning period. The presence of larvae in late April indicates spawning may occur late March through early April, assuming an incubation period of 27 to 56 days in water temperatures typical of that time of the season (WDFW 2015). Herring spawn survey data suggest that the proposed Amakdedori Port location is isolated from known spawning areas. Herring spawn primarily on eelgrass and rockweed, found predominantly south of the proposed port facility around reefs associated with Nordyke Island and Chenik Head, and near Contact Point, well north of the proposed port. The reefs associated with areas closer to the proposed facility were dominated by *Palmaria* spp., kelp, and other species that are little used by spawning herring (GeoEngineers 2018a).

The total CPUE found in trawl sets at Amakdedori Beach in 2018 was lower than catch rates found in other Cook Inlet locations studied in 2018. Historical catch rates within the Iniskin/Iliamna estuary (2004-2012), Ursus Cove (2012), and Rocky Cove (2012) averaged 33.3, 10.8, and 5.0 fish per trawl set respectively, higher than the 2018 catch rate of 2.8 fish per trawl set for Amakdedori Beach. This is likely because subtidal mixed and hard bottomed habitats at Amakdedori are less productive than other areas that have been sampled (GeoEngineers 2018a).

Discharge of fill material to construct the Amakdedori Port would permanently remove EFH, however PLP's fish surveys indicate the beach complex and subtidal mixed gravel habitat is less productive than other areas sampled in Kamishak Bay. Furthermore, habitat losses are negligible within the context of the availability of similar nearshore habitat at Amakdedori Beach; beach complex and subtidal mixed gravel would represent a reduction of 0.05 percent and 0.06 percent, respectively, of the total habitat mapped by PLP (Table 4-15).

Habitat near the port site may be degraded temporarily during construction because of activities, such as setting anchor or landing on the beach, that disturb benthic fauna or disrupt bottom habitat structure. Limited vessel anchoring would occur during construction as most barges and landing craft would land on the beach and use onshore mooring locations. Anchoring and beach landings would have a direct effect on the seabed. EFH habitat would be temporarily disturbed within the footprint of the scar that results when setting or breaking anchor or landing the vessel. Impacts would be temporary as near-shore sediments are expected to be very dynamic due to natural wave action.

The Amakdedori Port would alter localized currents and water circulation; however, this is not expected to be of consequence as organisms occupying the Amakdedori Port are likely already adapted to quickly changing water circulation and bottom conditions. The natural environment at Amakdedori Beach is a high-energy wave regime with a large tidal influence that is subject to constant redistribution of substrate through littoral transport, storm surge, and ice scour. The seabed is being continuously reformed as new sediments are redeposited.

EFH removed to construct the Amakdedori Port would be permanent, but minimal relative to the abundance of similar nearshore habitat on Amakdedori Beach. Construction-related disturbance of adjacent EFH is temporary. The degree of impact is moderate: the discharge of fill would permanently remove EFH (rearing and adult Pacific salmon; adult Atka mackerel and octopus; all life stages of flatfish species and walleye pollock; juvenile and adult GOA skate and sculpin species; larvae, juvenile, and adult Pacific cod, rockfish species, and sablefish; and forage complex species including surf smelt spawning and rearing) areas of low density use by managed species.

5.2.1.1.2 Spread Anchor Mooring Systems

PLP has proposed two lightering locations in Kamishak Bay each includes a spread anchor mooring system consisting of six floating mooring buoys attached to permanent anchors set on the seabed. The layout of the permanent anchors (10-12) set on the seabed will be confirmed in final design, but would typically consist of a large weight, such as a rock/concrete filled 40 ft by 8 ft by 8 ft (12.2 m x 2.4 m x 2.4 m) shipping container that is lowered to the sea floor. If sea floor conditions are not suitable for gravity anchors, alternatives include: (i) large spade anchors (similar to a conventional boat anchor); (ii) spiral screw anchors that would be twisted into the seabed using a hydraulic drill (not suitable in areas of rock or hard cobbles); and, (iii) anchors drilled into the seabed (suitable for areas of rock seabed). The spread anchor mooring system measures approximately 2,300 ft by 1,700 ft (701 m x 518.2 m), but the impact footprint on the sea bottom is limited to the 10 to 12 anchor locations. Drag and swing of the sea anchor chains would be minimized by positioning an approximately 3 by 3 by 3 ft (0.9 x 0.9 x 09 m) concrete block (sinker) on the sea floor with enough slack in the chain to allow the buoy to move closer to the main anchor without allowing much of the main anchor chain to sag further onto the bottom. Typical chain for this type of application would use 2 in (5 cm) diameter steel chain links. Exact anchor chain lengths would be developed in detailed design. Water depth at the proposed lightering locations is approximately 80 ft (24.4 m). The combined maximum footprint of the seafloor anchors is approximately 0.2 ac (0.1 ha).

Construction of the spread anchor mooring systems would take place between September Y1 and September Y2. Construction of each anchor point would require approximately one day of work at the site. If a drilled anchor is required, it would take 1 to 4 hours of drilling time within the day to prepare the hole for a grouted anchor or to directly drill in the screw anchor. It would take 10 to 12 days to establish all the anchors at each lightering location, or 20 to 24 days of work for both locations.

The mooring system could impact the benthic fauna or disrupt the seafloor habitat structure. There are two components of impact: the loss of habitat from the permanent anchor and the scraping or sweeping of the sea bottom from the movement (cable sweep) of anchor chains across the bottom. The weight of the permanent anchors on the seafloor would result in removal of EFH within the anchors' footprint, with impacts and recovery being short-term as new species colonize the anchor structures. Once colonized, the anchors would provide approximately 0.4 ac (0.2 ha) of reef type habitat. In contrast, the area affected by cable sweep is expected to be larger, but the effect on live bottom considerably less than the permanent anchors. It is expected that areas of live bottom (e.g. areas of live bottom organisms within depressions and areas where the cable does not make complete contact with the sediments or rock) would survive relatively intact from cable sweep during and after installation. The areas could provide stock material for a more rapid re-colonization and recovery of adjacent live bottom habitat. Once installed the mooring system design would minimize cable sweep.

The permanent loss of EFH from construction of the spread anchor mooring system is minimal, relative to habitat in Kamishak Bay. Recolonization of permanent anchors by aquatic species is expected to be short-term, potentially creating new habitat. Furthermore, the anchor design would minimize cable sweep impacts. The degree of impact is low: the effect may cause temporary degradation of EFH (rearing and adult Pacific salmon; adult Atka mackerel and octopus; all life stages of flatfish species and walleye pollock; juvenile and adult GOA skate and sculpin species; larvae, juvenile, and adult Pacific cod, rockfish species, and sablefish; and forage complex species) during construction, but EFH characteristics would be likely to return to normal after the activity ceases. EFH removed would be minimal and permanent, but this would be further minimized in the short-term once recolonized by aquatic organism creating new habitat.

5.2.1.2 Noise Disturbance

Construction (September Y1 – September Y2) activities would introduce in-water noise with direct potential to impact marine EFH. Noise generating activities and sources include: vibratory and impact pile-driving, placement of fill for the causeway and wharf from material supply barges, and vessel traffic during construction.

Excavated, dredged, and fill material to construct the causeway would be transferred between the water and barges. These activities would generate in-water noise potentially perceived by fish, and at an intensity that would cause habitat avoidance, however it is expected fish would return once noise ceased. Construction-related noise impacts are anticipated to be short term.

Wharf construction would install approximately 331 by 4.6 lineal ft (1.4 lineal m) wide sections, for a total length of approximately 1,520 ft (463 m). All sheet pile would extend to the dock surface, a height of 40 ft (12 m) above MLLW. The sheet piles would be placed in approximately 15–20 ft (4.6–6.1 m) of water. The causeway would be constructed by infilling on top of the seabed with competent fill and rock protection for the side slopes. The sheet pile would be installed using two vibratory hammers (APE 200 or similar) operating from a construction barge alongside the dock. The estimated time to drive a pair of sheet piles ranges from 30 minutes to two hours. Factoring the need for cooling and maintenance, each hammer is expected to operate for six to eight hours over a 24-hour period. If bedrock or hard soil is encountered, a small diesel impact hammer (Delmag D36-32 or similar) may be necessary to anchor the last few ft of sheet pile into the ground. The impact hammer would operate up to two hours in a 24-hour period. The time estimated to complete pile driving is 90 days depending on weather contingency and the amount of hard ground encountered (requiring delays to change out hammers).

Impulsive underwater noise from impact hammers has the potential to negatively affect managed species. The degree of effect is related to the level and duration of sound exposure by the individual fish, not just the distance from the noise source (Hastings and Popper 2005). The degree to which an individual fish exposed to sound would be affected depends on multiple factors including: fish species, fish size, presence of a swim bladder, physical condition of the fish, peak sound pressure and frequency, shape of the sound wave (rise time), depth of the water around the pile, depth of the fish in the water column, amount of air in the water, size and number of waves on the water surface, bottom substrate composition and texture, effectiveness of bubble curtains and other sound/pressure attenuation technology, tidal currents, and presence of predators. These factors can have negative effects on fish that range from behavioral changes to immediate mortality (Hastings and Popper 2005, Popper 2006).

The installation of sheet pile would limit exposure to noise to be consistent with criteria included in the "Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities" (FHWG 2008). These criteria have identified a peak sound pressure level of 206 decibels (dB) and an accumulated sound exposure level (SEL) of 187 dB for all fish weighing 2 grams or larger. For fish less than 2 grams, the criterion for accumulated SEL is 183 dB (FHWG 2008). If sound levels are anticipated to exceed these acceptable limits, PLP would implement appropriate mitigation measures, when practicable. Methods to reduce the SPLs and SELs include, the following:

- Drive piles during low tide when they are located in intertidal and shallow subtidal areas.
- When impact hammers are required due to seismic stability or substrate type, drive the pile as deep as possible with a vibratory hammer first and then use the impact hammer to drive the pile to its final position.
- Because the sound produced has a direct relationship to the force used to drive the pile, use a smaller hammer to reduce sound pressure.
- Use a hydraulic hammer if impact driving cannot be avoided. The force of the hammer blow can be controlled with hydraulic hammers; reducing the impact force will reduce the intensity of the resulting sound.
- Use bubble curtains or other sound attenuation devices to reduce the acoustical footprint.

The degree of impact is low: the effect may cause temporary degradation of EFH (rearing and adult pacific salmon; adult Atka mackerel and octopus; all life stages of flatfish species and walleye pollock; juvenile and adult GOA skate and sculpin species; larvae, juvenile, and adult Pacific cod, rockfish species, and sablefish; and forage complex species including surf smelt spawning and rearing), but EFH characteristics would return to normal after the activity ceases.

5.2.1.3 Water Quality

Construction activities at the Amakdedori Port (September Y1 – September Y2), including in-water work and modification of land-based areas, has the potential to intensify localized stormwater runoff, increasing silt and sediment loads and contaminants discharged to adjacent marine habitats. The dock could create water traps that accumulate contaminants or nutrients washed in from land-based sources, vessels, and facility structures. This has the potential to decrease the feeding efficiency of visual fishes, or create areas of low dissolved oxygen, algae blooms, and elevated toxins within the immediate area of the construction. However, because of the high flushing conditions at Amakdedori Beach, such impacts are unlikely to happen. Tidal ranges in Kamishak Bay, as measured by the tidal gauging station operated by NOAA at nearby Nordyke Island, average approximately 13 ft (4 m) between low and high tides. Extents range from average high tides of 14.5 ft (4.4 m) above MLLW to average low tides of 1.4 ft (0.4 m) below MLLW. Maximum tidal height is nearly 20 ft (6.1 m) above MLLW, while maximum low tides are nearly 6 ft (1.8 m) below MLLW. Additionally, PLP and their contractors must comply with construction stormwater management regulations, including the 2016 CGP AKR10000, to minimize erosion and reduce or eliminate the discharge of pollutants through implementation of control measures. The high flushing rate at Amakdedori Beach and open port design will minimize the persistence of construction-related turbidity and contaminants near the proposed port. Consequently, impacts from stormwater runoff, including sedimentation loads from in-water work would be temporary. The degree of impact is low: the effect may cause temporary degradation of EFH (rearing and adult Pacific salmon; adult Atka mackerel and octopus; all life stages of flatfish species and walleye pollock; juvenile and adult GOA skate and sculpin species; larvae, juvenile, and adult Pacific cod, rockfish species, and sablefish; and forage complex species including sand surf smelt spawning and rearing) but EFH characteristics would be likely to return to normal after the activity ceases.

5.2.1.4 Contaminant Release

Port construction (September Y1 – September Y2) would involve work aboard vessels, and other specialized land or marine based equipment that has the potential to release contaminants from incidental spills of petroleum lubricants and fuel. Potential incidental spill sources include: equipment failures, fuel transfers, accidents, or human error. Petroleum lubricants and fuels are considered acutely toxic. Mortality of fish, invertebrates, and plants that come in direct contact with a diesel spill may occur. Crabs and bivalves can also be impacted from small diesel spills in shallow, nearshore areas. These organisms bioaccumulate the oil but are also capable of depurating the oil, usually over a period of several weeks after exposure (Limpinsel et al. 2017, Michel et al. 2013).

PLP and their construction contractors must comply with all laws and regulations related to spill prevention and preparedness of petroleum lubricants and fuel, including 40 CFR Part 110, and those related to vessel-to-vessel transfers, including 33 CFR Part 155. PLP and their construction contractors must comply with all laws and regulations related to spill prevention and preparedness of petroleum lubricants and fuels, including 40 CFR Part 110. Spill prevention control measures would be included in construction operations; petroleum lubricants and fuel spills would be promptly cleaned up. Given the required spill prevention controls measures it is unlikely that an incidental spill would result in the release of enough petroleum lubricants and fuels to result in any consequential exposure of EFH. The persistence of contaminants near the proposed port is not expected because of the high flushing rate at Amakdedori Beach and the port's open design. Based upon regulatory compliance and implementation of control measures, impacts on EFH (rearing and adult pacific salmon; adult Atka mackerel and octopus; all life stages of flatfish species and walleye pollock; juvenile and adult GOA skate and sculpin species; larvae, juvenile, and adult Pacific cod, rockfish species, and sablefish; and forage complex species including surf smelt spawning and rearing) from contaminant releases during construction are expected to be negligible.

5.2.1.5 Invasive Species

The introduction of nonnative organisms from construction operations (September Y1 – September Y2) to new environments can have severe impacts to EFH including: habitat alteration, trophic alteration, spatial alteration, gene pool alteration, and introduction of diseases.

Habitat alteration includes the excessive colonization by sessile invasive species, which precludes the growth of endemic organisms. Invasive species may alter community structure, particularly the trophic structure, by preying on native species and by increasing their own population levels. Introduced organisms may compete with indigenous species or prey on indigenous species which can reduce native fish and shellfish populations (Limpinsel et al. 2017). Spatial alteration occurs when introduced territorial species compete with and displace native species. The introduction of invasive organisms threatens native biodiversity and could lead to changes in relative abundance of species and individuals that are of ecological and economic importance (Limpinsel et al. 2017).

Long-term impacts from the introduction of nonindigenous species can include a decrease in the overall fitness and genetic diversity of natural stocks. Although hybridization is rare, it may occur between native and introduced species and can result in gene pool deterioration. Potential long-term impacts also include the spread of lethal diseases. The introduction of bacteria, viruses, and parasites is a severe threat to EFH as it may reduce habitat quality and survival of managed species. New pathogens or higher concentrations of disease can be spread throughout the environment, resulting in deleterious habitat conditions (Limpinsel et al. 2017).

Potential introduction pathways include the release of ballast water from construction equipment. Ballast water is a major source of introducing invasive species into aquatic ecosystems (USEPA 2013). Project construction would employ unballasted barges, which would already be in operation in Cook Inlet and western Alaska, reducing the overall risk of introducing invasive species. Therefore, the introduction of invasive species risk is negligible.

5.2.1.6 Summary of Amakdedori Port Potential Effects to Marine Ecosystem EFH

Potential effects to marine ecosystem EFH associated with the Amakdedori Port are discussed in sections 5.2.1.1 through 5.2.1.5. Potential direct effects include the loss of habitat, noise disturbance, changes to water quality, and contaminant release, from the placement of fill into waters of the U.S. Indirect effects include the potential introduction of invasive species. A summary of potential impacts to EFH and their assessed degree of severity is included in Table 5-11.

Table 5-11: Summary of potential impacts to marine ecosystem EFH for the Amakdedori Port and mooring sites.

Potential Impact			
Impact (Source)	**Description**	**Duration**	**Degree**
Loss of habitat (Discharge of fill associated with construction of the Amakdedori Port, including light navigation buoys)	- Removal of approx. 11 ac (4.5 ha) of nearshore EFH habitat. - Disturbance of habitats abutting fill areas.	- Removed habitat would be **permanent**. - Habitat disturbance from construction activities outside the footprint of the fill would be **temporary**.	The degree of impact is **moderate:** - Habitat lost is of little biological significance for managed species. - Habitat loss is minimal relative to areas that would remain undisturbed in Amakdedori Beach. - - Disturbance of habitat adjacent to the construction would be temporary, as organisms are likely already adapted to quickly changing water circulation and bottom conditions.
Loss of habitat (Discharge of fill material and cable sweep for mooring sites)	- Removal of approx. 0.2 ac (0.1 ha) of seafloor habitat.	- Construction EFH disturbance is **temporary.** -Removed habitat would be **permanent** but minimized in **Short-term** once recolonized by aquatic organisms.	The degree of impact is **low**: - Habitat loss is minimal relative to the area that would remain undisturbed in Kamishak Bay. - Anchors would recolonize with live organisms in the short-term, potentially creating 0.4 ac (0.2 ha) of habitat. - Cable sweep would be minimized through design.

Potential Impact			
Impact (Source)	**Description**	**Duration**	**Degree**
In-Water noise (Vibratory pile-driving)	- Degradation of habitat due to the introduction of noise.	**Temporary**	The degree of impact is **low**: **-** Sound control measures would be implemented, if necessary, to limit noise exposures to fish consistent with criteria included in the 2008 Fisheries Hydroacoustic Working Group memorandum. These criteria have identified a peak sound pressure level of 206 dB and an accumulated SEL of 187 dB for all fish weighing 2 grams or larger. For fish less than 2 grams, the criterion for accumulated SEL is 183 dB (FHWG 2008). Common measures employed to reduce the underwater sound generated by in-water pile driving have proven successful.
Water quality (Changes in water quality due to increased siltation, sedimentation, and turbidity)	- Potential increases in turbidity and sedimentation.	**Temporary**	The degree of impact is **low**: - Effects of turbidity and sedimentation on EFH would be minimized through implementation of required stormwater management plans and BMPs. - The persistence of turbidity and contaminants near the proposed port is not expected because of the high flushing rate at Amakdedori Beach and port open design.
Contaminant release (Incidental spills of petroleum lubricants and fuel)	- Potential incidental spills of petroleum lubricants and fuels in EFH, which are toxic to fish.	**Not Applicable**	The degree of impact is **negligible**: - Compliance with 40 CFR Part 110, and related to vessel-to-vessel transfers, including 33 CFR Part 155. - Implementation of spill prevention control measures would be included in construction operations. - Petroleum lubricants and fuel spills would be promptly cleaned up. - The persistence of turbidity and contaminants near the proposed port is not expected because of the high flushing rate at Amakdedori Beach and port open design.
Invasive species (Movement of large ships and ballast water from the U.S. West Coast and Asia)	- Potential habitat alteration, trophic alteration, spatial alteration, gene pool alteration, and introduction of diseases.	**Not Applicable**	The degree of impact is **negligible**: - Project construction would employ locally-sourced unballasted barges, which would already be in operation in Cook Inlet and western Alaska, reducing the overall risk of introducing invasive species.

5.2.2 Natural Gas Pipeline and Fiber Optic Cable

Potential effects to EFH from construction of the natural gas pipeline (Figure 3-1, Figure 3-3) and fiber optic cable in marine ecosystem EFH discussed below are organized by: loss of habitat, noise disturbance, water quality, and contaminant release. A summary of impacts is included in Section 5.2.2.5.

Construction schedule for the installation of the natural gas pipeline and fiber optic cable in cook inlet includes:

- Cook Inlet sub-sea pipeline placement June Y2 - August Y2

5.2.2.1 Loss of Habitat

Construction of the natural gas pipeline and fiber optic place would start in June Y2 and end in August Y2. Potential impacts from the placement of anchors for the pipe lay barge include benthic fauna mortality and disruption to the seafloor habitat structure. Impact sources include anchor scarring each time an anchor is set, and the scraping or sweeping of the seafloor from the movement of the anchor cables across the seafloor (cable sweep). The typical sea anchor footprint is generally small, but the depression could be 7 - 8 ft (2.1 – 2.4 m) in soft bottom. The weight of the anchor and potential depth of the scar could potentially result in mortality of benthic fauna, including weathervane scallops, and severe disruption to the habitat structure within the footprint of the scar, with impact and recovery being short-term. Assuming an average anchor scar of 360 ft^2 (33.4 m^2) (10 x 36 ft [3 x 11 m]), with up to a 12-anchor array, and resetting the anchors twice per mile, for the 104.5 miles (168.2 km) length of the submarine pipeline, anchor scarring would total approximately 21 ac (8.5 ha).

The seafloor habitat potentially affected by cable sweep is expected to be larger relative to the anchor scar area, but the magnitude of the effect on a per unit area on bottom habitat would be considerably less. Impacts from cable sweep are expected to be milder, and some areas would survive relatively intact; these include areas of seafloor organisms within depressions and areas where the cable does not make complete contact with the seafloor. These areas could provide stock material for more rapid re-colonization and recovery of adjacent live bottom habitat.

Additional impacts to the seafloor habitat include the area of pipeline placement. Generally, the submarine portions of the pipeline would be constructed using heavy wall steel pipe placed on the seafloor. This would introduce a solid material and represents a change from the natural, softer substrate to the artificial substrate, for a combined area of approximately 11.5 ac (4.7 ha). It is expected that the pipeline would be colonized by marine life in the short-term. In soft substrate areas the colonized pipeline would provide a new habitat type, while hard substrate habitat would be closely mimicked. This habitat change would be permanent. Approximately 6.8 ac (2.8 ha) of weathervane scallop EFH would be impacted by placement of the pipeline. Unlike most adult fish that are mobile and able to actively avoid direct impacts from pipe laying activities, weathervane scallops may not be able to avoid the area, which could potentially result in weathervane scallop mortality. Because the area of localized effects of the actions is small compared to the weathervane scallop range in Cook Inlet that would not be affected, impacts would be undetectable. In shallower waters located close to shore the pipe would be buried flush with the substrate, or below if required to prevent it being a hazard to navigation and/or to protect it from ice scour. If required, trenching would be completed using an extended reach backhoe or suction dredge. Trenching would impact the benthic fauna or disrupt seafloor habitat, but the effects would be localized and reversed in the short-term.

Habitat losses resulting from pipeline installation would range from temporary to short-term and would be minimal within the context of existing habitat in lower Cook Inlet unaffected by this activity. Where the pipeline lays on top of the substrate, the habitat change would be permanent, but of minimal effect to EFH. This may result in temporary disturbance and displacement of managed species. The degree of impact is low: the effect may cause temporary to short-term degradation of EFH (rearing and adult Pacific salmon; adult Atka mackerel and octopus; all life stages of flatfish species and walleye pollock; juvenile and adult GOA skate and sculpin species; larvae, juvenile, and adult Pacific cod, rockfish species, and sablefish; forage complex species; and weathervane scallop, but EFH characteristics would likely to return to normal after the activity ceases, and habitat would be altered with minimal functional changes. Permanent loss of scallop EFH would be minimal.

5.2.2.2 Noise Disturbance

Construction activities (June Y2 – August Y2) would introduce in-water noise with potential to impact marine EFH. Noise generating activities and sources include: installation of the pipeline including trenching, placement of vessel anchors, and marine vessels. In-water noise has the potential to be perceived by fish and at an intensity that would result in fish avoiding the EFH. Construction-related noise impacts are anticipated to be temporary, and fish would return to the area once the in-water noise has ceased. The degree of impact is low: the effect may cause temporary degradation of EFH (rearing and adult Pacific salmon; adult Atka mackerel and octopus; all life stages of flatfish species and walleye pollock; juvenile and adult GOA skate and sculpin species; larvae, juvenile, and adult Pacific cod, rockfish species, and sablefish; forage complex species; and weathervane scallop), but EFH characteristics would be likely to return to normal after the activity ceases.

5.2.2.3 Water Quality

Placement of the natural gas pipeline and fiber optic cable on the seafloor (June Y2 – August Y2), including temporary placement of boat anchors, and trenching including side-casting of trench material and backfilling of trench (if required) of the pipeline, may result in temporary increases in sediment and turbidity in localized areas immediately adjacent to the pipeline. Most adult fish are mobile and would actively avoid direct impacts from the pipe laying and trenching activities. Some impairment of the ability of managed species to find prey items could occur, but this effect should be temporary and spatially limited to the immediate vicinity of pipeline construction activities. Sedentary managed species, such as scallops, may be affected by the temporary increase in sediment loads within the water columns during construction. The deposition of sediments can smother eggs and larvae. It is anticipated that most managed species would avoid construction areas, and potential impacts would be temporary and minor resulting in displacement of organisms, followed by rapid post-construction return or re-colonization by these species. Increased sediment loads in the water column are expected to be temporary due to the high flushing in lower Cook Inlet. The degree of impact is low: the effect may cause temporary to short-term degradation of EFH (rearing and adult Pacific salmon; adult Atka mackerel and octopus; all life stages of flatfish species and walleye pollock; juvenile and adult GOA skate and sculpin species; larvae, juvenile, and adult Pacific cod, rockfish species, and sablefish; forage complex species; and weathervane scallop), but EFH characteristics would be likely to return to normal after the activity ceases.

5.2.2.4 Contaminant Release

Potential sources of contaminant release from construction (June Y2 – August Y2) of the pipeline in the marine ecosystem include incidental spills of petroleum lubricants and fuels, and loss of fluid from HDD.

Incidental spills of petroleum lubricants and fuel during pipeline construction has the potential to impact EFH. These spills could originate from construction equipment or support vessels, as a result of equipment failures, fuel transfers, accidents, or human error. PLP and their construction contractors must comply with all laws and regulations related to handling of petroleum lubricants and fuels, including 40 CFR Part 110, and those related to vessel-to-vessel transfers, including 33 CFR Part 155. Construction operations would implement spill prevention control measures, and in the event of a spill would facilitate a rapid response and cleanup operation. Given the required spill prevention controls measures it is unlikely that an incidental spill would result in the release of enough petroleum lubricants and fuels to result in any consequential exposure of EFH.

Potential direct impacts from HDD activities include loss of fluid through subsurface fractures (frac-out) and unconsolidated gravel or coarse sand. Drilling mud (fluid) used in HDD is non-toxic and poses a low risk to waterbodies. However, fluid loss may result in a temporary increase in turbidity or siltation that can negatively impact aquatic life by covering spawning and feeding areas and clogging fish gills. Monitoring would be conducted throughout the HDD process to determine whether a subsurface fluid loss occurs. Details regarding prevention, detection, and response to a potential frac-out or drilling fluid release would be addressed in the HDD and SPCC plans. Based upon regulatory compliance and implementation of control measures, impacts to EFH (rearing and adult Pacific salmon; adult Atka mackerel and octopus; all life stages of flatfish species and walleye pollock; juvenile and adult GOA skate and sculpin species; larvae, juvenile, and adult Pacific cod, rockfish species, and sablefish; forage complex species; and weathervane scallop) from contaminants releases during construction are expected to be negligible.

5.2.2.5 Summary of Natural Gas Pipeline and Fiber Optic Cable Potential Effects to Marine Ecosystem EFH

Potential effects to marine ecosystem EFH associated within the natural gas pipeline and fiber optic cable segment of the transportation corridor are discussed in sections 5.2.2.1 through 5.2.2.4. Potential direct effects include the loss of habitat, noise disturbance, water quality and contaminant release from of the placement of fill into waters of the U.S. A summary of potential impacts to EFH and their assessed degree of severity is included in Table 5-12.

Table 5-12: Summary of potential impacts to marine ecosystem EFH for the natural gas pipeline and fiber optic cable.

Potential Impact			
Impact (Source)	**Description**	**Duration**	**Degree**
Loss of habitat (Pipeline installation)	- Approx. 21 ac (8.5 ha) of anchor scars. - Anchor cable sweep. - Trenching - Approximately 11.5 ac (4.7 ha) of change from natural substrate to artificial substrate.	**Temporary to Short-term** **Permanent**	The degree of impact is **low:** - Habitat loss is minimal relative to area that would remain unaffected in lower Cook Inlet. - Habitat disturbance and displacement of EFH would range from temporary to short-term. - Artificial substrate would be colonized and provide habitat
Noise disturbance (Pipeline installation)	- Pipeline installation, placement of anchors, and marine vessels.	**Temporary**	The degree of impact is **low:** - Construction-related noise impacts are anticipated to be temporary, and fish would return to the habitat once the in-water noise has ceased.
Water quality (Pipeline installation)	- Potential increases in sediment load and turbidity.	**Temporary**	The degree of impact is **low:** - Managed species would avoid construction areas, followed by rapid post-construction return or re-colonization by these species. - Increase of sediment loads in the water column are expected to be temporary due to the high flushing in lower Cook Inlet.
Contaminant release (Incidental spills of petroleum lubricants and fuel, and loss of fluid from HDD)	- Potential incidental spills of petroleum lubricants and fuels in EFH, which are toxic to fish. - Potential temporary increase in turbidity or siltation from frac-out that could negatively impact habitat.	**Not Applicable**	The degree of impact is **negligible**: - Compliance with 40 CFR Part 110, and related to vessel-to-vessel transfers, including 33 CFR Part 155. - Implementation of spill prevention control measures would be included in construction operations. - Petroleum lubricants and fuel spills would be promptly cleaned up. - Implementation of HDD plan.

6 MITIGATIVE MEASURES

Listed below are measures specifically developed for construction activities, including NMFS development guidelines (Limpinsel et al. 2017), that would be implemented by PLP during construction of the Project to minimize impacts to EFH.

6.1 Mining

- PLP will develop a plan to prevent fish passage into habitats proposed for removal prior to construction.
- Necessary in-water activities will be scheduled when the fewest species/least vulnerable life stages of federally managed species will be present, or consistent with permit stipulations.
- Spillage of dirt, fuel, oil, toxic materials, and other contaminants into EFH will be minimized through the preparation of spill prevention plans, as appropriate.
- Wastewater will be recycled and treated prior to discharge to streams. Wastewater will be tested before discharge for compliance with federal and state clean water standards.
- Effects of sedimentation on fish habitat will be minimized through implementation of required stormwater management plans and BMPs.
- Restore natural contours and use native vegetation to stabilize and restore habitat function to the extent practicable. Restoration sites will be monitored for an appropriate time to evaluate performance and implement corrective measures, if necessary.
- The aerial extent of ground disturbance will be minimized (e.g., through phasing of operations, and design). Disturbed lands will be stabilized to reduce erosion.

6.2 Road Building and Maintenance

- Where reasonable bridges rather than culverts for stream crossings were proposed. Culverts will be sized, constructed, and maintained to match the gradient and width of the stream to accommodate design flood flows, and large enough to provide for migratory passage of adult and juvenile fishes. Culvert design will use, as appropriate, the NMFS Northwest Region's Anadromous Salmonid Passage Facility Design (NMFS 2011) or the culvert guidelines contained in the ADF&G and ADOT&PF Fish Passage Memorandum of Agreement (ADF&G and ADOT&PF 2001).
- Bridge abutments will be designed to minimize disturbances to stream banks and placed outside of the floodplain whenever possible.
- Erosion control measures will be specified in road construction plans as applicable.
- Side-casting of road materials will be avoided on native surfaces and into streams.
- Native vegetation will be used in stabilization plantings.

- Seasonal restrictions will be used on instream activities to avoid impacts to habitat during species critical life stages (e.g., spawning and egg development periods), as required by permit stipulations.
- Water diversion methods, under the guidance of the ADF&G, could be employed were in-stream work could obstruct passage of fish for longer than 48 hours. Juvenile and adult fish passage facilities would be incorporated on all water diversion projects (e.g., fish bypass systems) as required by permit.
- Roadways and associated stormwater collection systems will be properly maintain as required by stormwater management plans and design requirements.

6.3 Material Sites

- Materials sites will include a reclamation plan and be restored as appropriate prior to closure.

6.4 Water Use

- Water diversion and impoundment projects will be designed to create flow conditions that provide for adequate fish passage, particularly during critical life stages. Low water levels that strand juveniles and dewater redds will be avoided unless authorized by water use permits. Juvenile and adult fish passage facilities will be incorporated on all water diversion projects (e.g., fish bypass systems) as required by permit. Screens at water diversions on fish-bearing streams will be installed, as needed.
- Water quality necessary to support fish populations will be maintained by monitoring and adjusting water temperature, sediment loads, and pollution levels in compliance with APDES.
- Appropriate flow velocity and water levels to support continued stream functions will be maintained consistent with water use authorization.

6.5 Discharge of Fill Material

- Fill materials will be tested and be within the neutral range of 7.5 to 8.4 pH. In marine waters, this pH range will maximize colonization of marine organisms. Excessively alkaline or acidic fill material will not be used. Only clean fill will be used.

6.6 Vessel Operations, Transportation and Navigation

- Riparian buffers will be left in place to help maintain water quality and nutrient input, where practicable.
- Vessels will be operated at sufficiently low speeds to reduce wake energy, and no-wake zones will be designated near sensitive habitats.
- BMPs will be implemented to prevent or minimize contamination from ship bilge waters, accidents, shipyard work, and nonpoint source contaminants from upland facilities related to vessel operations and navigation.

- Mooring buoys will be in waters deep enough to avoid grounding and to minimize the effects of prop wash. Subsurface floats or other methods will be used to prevent contact of the anchor line with the substrate.
- Catchment basins will be used for collecting and storing surface runoff from upland repair facilities, parking lots, and other impervious surfaces to remove contaminants prior to delivery to any receiving waters.
- The terminal at Amakdedori and the north and south lake terminals will be designed to include practical measures for reducing, containing, and cleaning up petroleum spills.
- Oil spill response equipment will be staged at strategic locations.

6.7 Pile Driving

Common measures to reduce the underwater sound generated by in-water pile driving will include treatments to reduce the transmission of sound through the water and treatments to reduce the sound generated by pile driving (CA DoT 2015). Conservation measures to prevent and minimize negative impacts of pile driving to EFH and to promote the conservation, enhancement, and proper functioning of EFH include:

- When impact hammers are required due to seismic stability or substrate type, drive the pile as deep as possible with a vibratory hammer first and then use the impact hammer to drive the pile to its final position.

Implement measures to attenuate the sound from impact hammer use should expected levels exceed the interim criteria thresholds: when peak SPLs reach 206 dB re 1 μPa during a single strike and/or when the accumulated SEL from multiple strikes reaches 187 dB re 1 μPa for large fishes (≥2 g [0.07 oz]) or 183 dB re 1 μPa for small fishes (< 2 g [0.07 oz]). If sound levels are anticipated to exceed these acceptable limits, implement appropriate mitigation measures, when practicable. Methods to reduce the SPLs and SELs include, but are not limited to, the following:

- Because the sound produced has a direct relationship to the force used to drive the pile, use a smaller hammer to reduce sound pressure.
- Use a hydraulic hammer if impact driving cannot be avoided. The force of the hammer blow can be controlled with hydraulic hammers; reducing the impact force will reduce the intensity of the resulting sound.
- Use bubble curtains or other sound attenuation devices to reduce the acoustical footprint.

6.8 Pipeline Installation

- HDD methods to bury the natural gas pipeline will be used on steep erodible bluff areas adjacent to the intertidal zone, as practicable.
- Excavated wetlands will be backfilled with either the same or comparable material capable of supporting similar wetland vegetation. Impacted sites will be restored to original marsh elevations. Topsoil and organic surface material, such as root mats, will be segregated as practicable and

returned to the surface of the restored site. After backfilling, erosion control BMPs will be implemented as needed.

- The pipeline will be buried in areas where scouring or wave activity may expose it.
- Inactive pipelines that remain in place, will be properly pigged, purged, filled with seawater, and capped.
- Install silt curtains or other barriers whenever possible to reduce turbidity and sedimentation near the project site.
- Suspend transmission lines beneath existing bridges or conduct directional boring under streams to reduce the environmental impact, as practical.

6.9 Invasive Species

- Uphold fish and game regulations of the Alaska Board of Fisheries (AS 16.05.251) and Board of Game (AS 16.05.255) which prohibit and regulate the live capture, possession, transport, or release of native or exotic fish or their eggs.
- Adhere to regulations and use BMPs outlined in the State of Alaska Aquatic Nuisance Species Management Plan (ADF&G 2002a) and Management Plan for Invasive Northern Pike in Alaska (ADF&G 2007a).
- Require vessels brought from other areas over land via trailer to clean any surfaces (e.g., propellers, hulls, anchors, fenders) that may harbor non-native plant or animal species. Bilges should be emptied and cleaned thoroughly by using hot water or a mild bleach solution. These activities should be performed in an upland area to prevent the introduction of non-native species during the cleaning process.

6.10 Compensatory Mitigation Plan

PLP has prepared a Draft Compensatory Mitigation Plan (CMP) to fulfill the requirements established by the USACE regulations (33 CFR 320.4(r) and 40 CFR 230). The plan includes a framework for selecting aquatic resource mitigation projects that will primarily focus on opportunities that benefit water quality and enhance or restore fish habitat. This framework has the potential to enhance or benefit EFH. Future revisions of the CMP will include detailed information on specific mitigation plans.

7 CONCLUSIONS

Potential impacts to EFH in freshwater and marine ecosystems from the Pebble Project are discussed in Section 5.0. Construction of the project would result in impacts to EFH with the degree of impact ranging from low to moderate and duration ranging from temporary to permanent for loss of habitat, blasting, water flow, water quality, and noise. No impact, or negligible effect, to EFH is anticipated from contaminant release resulting from potential spills of petroleum oil and lubricants, and invasive species. Impact types evaluated in this EFH, and the degree of impact and duration are summarized in Table 7-1.

Table 7-1: EFH impacts evaluation summary for the Pebble Project.

Project Component	Impacts Type	Degree of Impact	Duration			
			Temporary	Short-term	Long-Term	Permanent
FRESHWATER ECOSYSTEM						
Mine Site	Loss of habitat	Moderate	--	--	--	✓
	Blasting	Low	✓	--	--	--
	Water flow	Low	--	--	--	✓
	Water temperature	Low	--	--	--	✓
	Water quality	Low	--	--	✓	--
	Contaminant release	Negligible	--	--	--	--
Transportation Corridor	**Roads**					
	Fish Passage and habitat loss	Low	✓	✓	--	--
	Water use	Low	✓	--	--	--
	Water quality	Low	✓	--	--	--
	Blasting	Low	✓	--	--	--
	Contaminant release	Negligible	--	--	--	--
	Material source development	Negligible	--	--	--	--
	Invasive species	Negligible	--	--	--	--
	Ferry terminals					
	Loss of habitat	Moderate	--	✓	--	✓
	Noise disturbance	Low	✓	--	--	--
	Blasting	Low	✓	--	--	--
	Water quality	Low	✓	--	--	--
	Contaminant release	Negligible	--	--	--	--

Project Component	Impacts Type	Degree of Impact	Duration			
			Temporary	Short-term	Long-Term	Permanent
Natural Gas Pipeline and Fiber Optic Cable	Loss of habitat	Low	✓	✓	--	--
	Water use	Low	✓	--	--	--
	Water quality	Low	✓	--	--	--
	Contaminant release	Negligible	--	--	--	--
	Blasting	Low	✓	--	--	--
MARINE ECOSYSTEM						
Amakdedori Port	Loss of habitat (Amakdedori Port)	Moderate	--	✓	--	✓
	Loss of habitat (Spread Anchor Mooring Systems)	Low	✓	✓	--	✓
	Noise disturbance	Low	✓	✓	--	--
	Water Quality	Low	✓	--	--	--
	Contaminant release	Negligible	--	--	--	--
	Invasive species	Negligible	--	--	--	--
Natural Gas Pipeline and Fiber Optic Cable	Loss of habitat	Low	✓	✓	--	✓
	Noise disturbance	Low	✓	--	--	--
	Water Quality	Low	✓	--	--	--
	Contaminant release	Negligible	--	--	--	--

7.1 USACE Effect Determination

The majority of Project impacts to EFH evaluated in this assessment would result in a low degree of impact, including those that may result in disturbance or displacement of managed species, but mortalities are unlikely and EFH characteristics would return to normal shortly after the activity ceases, or in the short term. These effects would be further reduced by implementation of mitigative measures presented in Section 6.0 and compliance with environmental guidelines and permit conditions placed on the Project. Other potential impacts would result in a negligible degree of impact considering compliance with regulatory guidelines. Discharges of fill for construction of the mine site, ferry terminals, and Amakdedori Port would result in permanent removal of EFH. This loss of EFH is minimal relative to area that would remain undisturbed. Furthermore, habitat removed is generally of low biological importance. Based upon the project design, the temporary and short-term duration of impacts, minimal permanent impacts, and the proposed conservation measures, **the U.S. Army Corps of Engineers has determined the Project may adversely affect EFH**.

8 REFERENCES

Abookire, A, J.F. Piatt, B.L. Norcross. 2001. Juvenile groundfish habitat in Kachemak Bay, Alaska, during late summer. Alaska Fishery Research Bulletin 8(1):45-56.

Abookire, A. A. and B. J. Macewicz. 2003. Latitudinal variation in reproductive biology and growth of female Dover sole (Microstomus pacificus) in the North Pacific, with emphasis on the Gulf of Alaska stock. J. Sea Res. 50: 187-197.

Abookire, A.A. 2006. Reproductive biology, spawning season, and growth of female rex sole (*Glyptocephalus zachirus*) in the Gulf of Alaska. Fish. Bull. 104: 350-359.

Abookire, A.A. and K.M. Bailey. 2007. The distribution of life cycle stages of two deep-water pleuronectids, Dover sole (*Microstomus pacificus*) and rex sole (*Glyptocephalus zachirus*), at the northern extent of their range in the Gulf of Alaska. J. Sea Res. 57:198-208.

Abookire, A.A., J.T. Duffy-Anderson, and C.M. Jump. 2007. Habitat associations and diet of young-of-the-year Pacific cod (*Gadus macrocephalus*) near Kodiak, Alaska. Marine Biology 150:713-726.

Ainley, D.G., W.J. Sydeman., R.H. Parrish., and W.H. Lenarz. 1993. Oceanic factors influencing distribution of young rockfish (Sebastes) in central California: A predator's perspective. CalCOFI Report 34: 133-139.

Alaska Department of Environmental Conservation (ADEC). 2012. 18 AAC 70 Water quality standards as amended of April 8, 2012. Alaska Department of Environmental Conservation. Division of Water. Juneau, AK. Available at: http://dec.alaska.gov/water/wqsar/wqs/index.htm accessed on August 14, 2018.

Alaska Department of Fish and Game (ADF&G). 2002a. Aquatic Nuisance Species Management Plan. 55 p.

Alaska Department of Fish and Game (ADF&G). 2002b. Kamishak Bay Herring Data Synthesis, Version 1.0a. CD-ROM. Division of Commercial Fisheries. Homer, Alaska.

Alaska Department of Fish and Game (ADF&G). 2005. Species Descriptions: Capelin. www.adfg.alaska.gov/static/species/speciesinfo/_aknhp/Capelin_AKNHP.pdf. Accessed 10/26/2015.

Alaska Department of Fish and Game (ADF&G). 2007a. Southcentral Alaska Northern Pike Control Committee. Management Plan for Invasive Northern Pike in Alaska. 58 p.

Alaska Department of Fish and Game (ADF&G). 2007b. Wildlife Notebook Series. coho Salmon Species Profile.

Alaska Department of Fish and Game (ADF&G). 2014. Sockeye Salmon (Oncorhynclus nerka) Species Profile. https://www.adfg.alaska.gov/index.cfm?adfg=sockeyesalmon.main

Alaska Department of Fish and Game (ADF&G) and Alaska Department of Transportation and Public Facilities (ADOT&PF). 2001. Memorandum of Agreement between the Alaska Department of Fish and Game and Alaska Department of Transportation and Public Facilities for the Design, Permitting, and Construction of Culverts for Fish Passage. August 2001. 33 p.

Allen, M.J., and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the BS and northeastern Pacific. U.S. Dep. Commer., NOAA Tech. Rept. NMFS 66, 151 p.

Alton, M.S., and T.M. Sample. 1976. Rock sole (Family Pleuronectidae) p. 461-474. *In*: Demersal fish and shellfish resources in the BS in the baseline year 1975. Principal investigators Walter T. Pereyra, Jerry E. Reeves, and Richard Bakkala. U.S. Dep. Comm., Natl. Oceanic Atmos. Admin., Natl. Mar. Serv., Northwest and Alaska Fish Center, Seattle, WA. Processed Rep., 619 p.

Archibald, C.P., W. Shaw, and B.M. Leaman. 1981. Growth and mortality estimates of rockfishes (Scorpaenidae) from B.C. coastal waters, 1977-79. Can. Tech. Rep. Fish. Aquat. Sci. 1048, 57 p.

Armistead, C.E., and D.G. Nichol. 1993. 1990 Bottom Trawl Survey of the EBS Continental Shelf. U.S. Dep. Commer., NOAA Tech. Mem. NMFS-AFSC-7, 190 p.

Aydin, K., S. Gaichas, I. Ortiz, D. Kinzey, and N. Friday. 2007. A comparison of the Bering Sea, Gulf of Alaska, and Aleutian Islands large marine ecosystems through food web modeling. NOAA NMFS Tech Memo, NMFS-AFSC-178. 298 p.

Bash J., Berman C., and S. Bolton. 2001. Effects of Turbidity and Suspended Solids on Salmonids. Center for Streamside Studies. Univ. of Washington, Seattle. November 2001.

Brodeur, R.D. 2001. Habitat-specific distribution of Pacific ocean perch (*Sebastes alutus*) in Pribilof Canyon, BS. Cont. Shelf Res. 21: 207-224.

Buckley, T.W., G.E. Tyler, D.M. Smith and P.A. Livingston. 1999. Food habits of some commercially important groundfish off the costs of California, Oregon, Washington, and British Columbia. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-102, 173 p.

Buhl, K. J. and S. J. Hamilton. 1991. Relative sensitivity of early life stages of arctic grayling, coho salmon, and rainbow trout to nine inorganics. Ecotoxicology and Environmental Safety 22:184-197.

California Department of Transportation (CADoT). 2015. Technical guidance for assessment and mitigation of the hydroacoustic effects of pile driving on fish. Report no. CTHWANP-RT-15-306.01.01. Division of Environmental Analysis, California Department of Transportation, Sacramento, California.

Carlson, H.R., and R.E. Haight. 1976. Juvenile life of Pacific ocean perch, *Sebastes alutus*, in coastal fiords of southeast Alaska: their environment, growth, food habits, and schooling behavior. Trans. Am. Fish. Soc. 105:191-201.

Carlson, H.R., and R.R. Straty. 1981. Habitat and nursery grounds of Pacific rockfish, *Sebastes* spp., in rocky coastal areas of Southeast Alaska. Mar. Fish. Rev. 43: 13-19.

Casper, B.M., F.M. Matthews, M.B. Halvorsen, T.J. Carlson, and A.N. Popper. 2011. Recovery from exposure to pile driving signals by Chinook salmon. J. Acoust. Soc. Am. 129(4):2436.

Chambers, D., R. Moran, and L. Trasky. 2012. Bristol Bay's wild salmon ecosystems and the Pebble Mine: key considerations for a large-scale mine proposal. Wild Salmon Center and Trout Unlimited.

Chilton, D.E., and R.J. Beamish. 1982. Age determination methods for fishes studied by the Groundfish Program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60, 102 p.

Christie, D., E. Allen, and G. J. Jobsis. 1993. Diversions. In Bryan, C.F. and D.A. Rutherford eds. Impacts on warm water streams: Guidelines for evaluation. 181-186 p. Southern Division, American Fisheries Society, Little Rock, AR.

Clausen, D.M. 2007. Shortraker rockfish and other slope rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the GOA, p. 735-780. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99501.

Clausen, D.M., and J.T. Fujioka. 2007. Variability in trawl survey catches of Pacific ocean perch, shortraker rockfish, and rougheye rockfish in the Gulf of Alaska. In J. Heifetz, J. DiCosimo, A.J. Gharrett, M.S. Love, V.M. O'Connell, and R.D. Stanley (editors), Biology, assessment, and management of North Pacific rockfishes, p. 411-428. Alaska Sea Grant, Univ. of Alaska Fairbanks.

Clausen, D.M., and J. Heifetz. 2002. The northern rockfish, *Sebastes polyspinis*, in Alaska: commercial fishery, distribution, and biology. Mar. Fish. Rev. 64(4): 1-28.

Clausen, D.M., J.T. Fujioka, and J. Heifetz. 2003. Shortraker/rougheye and other slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the GOA, p. 531-572. Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Conners, M.E. and E. Jorgensen. 2008. Octopus Complex in the Gulf of Alaska. In: Stock assessment and fishery evaluation report for the groundfish resources in Gulf of Alaska. North Pac. Fish. Mgmt. Council, Anchorage, AK.

Demory R. L., R. F. Orrell, D. R. Heinle. 1964. Spawning ground catalog of the Kvichak River system, Bristol Bay, Alaska. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. No. 488.

Doyle, M. J., Busby, M. S., Duffy-Anderson, J. T., Picquelle, S. J., and Matarese, A. C. 2002. Early life history of capelin (*Mallotus villosus*) in the northwest Gulf of Alaska: a historical perspective based on larval collections, October 1977–March 1979. ICES Journal of Marine Science, 59: 997–1005.

Elison, T., P. Salomone, T. Sands, G. Buck, K. Sechrist and D. Koster. 2018. 2017 Bristol Bay Area Annual Management Report. Fishery Management Report No. 18-11. Division of Sport Fish, Research and Technical Services. Alaska Department of Fish and Game. Anchorage, AK

Environmental Protection Agency [EPA]. 2018 Compensatory Mitigation for Looses of Aquatic Resources guidelines.

Eschmeyer, W.N., E.S. Herald, and H. Hammann. 1983. A field guide to Pacific fishes of North America from the Gulf of Alaska to Baja California. Boston: Houghton Mifflin.

Fadeev, N.W. 1965. Comparative outline of the biology of fishes in the southeastern part of the Bering Sea and condition of their resources. [In Russ.] Tr. Vses. Nauchno-issled. Inst.Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled Inst. Morsk. Rybn. Khoz. Okeanogr. 53):121-138. (Trans. By Isr. Prog. Sci. Transl., 1968), p 112-129. In P.A. Moiseev (Editor), Soviet Fisheries Investigations in the northeastern Pacific, Pt. IV. Avail. Natl. Tech. Inf. Serv., Springfield, Va. As TT 67-51206.

Fajen, O.F. and J.B. Layzer. 1993. Agricultural practices. In Bryan, C.F. and D.A. Rutherford, eds. Impacts on warmwater streams: Guidelines for evaluation. 257-267 p. Southern Division, American Fisheries Society. Little Rock, AR.

Fisheries Hydroacoustic Working Group (FHWG). 2008. Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities. June 11, 2008 Memorandum from the Technical/Policy Meeting, Vancouver, Washington.

Forrester, C.R. 1964. Demersal Quality of fertilized eggs of rock sole. J. Fish. Res. Bd. Canada, 21(6), 1964. P. 1531.

Forrester, C.R., and J.A. Thompson. 1969. Population studies on the rock sole, *Lepidopsetta bilineata*, of northern Hecate Strait British Columbia. Fish. Res. Bd. Canada, Tech. Rep. No. 108, 1969. 104 p.

Freese, J.L., and B.L. Wing. 2003. Juvenile red rockfish, *Sebastes* sp., associations with sponges in the Gulf of Alaska. Mar. Fish. Rev. 65(3): 38-42.

GeoEngineers. 2018a. 2018 Fisheries Studies Data Summary Report. Port Alternatives and Transportation Studies Amakdedori Beach; Third Party EIS Support Southcentral Alaska. File No. 22802-001-01. Redmond, WA.

GeoEngineers. 2018b. 2018 Synthesis of Nearshore Habitats of Current and Proposed Port Alternatives for the Pebble Mine Project, Cook Inlet Alaska. Prepared for Pebble Limited Partnership. October 5, 2018.

Gharrett, A.J., Z. Li, C.M. Kondzela, and A.W. Kendall. 2002. Final report: species of rockfish (*Sebastes* spp.) collected during ABL-OCC cruises in the GOA in 1998-2002. (Unpubl. manuscr. available from the NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau AK 99801.)

Goldstein, J. N., D. F. Woodward, and A. M. Farag. 1999. Movements of adult Chinook salmon during spawning migration in a metals-contaminated system, Coeur d'Alene River, Idaho. Transactions of the American Fisheries Society 128:121-129.

Gray, A.K., A.W. Kendall, B.L. Wing, M.G. Carls, J. Heifetz, Z. Li, and A.J. Gharrett. 2006. Identification and first documentation of larval rockfishes in Southeast Alaskan waters was possible using mitochondrial markers but not pigmentation patterns. Trans. Am. Fish. Soc. 135: 1-11.

Gregory, R.S. 1992. The influence of ontogeny, perceived risk of predation, and visual ability on the foraging behavior of juvenile Chinook salmon. Theory and Application of Fish Feeding Ecology 18: 271-284.

Gustafson, R.L., and W.R. Bechtol. 2005. Kachemak Bay small-mesh trawl survey, 2000. Alaska Department of Fish and Game, Fishery Data Series No. 05-54, Anchorage, AK.

Hanselman, D.H., T.J. Quinn., II, J. Heifetz., D. Clausen., and C. Lunsford. 2001. Spatial inferences from adaptive cluster sampling of GOA rockfish. *In* Spatial Processes and Management of Marine Populations. University of Alaska Sea Grant, PO Box 755040 203 O'Neill Bldg. Fairbanks AK 99775-5040, http //www.uaf.alaska.edu/seagrant/.

Harrison, R.C. 1993. Data report: 1991 bottom trawl survey of the Aleutian Islands area. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-12, 144 p.

Hart, J.L. 1942. New Item. Red snapper fecundity. Fish. Res. Board. Can. Pac. Progr. Rep. 52: 18.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Canada, Bull. No. 180. 740 p.

Hart Crowser. 2018a. 2013 Pebble Data Synthesis – Amakdedori Beach and Iliamna Lake. Technical memorandum to Tim Havey, Pebble Limited Partnership, Anchorage, AK. 25 p.

Hart Crowser. 2018b. 2017 Data Report Amakdedori and Iliamna Lake Field Studies. Technical Report to Pebble Limited Partnership, Anchorage, AK. 85 p.

Hastings, M. C., and A. N. Popper. 2005. Effects of sound on fish. Prepared for the California Department of Transportation by Jones & Stokes, Sacramento, California.

Healey, M.C. 1991. Life history of Chinook salmon (Oncorhynchus tshawytscha). In: C. Groot and L Margolis (eds.). Pacific Salmon Life Histories. UBC Press. Vancouver, British Columbia p. 311-393.

Heifetz, J., D. Hanselman, D. Courtney, and J. Ianelli. 2007. Gulf of Alaska northern rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 623-674. Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Hirschberger, W.A., and G.B. Smith. 1983. Spawning of twelve groundfish species in the Alaska and Pacific coast regions. 50 p. NOAA Tech. Mem. NMFS F/NWC-44. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Hollowell, G., E.O. Otis, and E. Ford. 2016. 2015 Lower Cook Inlet finfish management report. Fishery Management Report No. 16-19. Division of Sport Fish, Research and Technical Services. Alaska Department of Fish and Game. Anchorage, AK.

Hosie, M.J. 1976. The arrowtooth flounder. Oregon Dep. Fish. Wildl. Info. Rep. 76-3, 4 p.

Hosie, M.J., and H.F. Horton. 1977. Biology of the rex sole, *Glyptocephalus zachirus*, in waters off Oregon. Fish. Bull. Vol. 75, No. 1, 1977, p. 51-60.

Hunter, J.R., J.L. Butler, C.A. Kimbrell, and E.A. Lynn. 1990. Bathymetric patterns in size, age, sexual maturity, water content, caloric density of Dover sole, *Microstomus pacificus*. CALCOFI Rep., Vol. 31, 1990.

Hutchinson, C.E. 2004. Using radioisotopes in the age determination of shortraker (*Sebastes borealis*) and canary (*Sebastes pinniger*) rockfish. Master's Thesis. Univ. Washington, Seattle. 84 p.

Ito, D.H. 1999. Assessing shortraker and rougheye rockfishes in the GOA: addressing a problem of habitat specificity and sampling capability. PhD. Dissertation. Univ. Washington, Seattle. 205 p.

Jacobson, K.C., M.R. Arkoosh, A.N. Kagley, E.R. Clemons, T.K. Collier, and E. Casillas. 2003. Cumulative effects of natural and anthropogenic stress on immune function and disease resistance in juvenile Chinook salmon. Journal of Aquatic Animal Health 15:1-12.

Jacobson, L.D., and J.R. Hunter. 1993. Bathymetric Demography and Management of Dover Sole. NAJFM 13:405-420. 1993.

Johnson, J. and B. Blossom 2017. Catalog of waters important for spawning, rearing, or migration of anadromous fishes - Southwestern Region, Effective June 1, 2017. Alaska Department of Fish and Game, Special Publication No. 17-05, Anchorage.

Kendall, A.W. 1989. Additions to knowledge of *Sebastes* larvae through recent rearing. NWAFC Proc. Rept. 89-21. 46 p.

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. NOAA Tech. Rep. NMFS 20, U.S. Dep. Commer, NOAA, Natl. Mar. Fish. Serv.

Kendall, A.W., and W.H. Lenarz. 1986. Status of early life history studies of northeast Pacific rockfishes. Proc. Int. Rockfish Symp. Oct. 1986, Anchorage Alaska; p. 99-117.

Kerns, O.R., and Donaldson, J.R. 1968. Behavior and distribution of spawning sockeye salmon on island beaches in Iliamna Lake, Alaska, 1965. J. Fish. Res. Board Can. 25: 485–494.Leonetti 1996.

Knight Piésold Consulting. 2018a. Pebble mine site operations water management plan. 63 p.

Knight Piésold Consulting. July 11, 2018b. Pebble Project: RF019 Part 2 Streamflow Reductions at End of Mine Life Excluding Water Treatment Plant Discharges.

Kolden, K. D., and C. Aimone-Martin. 2013. Blasting effects on salmonids. Prepared by Alaska Seismic and Environmental, LLC and Aimone-Martin Associates, LLC for Alaska Dept. of Fish and Game. Juneau, AK. 31 p.

Kondzela, C.M., A.W. Kendall, Z. Li, D.M. Clausen, and A.J. Gharrett. 2007. Preliminary identification of pelagic juvenile rockfishes collected in the Gulf of Alaska. In J. Heifetz, J. DiCosimo, A.J. Gharrett, M.S. Love, V.M. O'Connell, and R.D. Stanley (editors), Biology, assessment, and management of North Pacific rockfishes, p. 153-166. Alaska Sea Grant, Univ. of Alaska Fairbanks.

Kramer, D.E., and V.M. O'Connell. 1988. A Guide to Northeast Pacific Rockfishes: Genera Sebastes and Sebastolobus. In: Alaska Sea Grant Advisory Bulletin, 25. In National Marine Fisheries Service 2001(a).

Krieger, K. 1992. Shortraker rockfish, *Sebastes borealis*, observed from a manned submersible. Mar. Fish. Rev., 54(4): 34-37.

Krieger, K.J. 1993. Distribution and abundance of rockfish determined from a submersible and by bottom trawling. Fish. Bull., U.S. 91:87-96.

Krieger, K.J., and D.H. Ito. 1999. Distribution and abundance of shortraker rockfish, *Sebastes borealis*, and rougheye rockfish, *Sebastes aleutianus*, determined from a manned submersible. Fish. Bull. 97: 264-272.

Krieger, K.J., and B.L. Wing. 2002. Megafauna associations with deepwater corals (*Primnoa* spp.) in the GOA. Hydrobiologia 471: 83-90.

Leaman, B.M. 1991. Reproductive styles and life history variables relative to exploitation and management of Sebastes stocks. Environmental Biology of Fishes 30: 253-271.

Lewis-Russ, A. 1997. Groundwater quality. Pages 162-165 in J.J. Marcus, editor. Mining environmental handbook: effects of mining on the environment and American environmental controls on mining. Imperial College Press, London, England.

Li, Z., A.K. Gray, M.S. Love, A. Goto, T. Asahida, and A.J. Gharrett. 2006. A key to selected rockfishes (*Sebastes* spp.) based on mitochondrial DNA restriction fragment analysis. Fish. Bull. 104: 182-196.

Limpinsel, D. E., Eagleton, M. P., and Hanson, J. L, 2017. Impacts to Essential Fish Habitat from Non-Fishing Activities in Alaska. EFH 5 Year Review: 2010 through 2015. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/AKR-14, 229 p.

Love, M.S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the northeast Pacific. U. of Calif. Press, Berkeley. 405 p.

Maloney, N. E. 2004. Sablefish, *Anoplopoma fimbria*, populations on Gulf of Alaska seamounts. Mar. Fish. Rev. 66(3): 1-12.

Markle, D.F., Harris, P, and C. Toole. 1992. Metamorphosis and an overview of early-life-history stages in Dover sole *Microstomus pacificus*. Fish. Bull. 90:285-301.

Martin, M.H., and D.M. Clausen. 1995. Data report: 1993 GOA Bottom Trawl Survey. U.S. Dept. Commer., NOAA, Natl. Mar. Fish. Serv., NOAA Tech. Mem. NMFS-AFSC-59, 217 p. Mecklenburg, C.W., T.A. Mecklenburg, and L.K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society, Bethesda, MD. 1037 p.

Matarese, A.C., A.W. Kendall, Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of Northeast Pacific fishes. U.S. Dep. Commer. NOAA Tech. Rept. NMFS 80, 652 p.

Matthews, K.R., J.R. Candy, L.J. Richards, and C.M. Hand. 1989. Experimental gill net fishing on trawlable and untrawlable areas off northwestern Vancouver Island, from the MV Caledonian, August 15-28, 1989. Can. Manuscr. Rep. Fish. Aquat. Sci. 2046, 78 p.

McDermott, S.F. 1994. Reproductive biology of rougheye and shortraker rockfish, *Sebastes aleutianus* and *Sebastes borealis*. Masters Thesis. Univ. Washington, Seattle.76 p.

Mecklenburg, C.W., T.A. Mecklenburg, and L.K. Thorsteinson. 2002. Fishes of Alaska. Am. Fish. Soc., Bethesda, Maryland. 1037 p.

Michel, J., A.C. Bejarano, C.H. Peterson, and C. Voss. 2013. Review of biological and biophysical impacts from dredging and handling of offshore sand. OCS Study BOEM 2013-0119. U.S. Department of the Interior of Ocean Energy Management, Herndon, Virginia.

Miller, D.J., and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dep. Fish. Game, Fish. Bull. 157, 235 p.

Moulton, L.L. 1997. Early marine residence, growth, and feeding by juvenile salmon in northern Cook Inlet. Alaska Fisheries Research Bulletin 4(2):154-177.

Moulton, L.L. and D. Penttila. 2001. Field manual for sampling forage fish spawn in intertidal shore regions. San Juan County Forage Fish Assessment Project. 23 p.

Munk, K.M. 2001. Maximum ages of groundfishes off Alaska and British Columbia and considerations of age determination. Alaska Fish. Res. Bull. 8(1): 12-21.

Musienko, L.N. 1963. Ichthyoplankton of the BS (data of the BS expedition of 1958-59). Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 50)239-269. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 251-286. In P. A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part I. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT67-51203.

National Marine Fisheries Services (NMFS). 2005. Final Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska. Alaska Region.

National Marine Fisheries Service (NMFS). 2011. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon. 138 p.

Nelson, B.D., and T.J. Quinn. 1987. Population parameters of rougheye rockfish (*Sebastes aleutianus*). In Proc. Int. Rockfish Symp. pp. 209-228. Univ. Alaska Sea Grant Report No. 87-2. Anchorage, AK.

Norcross, B.L., B.A. Holladay, S.C. Dressel, and M. Frandsen. 1996. Recruitment of juvenile flatfishes in Alaska: habitat preference near Kodiak Island. U. Alaska Coastal Marine Institute, OCS Study MMS 96-0003, Vol. 1. NPFMC. 2017.

North Pacific Fishery Management Council (NPFMC). 2018a. Fishery Management Plan for Groundfish of the Gulf of Alaska. North Pacific Fishery Management Council. Anchorage, Alaska. 129 pages. Accessed on 8/14/2018. https://www.npfmc.org/wp-content/PDFdocuments/fmp/BSAI/BSAIfmp.pdf

North Pacific Fishery Management Council (NPFMC). 2018b. Fishery Management Plan for Groundfish of the Gulf of Alaska Appendices. North Pacific Fishery Management Council. Anchorage, Alaska.

North Pacific Fishery Management Council (NPFMC). 2012. Fishery Management Plan for the Salmon Fisheries in the EEZ off Alaska. North Pacific Fishery Management Council, Anchorage, Alaska. 59 pages. Accessed on 8/14/2018. https://www.npfmc.org/wpcontent/PDFdocuments/fmp/Salmon/SalmonFMPfinal1212.pdf.

North Pacific Fishery Management Council (NPFMC). 2014. Fishery Management Plan for the Scallop Fishery off Alaska. North Pacific Fishery Management Council. Anchorage, Alaska. 175 pages. Accessed on 8/14/2018. https://www.npfmc.org/wp-content/PDFdocuments/fmp/Scallop/ScallopFMP2014.pdf.

O'Connell, V.M., and D.C Carlile. 1993. Habitat-specific density of adult yelloweye rockfish Sebastes ruberrimus in the eastern GOA. Fishery Bull. 91:304-309.

O'Connell, V.M., and J.T. Fujioka. 1991. Demersal Shelf Rockfishes. In Loh-Lee Low (ed.), Status of living marine resources off Alaska as assessed in 1991, p. 46-47. NOAA Tech. Memo. NMFS F/NWC-211, Northwest Fish. Sci. Cent., Auke Bay AK 95 P.

O'Connell, V.M., and F.C. Funk. 1987. Age and growth of yelloweye rockfish (*Sebastes ruberrimus*) landed in southeast Alaska. In B.R. Melteff (ed.), Proceedings of the International Rockfish Symposium. p 171-185. Alaska Sea Grant Report No. 87-2.

O'Connell, V.M., C.K. Brylinsky, and H.G. Greene. 2007. The use of geophysical survey data in fisheries management: a case history from Southeast Alaska. In Mapping the Seafloor for Habitat Characterization. p 319-328. Geological Association of Canada Special paper 47.

Olsen, J.C. 1968. Physical environment and egg development in a mainland beach area and an island beach area of Iliamna Lake. Pages 169-196. In: R.L. Burgner, editor. Further studies of Alaska sockeye salmon. University of Washington. Seattle.

Orlov, A. M. 2001. Ocean current patterns and aspects of life history of some northwestern Pacific scorpaenids. In: G. H. Kruse, N. Bez, A. Booth, M. W. Dorn, A. Hills, R. N. Lipcius, D. Pelletier, C. Roy, S. J. Smith, and D. Witherell (editors), Spatial processes and management of marine populations. Pub. No. AK-SG-01-02. Univ. Alaska Sea Grant College Program, Fairbanks AK.

Orr, J.W. and J.E. Blackburn. 2004. The dusky rockfishes (Teleostei: Scorpaeniformes) of the North Pacific Ocean: resurrection of *Sebastes variabilis* (Pallas, 1814) and a redescription of *Sebastes ciliatus* (Tilesius, 1813). Fish Bull., U.S. 1002:328-348.

Orr, J.W. and S. Hawkins. 2008. Species of the rougheye rockfish complex: resurrection of *Sebastes melanostictus* (Matsubara, 1934) and a redescription of *Sebastes aleutianus* (Jordan and Evermann, 1898) (Teleostei: Scorpaeniformes). Fisheries Bulletin. 106: 111-134.

Orr, J.W. and A.C. Matarese. 2000. Revision of the genus *Lepidopsetta* Gill, 1862 (Teleostei: Pleuronectidae) based on larval and adult morphology, with a description of a new species from the North Pacific Ocean and Bering Sea. Fish. Bull. 98:539-582 (2000).

Paradox NR. 2018a. Summary of 2018 Nearshore Fish Sampling in Iliamna Lake. Technical memorandum to Tim Havey, Pebble Limited Partnership, Anchorage, AK. 15 p.

Paradox NR. 2018b. Summary of 2018 Surveys of Adult Sockeye Salmon in Iliamna Lake. Technical memorandum to Tim Havey, Pebble Limited Partnership, Anchorage, AK. 13 p.

Paradox NR. 2018c. Review of Literature on Iliamna Lake. Technical memorandum to Tim Havey, Pebble Limited Partnership, Anchorage, AK. 41 p.

Pebble Limited Partnership (PLP). 2011. R2 Resource Consultants, Inc., HDR Alaska, Inc., EchoFish, Inter-Fluve, and Pacific Hydrologic, Inc. 2011. Pebble Project Environmental Baseline Document, 2004 through 2008. Chapter 15. Fish and Aquatic Invertebrates. Bristol Bay Drainages. R2 Resource Consultants, Inc. Anchorage, Alaska.

Pebble Limited Partnership (PLP). 2013. Pebble Project Environmental Baseline Document, 2004 through 2012. Chapter 43. Marine Fish and Invertebrates. Cook Inlet Drainages. Update August 2013.

Pebble Limited Partnership (PLP). 2018a. Pebble Project Supplemental Environmental Baseline Document, 2004 through 2008. Chapter 15. Fish and Aquatic Invertebrates. Bristol Bay Drainages. Update May 2018.

Pebble Limited Partnership (PLP). 2018b. Pebble Project: RFI089 Fish/Waterbody Crossings. Memo dated 1 October 2018.

Pebble Limited Partnership (PLP). 2018c. Pebble Project: RFI085 2018 Field Data/Biological Resources. Memo dated 3 October 2018.

Pentec. 2005. 2004-2005 Marine Fish and Benthos Studies – Port of Anchorage. Anchorage, Alaska. Prepared for Integrated Concepts and Research Corporation. #12618-01 Nov 15, 2005.

Penttila, D. 2007. Marine Forage Fishes in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-03. Published by Seattle District, U.W. Army Corps of Engineers, Seattle, Washington.

Pertseva-Ostroumova, T.A. 1961. The reproduction and development of far eastern flounders. (Transl. By Fish. Res. Bd. Can. 1967. Transl. Ser. 856, 1003 p.).

Porter, S.M. 2004.Temporal and spatial distribution and abundance of flathead sole (*Hippoglossoides elassodon*) eggs and larvae in the western Gulf of Alaska. Fish. Bull. 103:648-658.

Quast, J.C. and E.L. Hall. 1972. List of fishes of Alaska and adjacent waters with a guide to some of their literature. U.S. Dep. Commer. NOAA, Tech. Rep. NMFS SSRF-658, 48p.

Popper, A.M. 2006. What do we know about pile driving and fish? Proceedings of the 2005 International Conference on Ecology and Transportation. North Carolina State University, Raleigh, North Carolina. p. 26-28.

R2 Resource Consultants, Inc. 2018a. Fish densities by site for all reaches sample by HDR and R2 query 30 and 60. The Pebble Partnership, Inc. [Data files] PLP CUR13 Appx 30 FishDensityByHabHDR AllReaches 20180307.xlsx; PLP CUR13 Appx 60 FishAbundDensityR2 AllReaches 20180307.xlsx

R2 Resource Consultants, Inc. 2018b. Fish densities by site for all reaches sampled by HDR and R2 query 40 and 90. The Pebble Partnership, Inc. [Data files] Filenames: PLP CUR13 Appx 40 MCSCOCFishDensBySiteTypeHDR AllReaches 20180307.xlsx; PLP CUR13 Appx 90 MSIndex_FishDensByHabR2 08-09 All Reaches 20180307.xls

R2 Resource Consultants, Inc. 2018c. Response to RFI #47: Potential mine effects on water temperatures. 40 p.

R2 Resource Consultants, Inc. 2018d. Response to RFI #48: HABSYN

Reuter, R.F. 1999. Describing dusky rockfish (*Sebastes ciliatus*) habitat in the GOA using historical data. M.S. Thesis, Calif. State Univ., Hayward CA. 83 p.

Rickey, M.H. 1994. Maturity, spawning, and seasonal movement of arrowtooth flounder, *Atheresthes stomias*, off Washington. Fish. Bull. 93:127-138 (1995).

Salo, E.O. 1991. Life history of chum salmon (Oncorhynchus keta). In: C. Groot and L Margolis (eds.). Pacific Salmon Life Histories. UBC Press. Vancouver, British Columbia p. 23 1-309.

Schumacher, J.D., N.A. Bond, R.D. Brodeur, P.A. Livingston, J.M. Napp, and P.J. Stabeno. 2003. Climate change in the Southeastern Bering Sea and some consequences for biota. Pp. 17-40 in Large Marine Ecosystems of the World: Trends in Exploitation, Protection, and Research, G. Hempel, and K. Sherman, eds. Amsterdam: Elsevier Science.

Shotwell, S.K., D. Hanselman, and D. Clausen. 2007. Gulf of Alaska rougheye rockfish. *In* Stock assessment and fishery evaluation report for the groundfish fisheries of the Gulf of Alaska. North Pacific Fishery Management Council, 605 W 4th Avenue, Suite 306, Anchorage, AK 99510.

Shubnikov, D.A., and L.A. Lisovenko. 1964. Data on the biology of rock sole in the southeastern BS. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49 (Izv. Tikookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 51): 209-214. (Transl. In Soviet Fisheries Investigations in the Northeast Pacific, Part II, p. 220-226, by Israel Program Sci. Transl., 1968, available Natl. Tech. Inf. Serv., Springfield, VA, as TT 67-51204).

Shvetsov, F.G. 1978. Distribution and migrations of the rock sole, *Lepidopsetta bilineata*, in the regions of the Okhotsk Sea coast of Paramushir and Shumshu Islands. J. Ichthol., 18 (1), 56-62, 1978.

Sigler, M.F., T.L. Rutecki, D.L. Courtney, J.F. Karinen, and M.S. Yang. 2001. Young-of-the-year sablefish abundance, growth, and diet. Alaska Fisheries Research Bulletin 8(1): 57-70.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services Corp., Corvallis, OR. 356 pp. (Available from the NMFS Habitat Branch, Portland, OR).

Spromberg, J. A. and J. P. Meador. 2005. Relating results of chronic toxicity responses to population-level effects: modeling effects on wild Chinook salmon populations. Integrated Environmental Assessment and Management 1:9-21.

Stark, J.W. 2004. A comparison of the maturation and growth of female flathead sole in the central Gulf of Alaska and south-eastern Bering Sea. J. Fish. Biol. 64: 876-889.

Stark, J.W., and D. A. Somerton. 2002. Maturation, spawning and growth of rock soles off Kodiak Island in the GOA. J. Fish. Biology (2002) 61, 417-431.

Stockhauen, W.T., B.J. Turnock, M.E. Wilkins and M.H. Martin. 2007. 5. Gulf of Alaska Deepwater Flatfish. In: Appendix B Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. p 339-398. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Stockhausen, W.T., B. Matta, B.J. Turnock, M.E. Wilkins and M.H. Martin. 2007. 6. Gulf of Alaska Rex Sole Stock Assessment. *In* Appendix B: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. p 399-450. North Pac. Fish. Mgmt. Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Stockhausen, W.T., M.E. Wilkins and M.H. Martin. 2007. 8. Gulf of Alaska Flathead Sole Stock Assessment. . *In* Appendix B: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. p 505-562. North Pac. Fish. Mgmt. Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Tierney, K. B., D. H. Baldwin, T. J. Hara, P. S. Ross, N. L. Scholz, and C. J. Kennedy. 2010. Olfactory toxicity in fishes. Aquatic Toxicology 96:2-26.

Timothy, J. 2013. Alaska blasting standard for the proper protection of fish. Alaska Department of Fish and Game Habitat Division Technical Report 13-02. Douglas, AK.

Trombulak, S. C. and C. A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18-30.

Turnock, B.J., T.K. Wilderbuer, and E.S. Brown. 2002. Flatfish. In Appendix B Stock Assessment and Fishery Evaluation for Groundfish Resources of the GOA Region. Pages 169-197. Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Turnock, B.J., T.K. Wilderbuer, and E.S. Brown. 2009. Arrowtooth flounder. In Appendix B Stock Assessment and Fishery Evaluation Report for the groundfish resources of the GOA. Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

U.S. Army Corps of Engineers (USACE). 2008. Chemical Data Report, Anchorage Port Expansion Study, Anchorage Port Expansion, Anchorage, Alaska, NPDL WO#07-083, March 2008.

U.S. Environmental Protection Agency (USEPA). 2013. Final Issuance of National Pollution Discharge Elimination System (NPDES) Vessel General Permit (VSG) for Discharges Incidental to the Normal Operation of Vessel Fact Sheet.

Vetter, R.D., E.A. Lynn, M. Garza, and A.S. Costa. 1994. Depth zonation and metabolic adaptation in Dover sole, *Microstomus pacificus*, and other deep-living flatfishes: factors that affect the sole. Mar. Biol. (1994) 120:145-159.

Waldron, K.D., and B.M. Vinter. 1978. Ichthyoplankton of the EBS. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv. Seattle, WA, Processed rep., 88 p.

Washington Department of Fish and Wildlife (WDFW). 2015. Washington State Surf Smelt Fact Sheet. https://wdfw.wa.gov/publications/01219/wdfw01219.pdf. Accessed 10/20/2018.

Weber-Scannell, P. K. 1991. Influence of temperature on freshwater fishes: a literature review with emphasis on species in Alaska. Alaska Department of Fish and Game., Division of Habitat. Technical Report No. 91-1. Fairbanks, AK. 47 p

Westrheim, S.J. 1970. Survey of rockfishes, especially Pacific ocean perch, in the northeast Pacific Ocean, 1963-66. J. Fish. Res. Bd. Canada 27: 1781-1809.

Wilderbuer, T.K., D.G. Nichol, and K. Aydin. 2009. Arrowtooth flounder. In Stock Assessment and Fishery Evaluation Report for the groundfish resources of the BSAI. Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the GOA in 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Yang, M-S. 1996. Diets of the important groundfishes in the AI in summer 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

Zale, A.V., O.E. Maughan, D.J. Orth, and W. Layher. 1993. Withdrawals. In Bryan, C.F and D.A. Rutherford, eds. Impacts on warmwater streams: Guidelines for evaluation. Pp. 271-281. Southern Division, American Fisheries Society, Little Rock, AR.

Zenger, H.H., Jr. and M.F. Sigler. 1992. Relative abundance of GOA sablefish and other groundfish based on National Marine Fisheries Service longline surveys, 1988-90. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-216, 103 pp.

Zhang, C.I. 1987. Biology and Population Dynamics of Alaska plaice, *Pleuronectes quadrituberculatus,* in the Eastern Bering Sea. PhD. dissertation, University of Washington: p.1-225.

Zimmerman, M. 1997. Maturity and fecundity of arrowtooth flounder, *Atheresthes stomias,* from the GOA. Fish. Bull. 95:598-611 (1997).

FIGURES

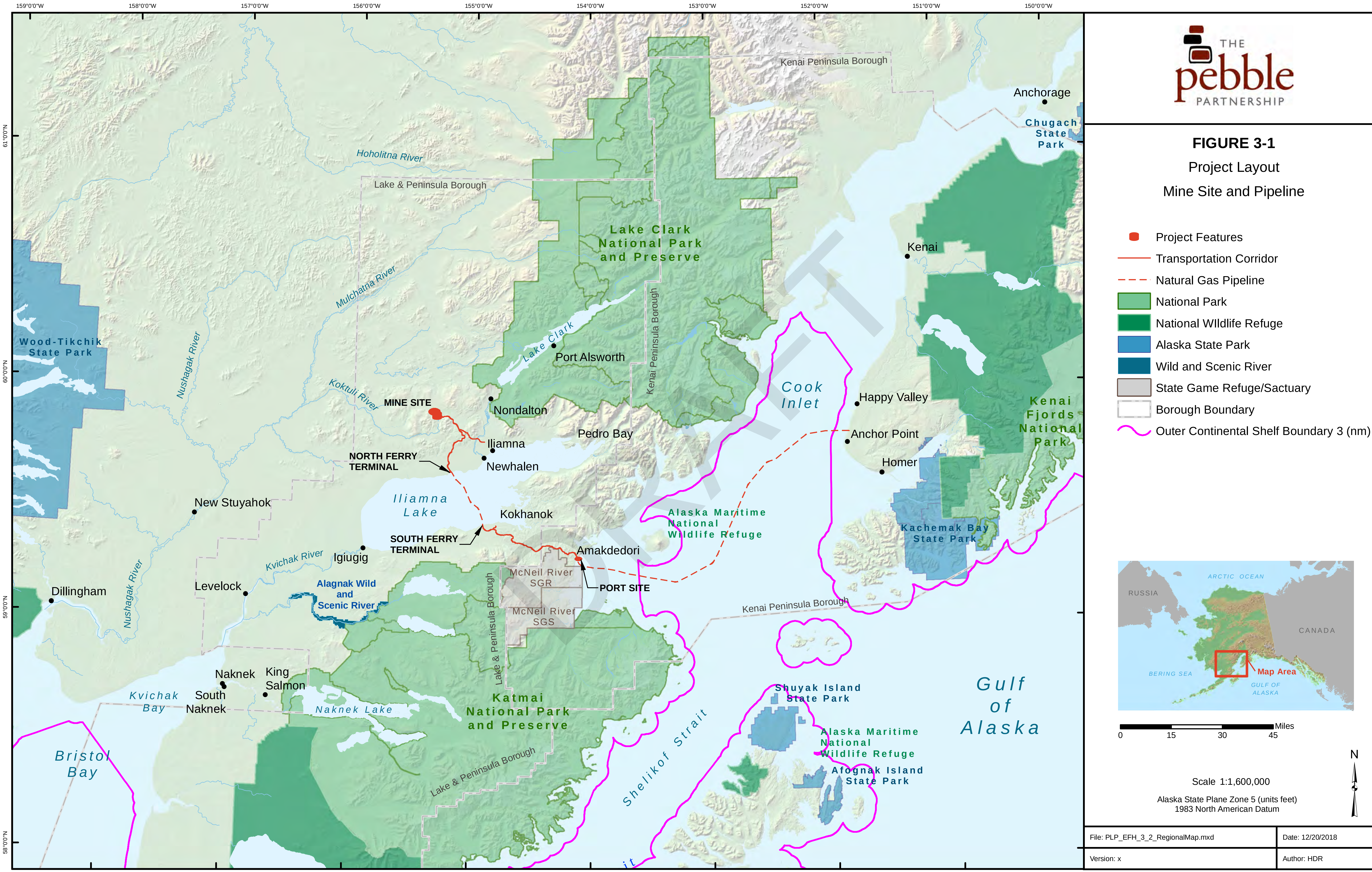
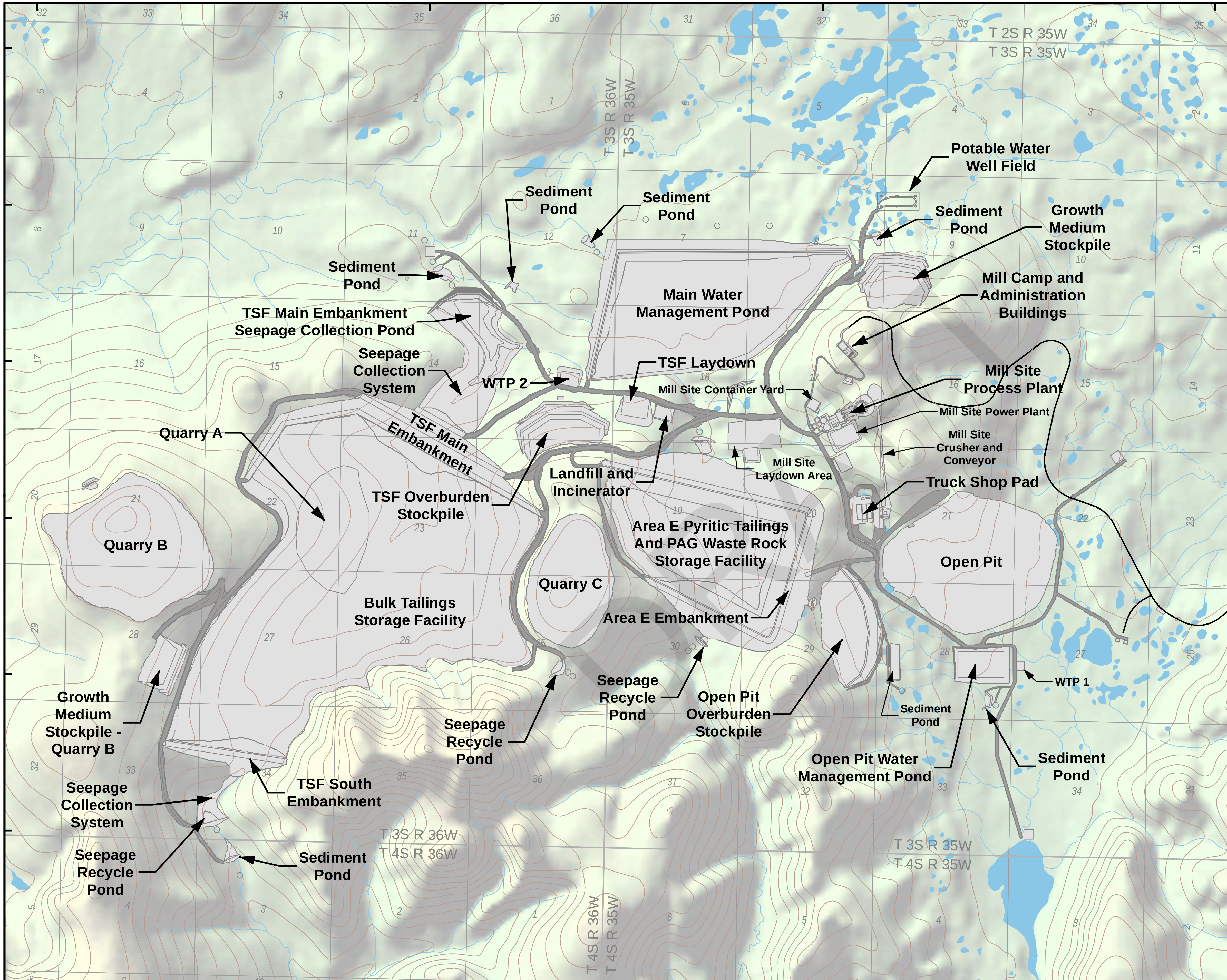


FIGURE 3-1
Project Layout
Mine Site and Pipeline

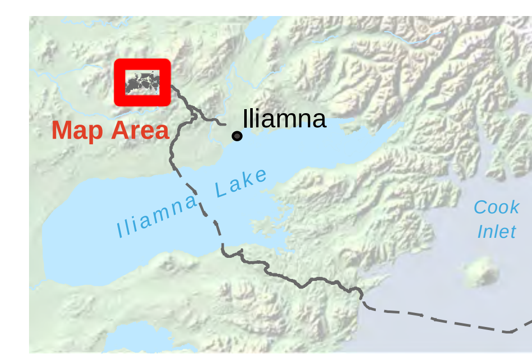


THE pebble PARTNERSHIP

FIGURE 3-2

Mine Site

Mine Site Footprint
Haul/Service Road
Mine Site Access Road
50' Contour (Existing)
Township Boundary
Section Boundary



0 0.5 1 1.5 Miles

N

Scale 1:46,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

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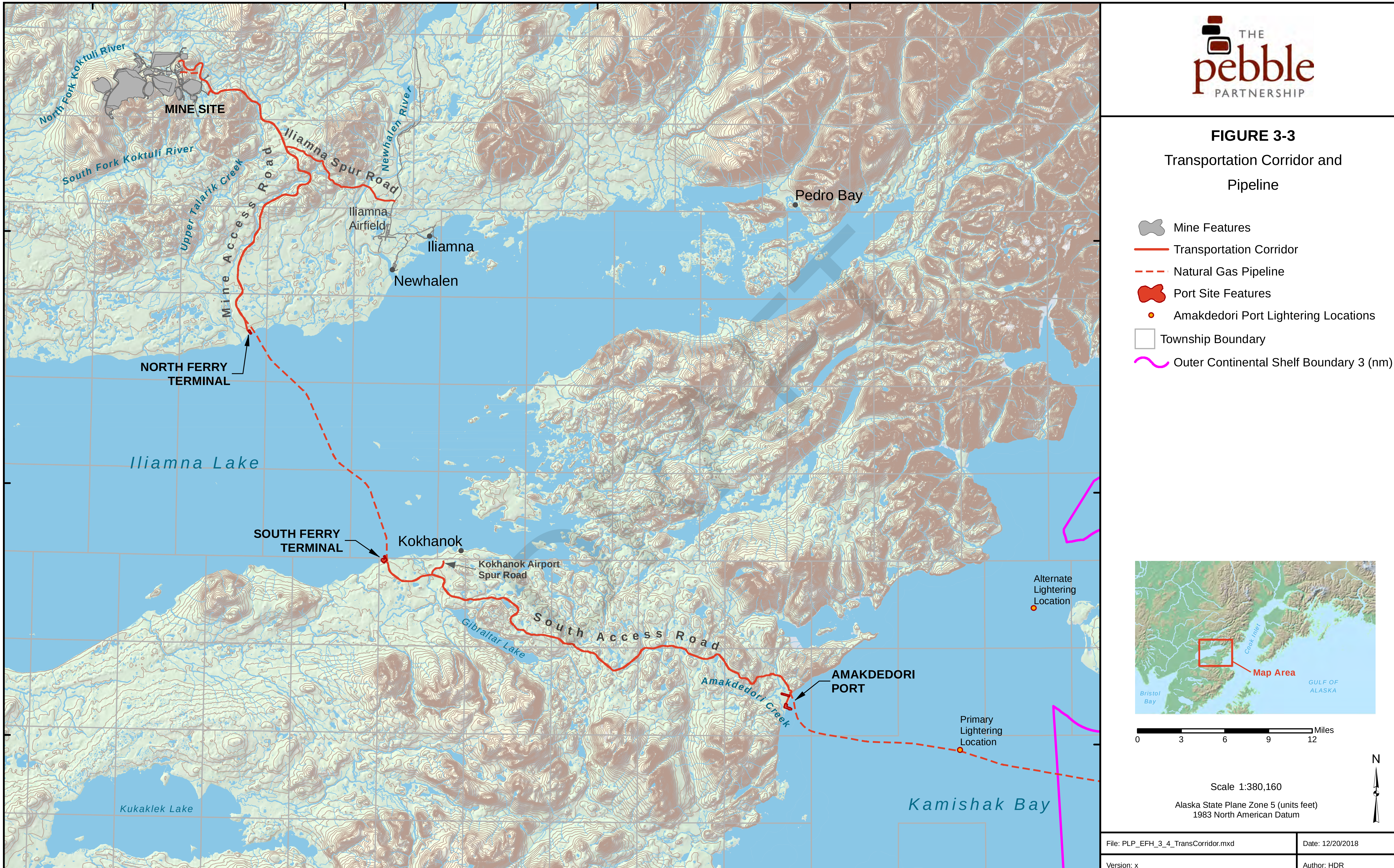
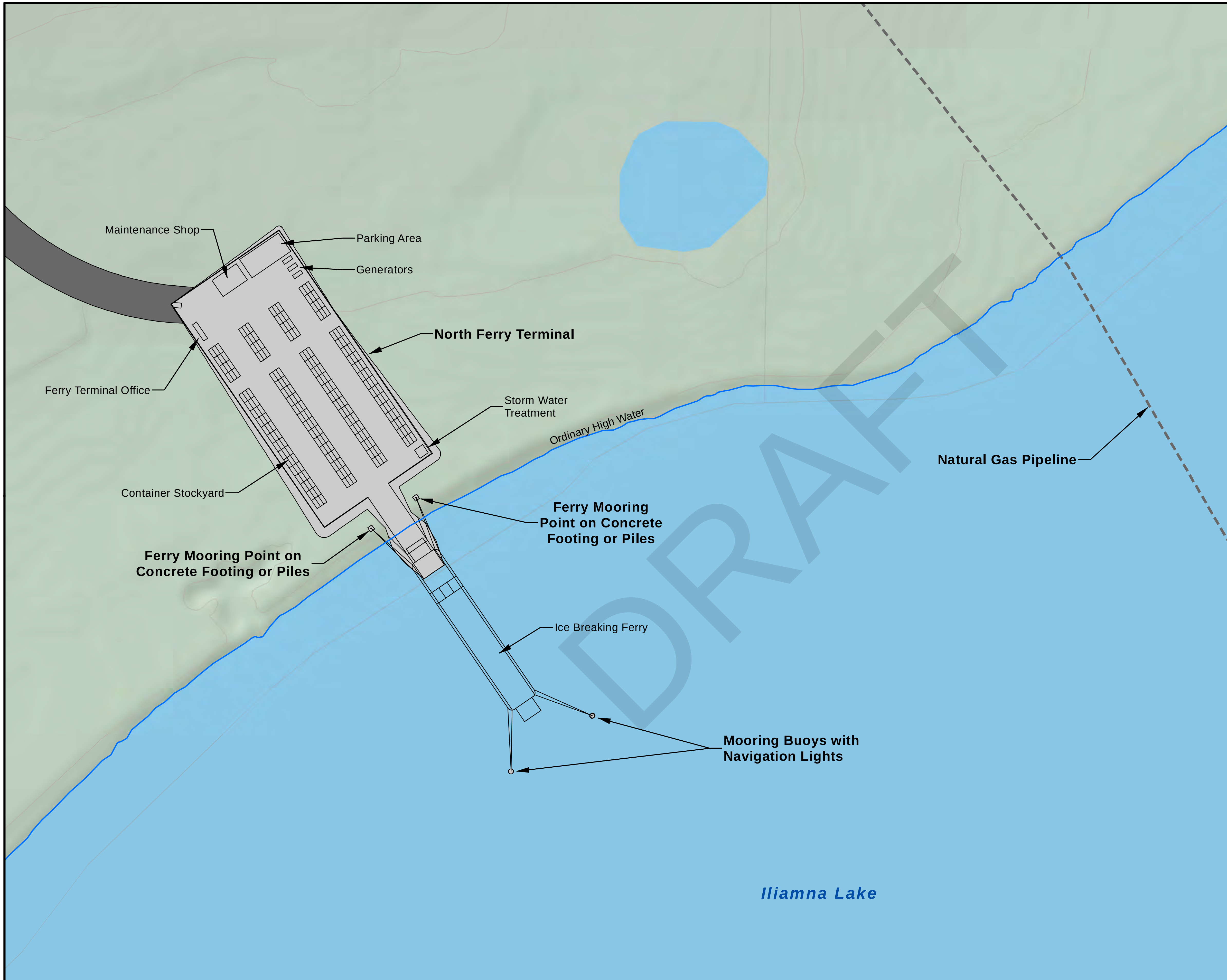


FIGURE 3-3
Transportation Corridor and Pipeline

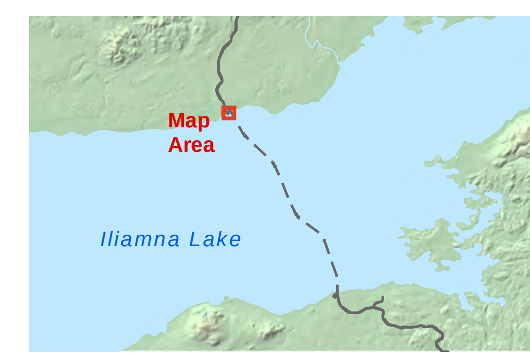


THE pebble PARTNERSHIP

FIGURE 3-4

North Ferry Terminal

- North Ferry Terminal Footprint
- Transportation Corridor
- Natural Gas Pipeline
- Ordinary High Water



0 200 400 Feet

N

Scale 1:2,400

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

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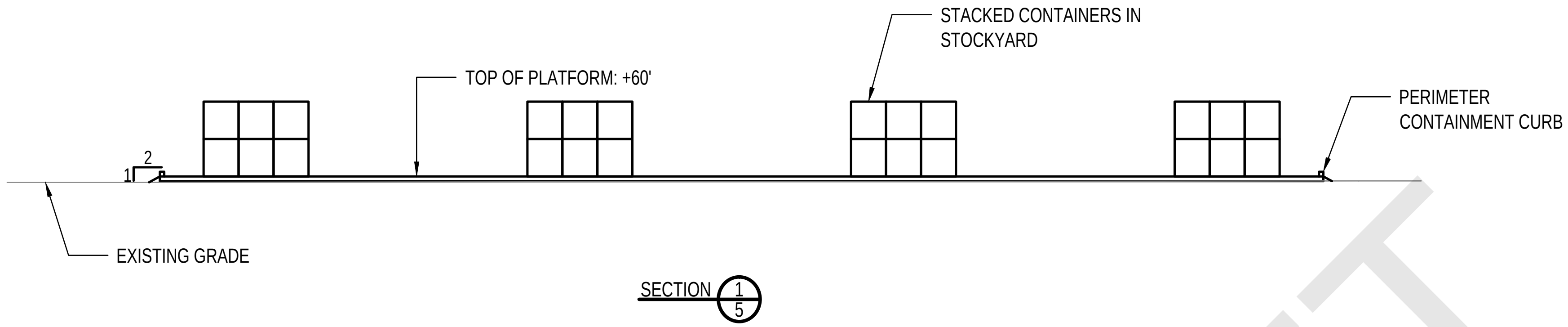
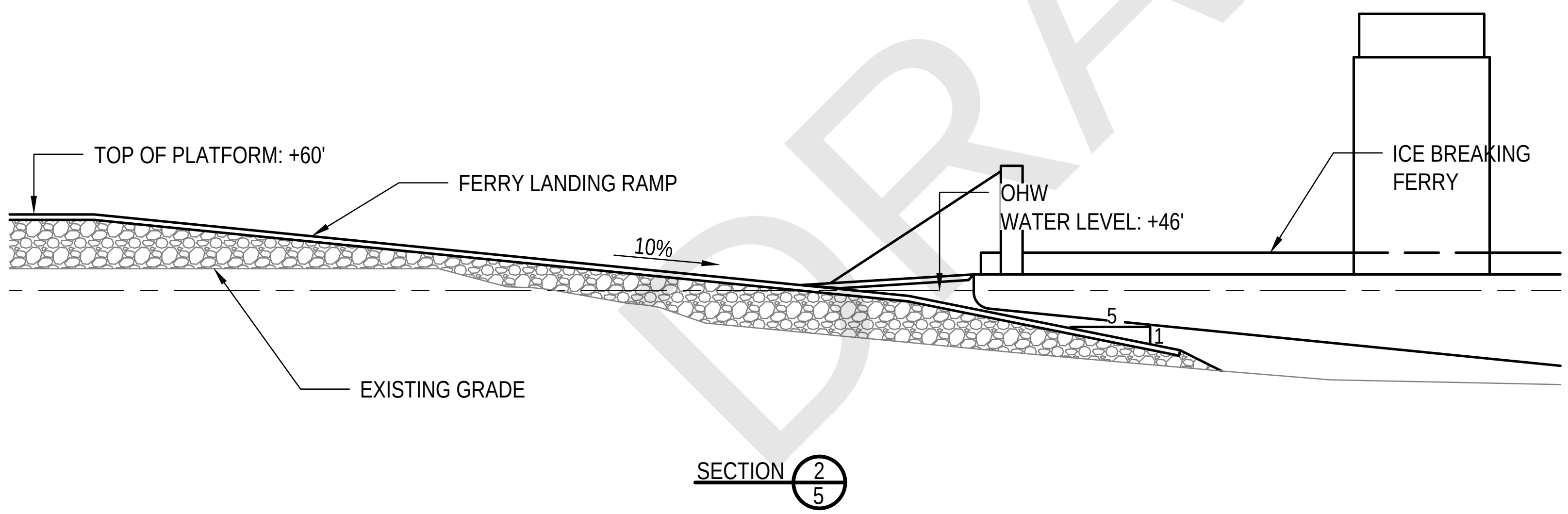
THE pebble PARTNERSHIP

FIGURE 3-5

North Ferry Terminal Cross Sections





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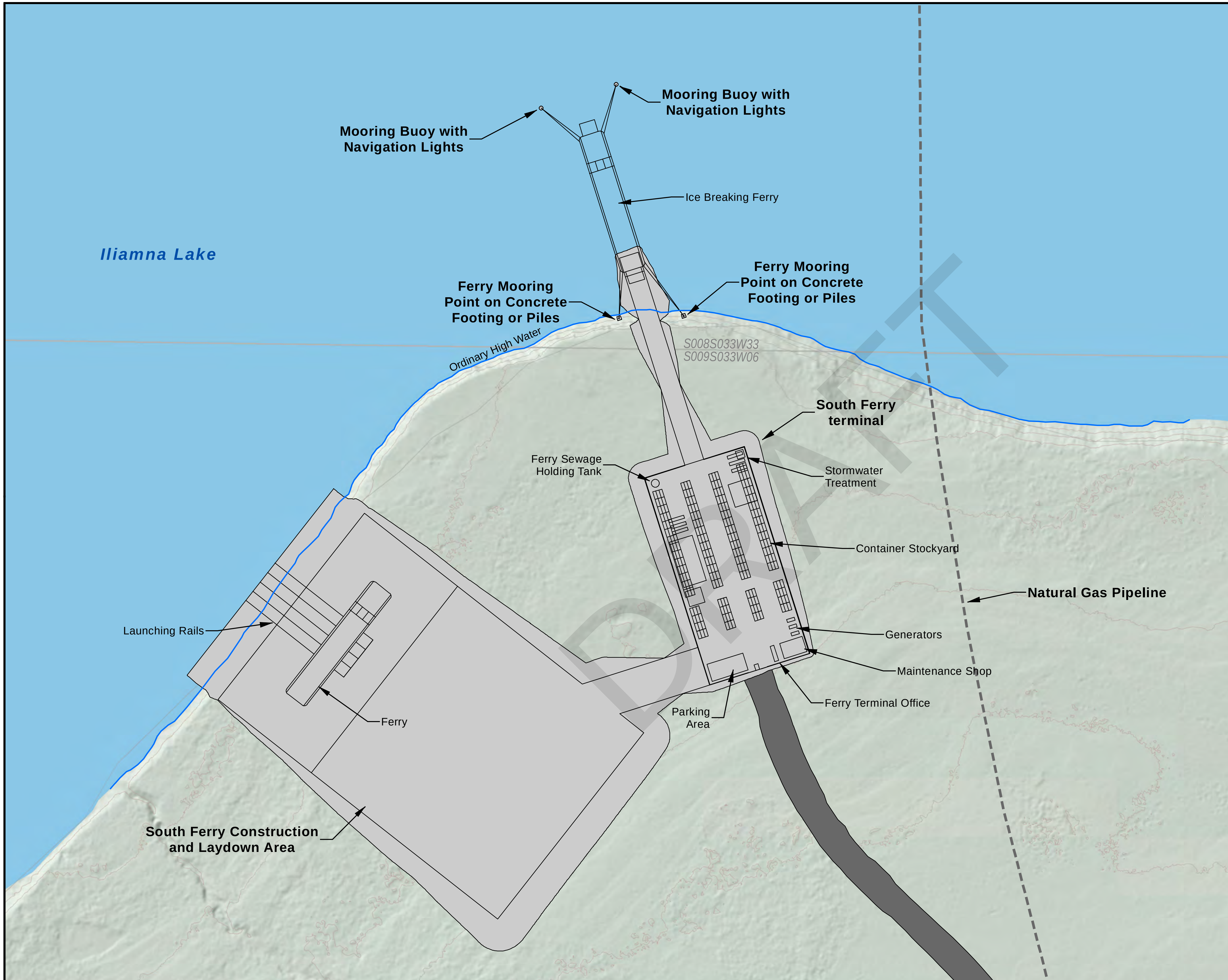
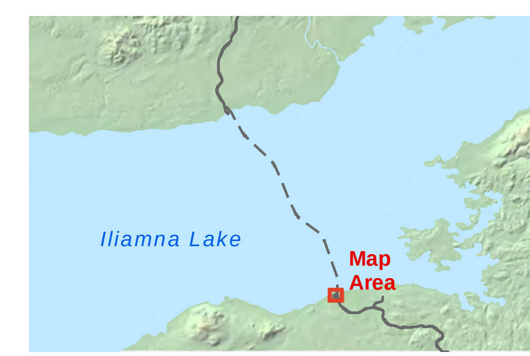


THE pebble PARTNERSHIP

FIGURE 3-6

South Ferry Terminal

- South Ferry Terminal Footprint
- Transportation Corridor
- Natural Gas Pipeline
- Ordinary High Water



0 250 500 Feet

N

Scale 1:3,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

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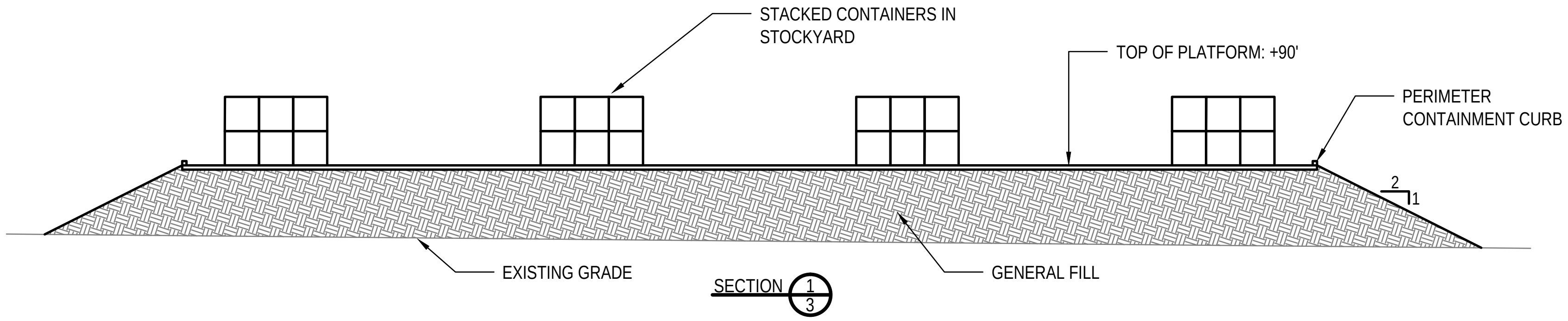

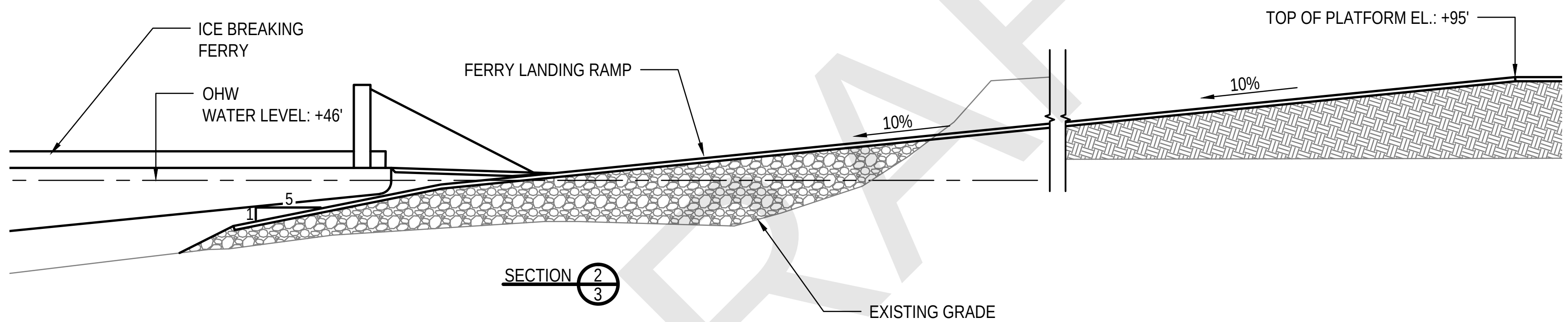

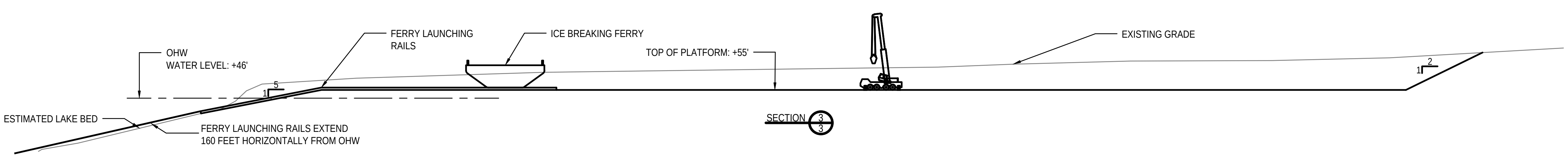

THE pebble PARTNERSHIP

FIGURE 3-7

South Ferry Terminal Cross Sections

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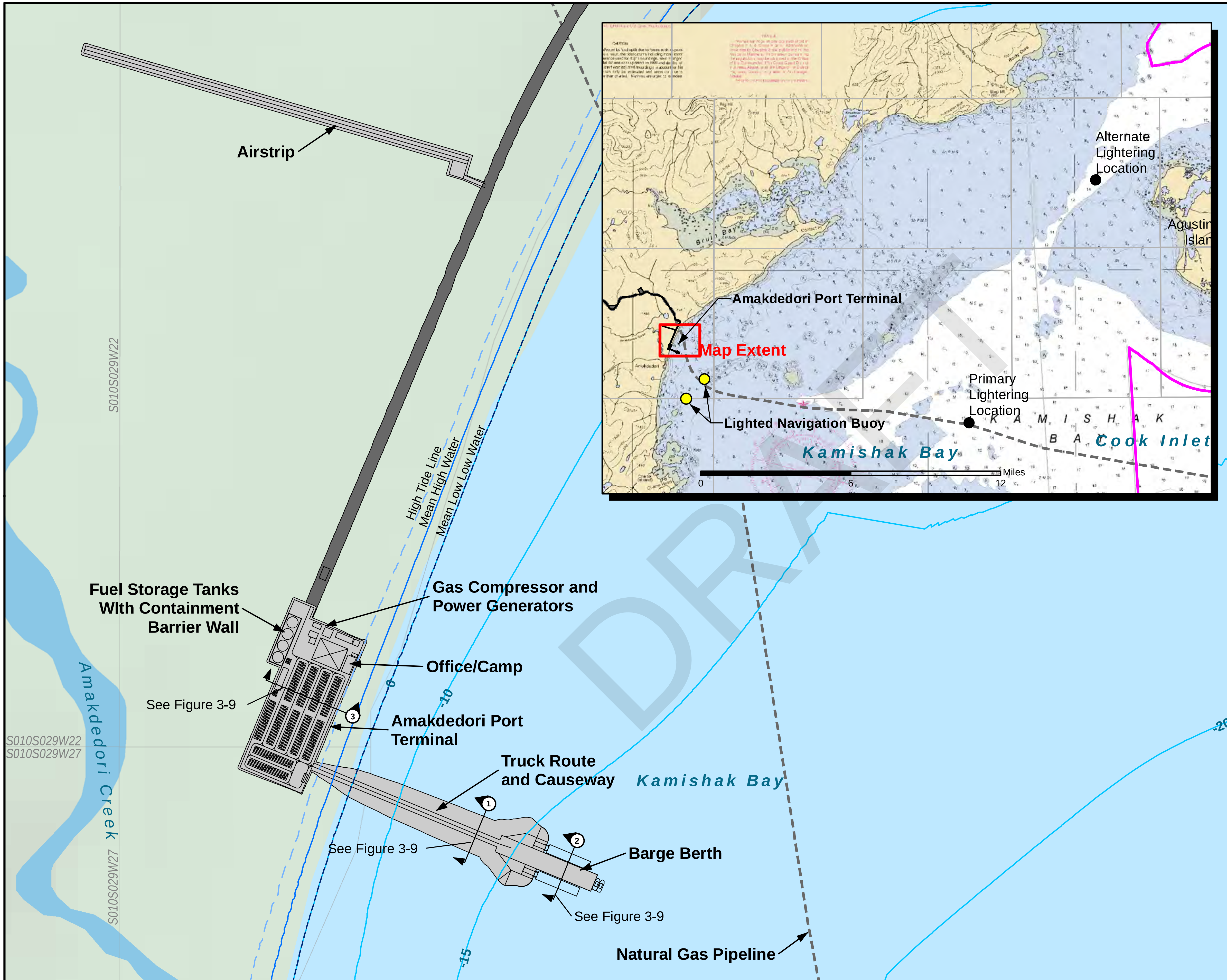
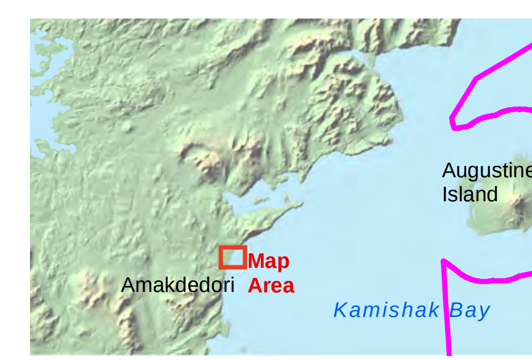


FIGURE 3-8

Amakdedori Port and Lightering Locations

- Amakdedori Port Site Footprint
- Primary / Alternate Lightering Locations
- Lighted Navigation Buoy
- Transportation Corridor
- Natural Gas Pipeline
- High Tide Line
- Mean High Water
- Mean Low Low Water (MLLW)
- Bathymetric Contours (Feet from MLLW)*
- State Seaward Boundary

*Offshore contours developed from Terrasond bathymetric survey dated August 20 to 27, 2017. Elevations surveyed to geodetic datum (GEOID 99) and are shifted to mean lower low water (MLLW) level based on limited field measured tidal data. Preliminary shift between geodetic and MLLW is +8.37' (0' geodetic = 8.37' MLLW)



0 500 1,000 Feet

N

Scale 1:8,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

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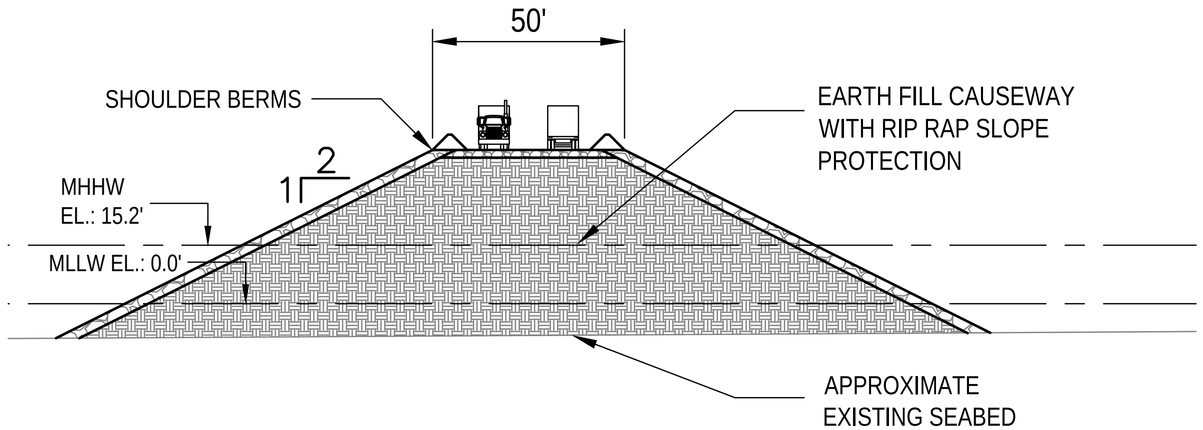
THE pebble PARTNERSHIP

FIGURE 3-9

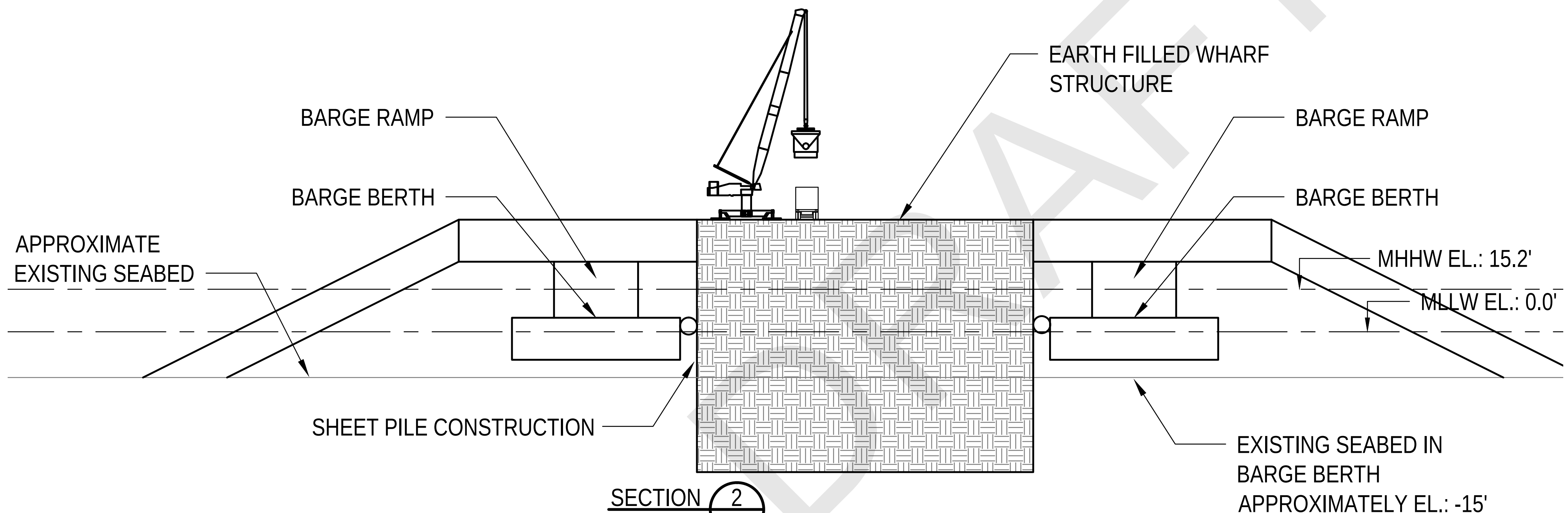
Amakdedori Port Cross Sections

NOTES:

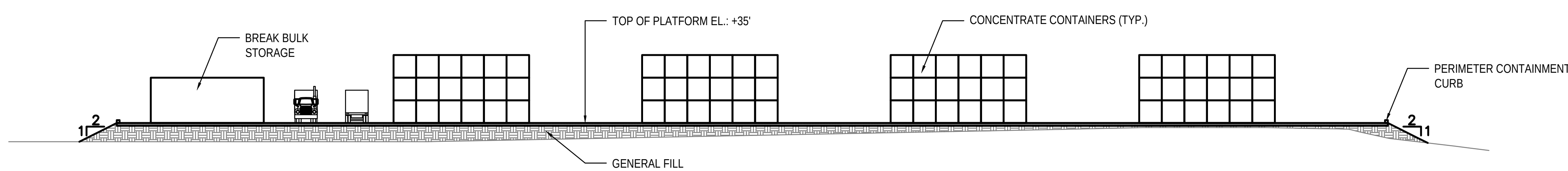
1. DIMENSIONS IN FEET
3. HORIZONTAL DATUM TO UTM NAD83, ALASKA STATE PLANE ZONE 5, US SURVEY FEET
4. ELEVATIONS ARE IN FEET TO MEAN LOWER LOW WATER (MLLW)
5. MEAN LOWER LOW WATER (MLLW), HIGH TIDE LINE (HTL), AND MEAN HIGH WATER (MHW) ARE BASED ON USACE ALASKA DISTRICT TIDE DATA AT SELDOVIA



SECTION 1/2

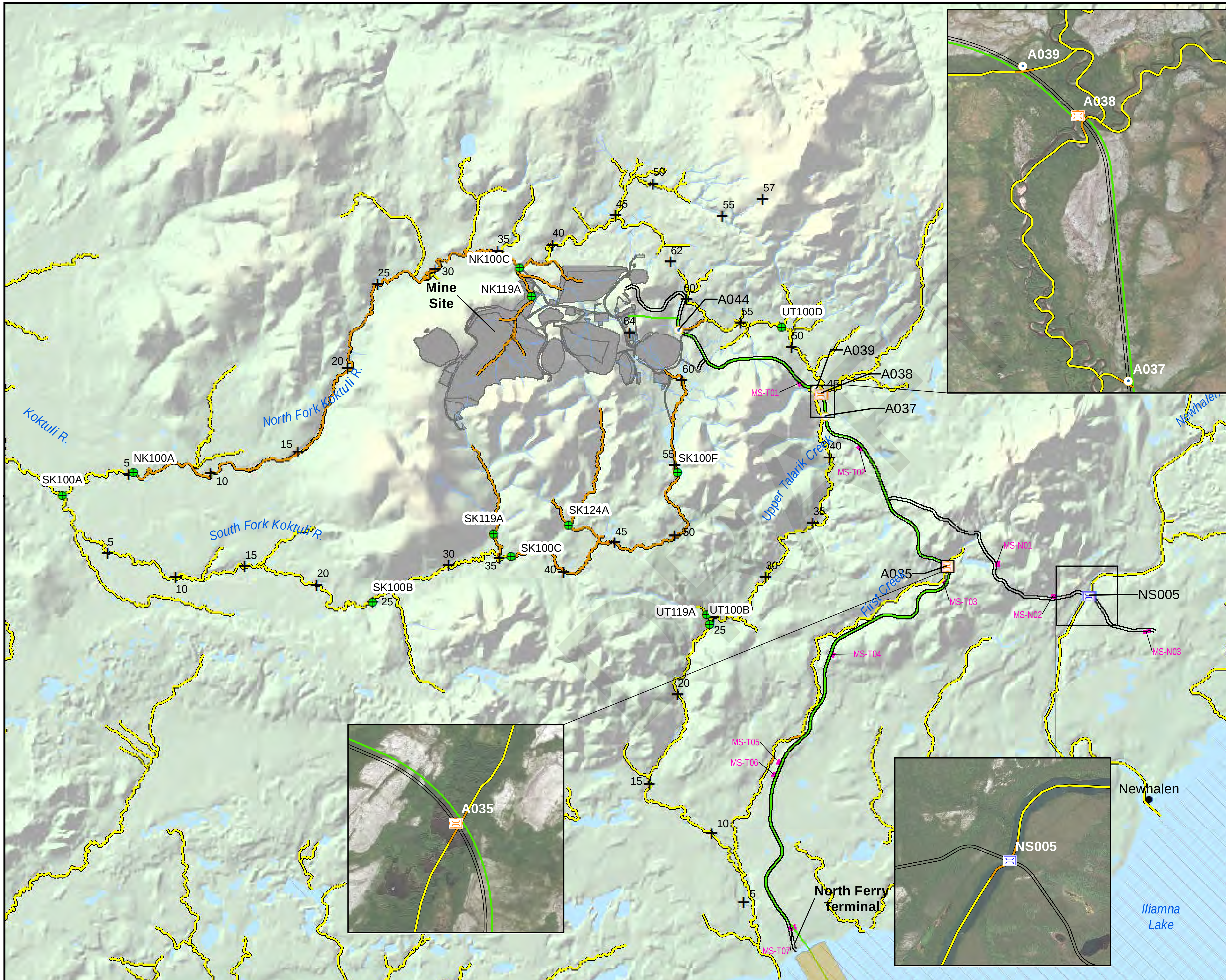


SECTION 2/2



SECTION 3/2

File: PLP_AmakdedoriPort_CrossSections.mxd	Date: 10/9/2018
Version: x	Author: HDR



THE pebble PARTNERSHIP

- EFH Action Area
- EFH Action Area
- Pacific Salmon EFH (ADF&G AWC)
- Pacific Salmon EFH (ADF&G AWC)
- Proposed Mine Site
- Proposed Access Road
- Proposed Natural Gas Pipeline
- Culvert/Pipeline
- Bridge
- Bridge/Pipeline
- Material Site
- Flow Station
- River Kilometer

Miles
0 2 4 6 8

Scale 1:175,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

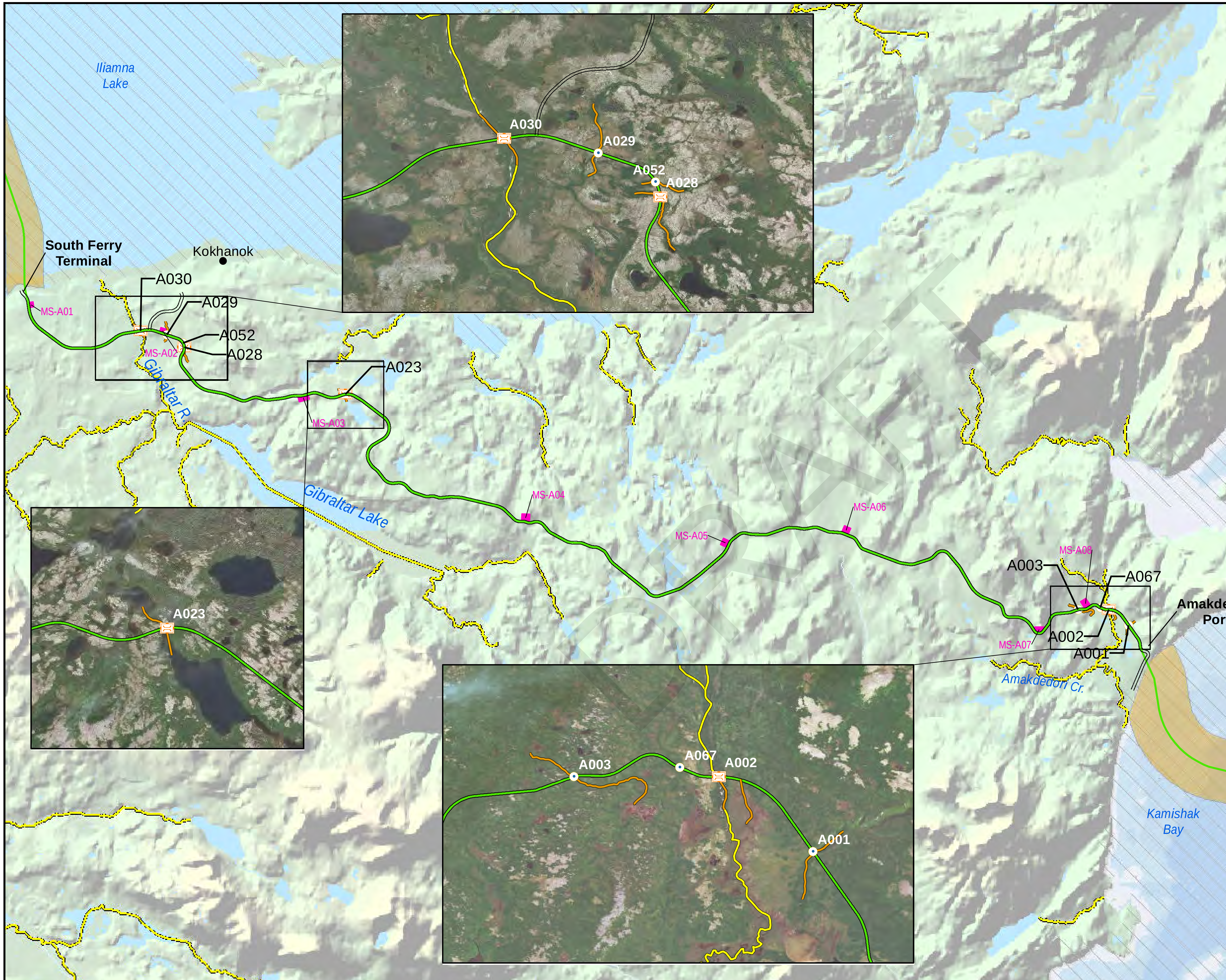
Figure:
3-10

EFH Action Area - Mine Site and North Transportation Corridor

Essential Fish Habitat Assessment
Pebble Project

File: PLP133	Date: 1/14/2019
Revision: 10	Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP133.mxd



THE pebble PARTNERSHIP

- EFH Action Area
- EFH Action Area
- Pacific Salmon EFH (ADF&G AWC)
- Pacific Salmon EFH (ADF&G AWC)
- Proposed Access Road
- Proposed Natural Gas Pipeline
- Culvert/Pipeline
- Bridge/Pipeline
- Material Site

Miles

0 2 4 6 8

Scale 1:154,334

NAD 1983 StatePlane Alaska 5 FIPS 5005 Seward Meridian

Figure: 3-11

EFH Action Area - SouthTransportation Corridor

Essential Fish Habitat Assessment
Pebble Project

File: PLP118	Date: 1/14/2019
Revision: 12	Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP118.mxd

THE pebble PARTNERSHIP

EFH Action Area
EFH Action Area
Pacific Salmon EFH (ADF&G AWC)
Pacific Salmon EFH (ADF&G AWC)
Proposed Access Road
Proposed Natural Gas Pipeline
Culvert/Pipeline
Bridge/Pipeline
Material Site

Miles
0 2 4 6 8
Scale 1:180,000

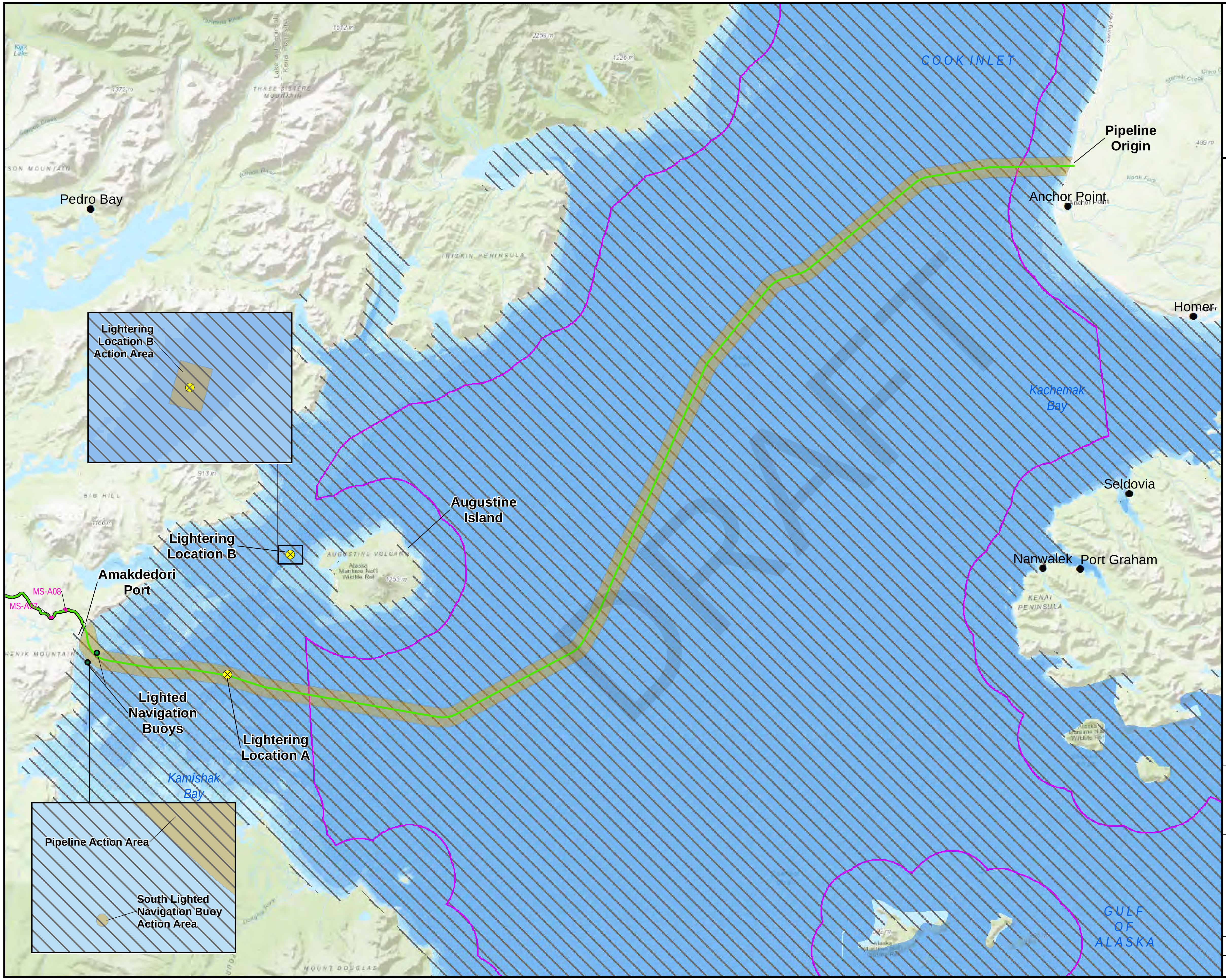
NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure: **3-12**

EFH Action Area - Iliamna Lake

Essential Fish Habitat Assessment
Pebble Project

File: PLP134	Date: 1/11/2019
Revision: 05	Author: RC/OR



EFH Action Area
Gulf of Alaska Groundfish and Pacific Salmon EFH
Lighted Navigation Buoys
Lightering Locations
Proposed Access Road
Proposed Natural Gas Pipeline
Outer Continental Shelf Boundary (3nm)
Material Site

Miles
0 5 10 15 20
Scale 1:500,000

THE pebble PARTNERSHIP

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

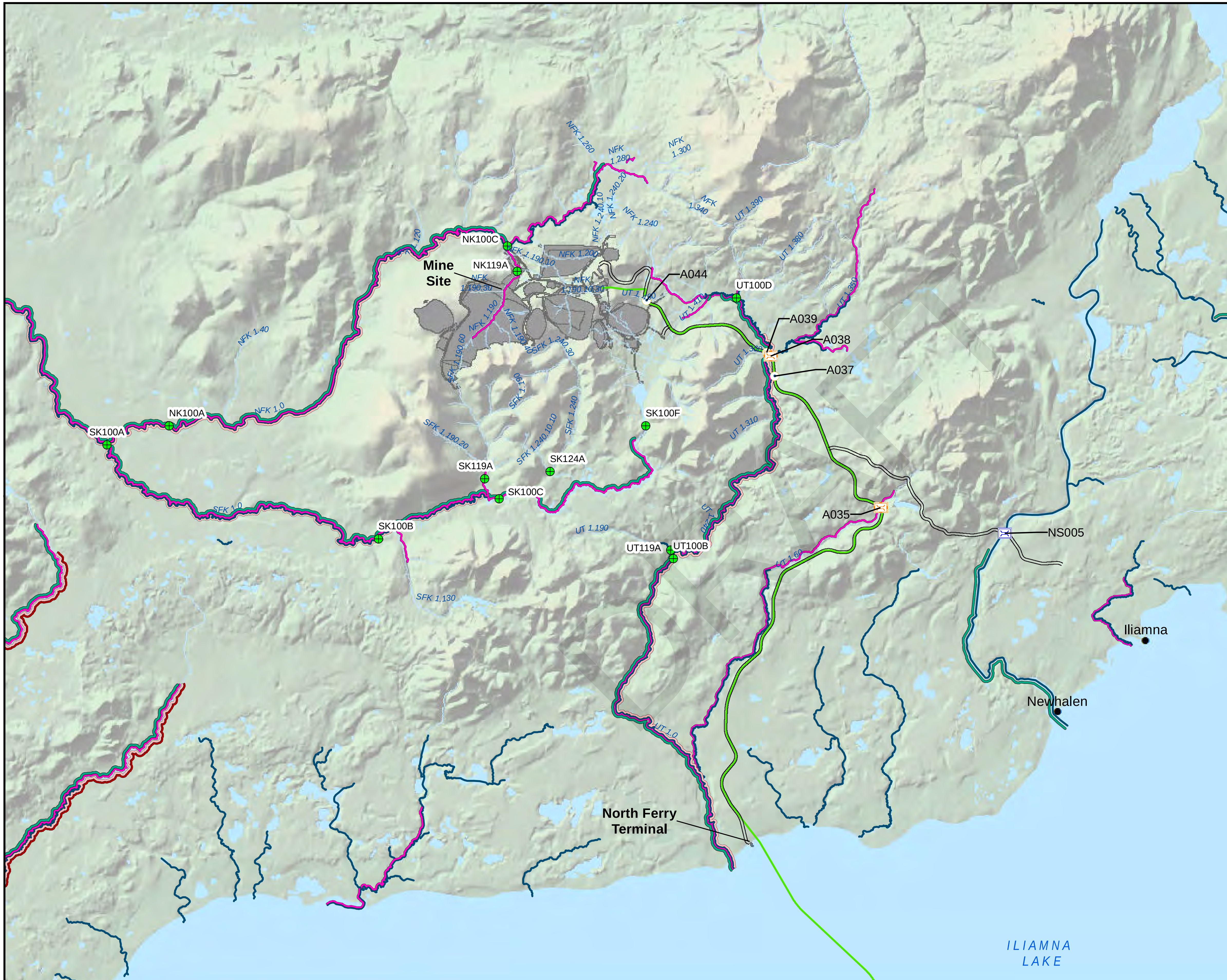
Figure: 3-13

EFH Action Area - Cook Inlet

Essential Fish Habitat Assessment
Pebble Project

File: PLP135	Date: 1/11/2019
Revision: 07	Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP135.mxd



THE pebble PARTNERSHIP

Proposed Mine Site
Proposed Access Road
Proposed Natural Gas Pipeline
Culvert/Pipeline
Bridge
Bridge/Pipeline
Flow Station

Spawning Salmon Distribution by Species

Chinook
Coho
Sockeye
Chum
Pink

Miles
0 2.5 5 7.5 10

Scale 1:200,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
4-1

Documented Pacific Salmon Spawning Habitat Within Action Area North of Iliamna Lake

Essential Fish Habitat Assessment
Pebble Project

File: PLP079	Date: 1/14/2019
Revision: 11	Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP079.mxd

THE pebble PARTNERSHIP

Proposed Mine Site
Proposed Access
Proposed Natural Gas Pipeline
Culvert/Pipeline
Bridge
Bridge/Pipeline

Aerial Survey Counts of Adult Chinook Salmon, 2008

1 - 22
23 - 60
61 - 114
115 - 189

Chinook Salmon - Life Stage

Present
Rearing
Spawning
Early Juvenile/Adults

Miles
0 2 4 6 8 10
Scale 1:200,000

NAD 1983 StatePlane Alaska 5 FIPS 5005 Seward Meridian

Figure: **4-2**

Chinook Salmon Distribution within Action Area North of Iliamna Lake

Essential Fish Habitat Assessment
Pebble Project

File: PLP067	Date: 1/14/2019
Revision: 14	Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP067.mxd

THE pebble PARTNERSHIP

Proposed Access Road
Proposed Natural Gas Pipeline
Culvert/Pipeline
Bridge/Pipeline

Chinook Salmon - Life Stage

Present
Rearing
Spawning
Early Juvenile/Adults
Late Juvenile/Adult Rearing

Miles
0 2 4 6 8 10
Scale 1:200,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
4-3

Chinook Salmon Distribution within Action Area South of Iliamna Lake

Essential Fish Habitat Assessment
Pebble Project

File: PLP072	Date: 12/26/2018
Revision: 13	Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP072.mxd

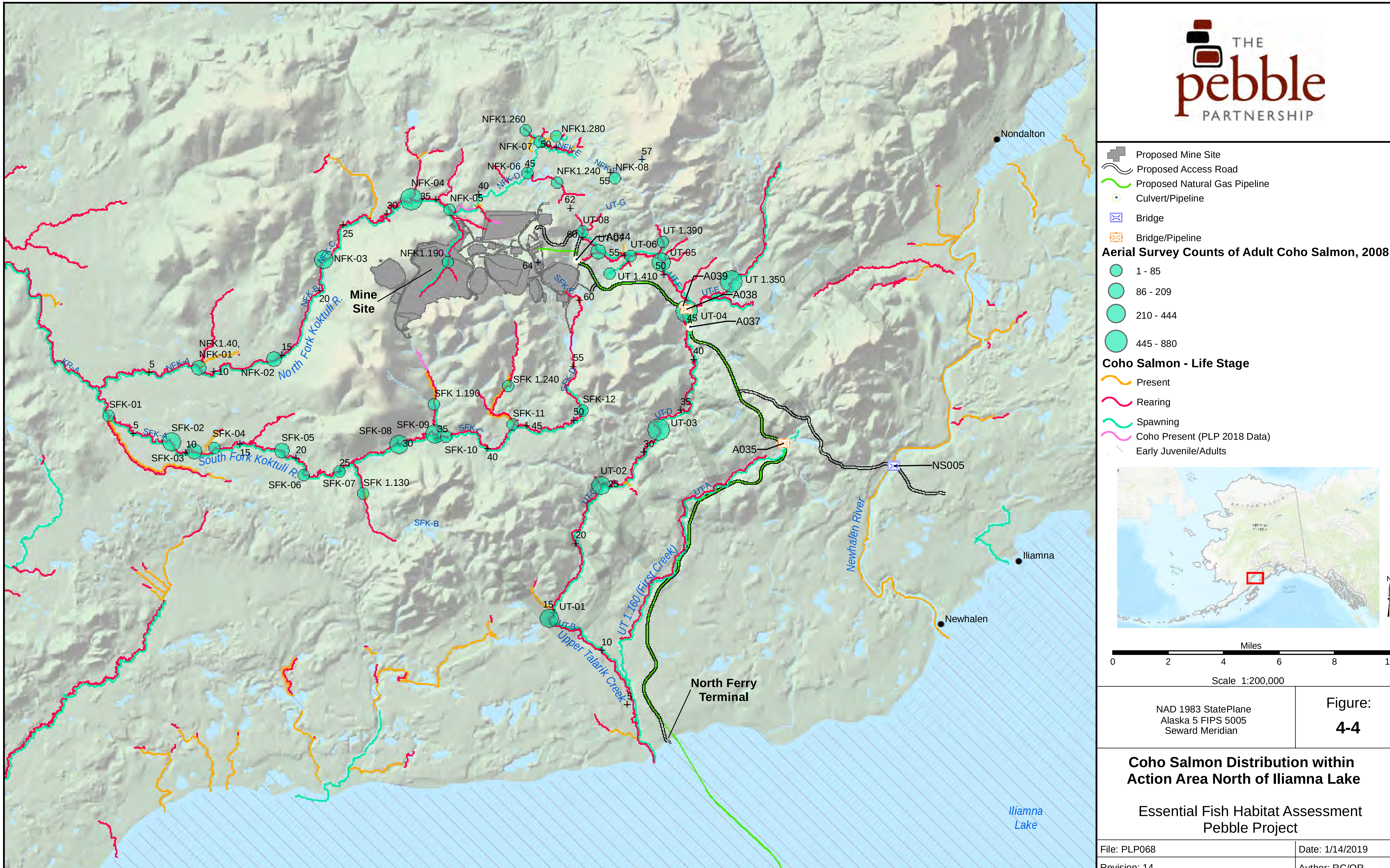


Figure: 4-4

Coho Salmon Distribution within Action Area North of Iliamna Lake

Essential Fish Habitat Assessment
Pebble Project

File: PLP068 | Date: 1/14/2019
Revision: 14 | Author: RC/OR

THE pebble PARTNERSHIP

Proposed Access Road
Proposed Natural Gas Pipeline
Culvert/Pipeline
Bridge/Pipeline

Coho Salmon - Life Stage

Present
Rearing
Spawning
Coho Present (PLP 2018 Data)
Early Juvenile/Adults
Late Juvenile/Adult Rearing

Miles
0 2 4 6 8 10

Scale 1:200,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

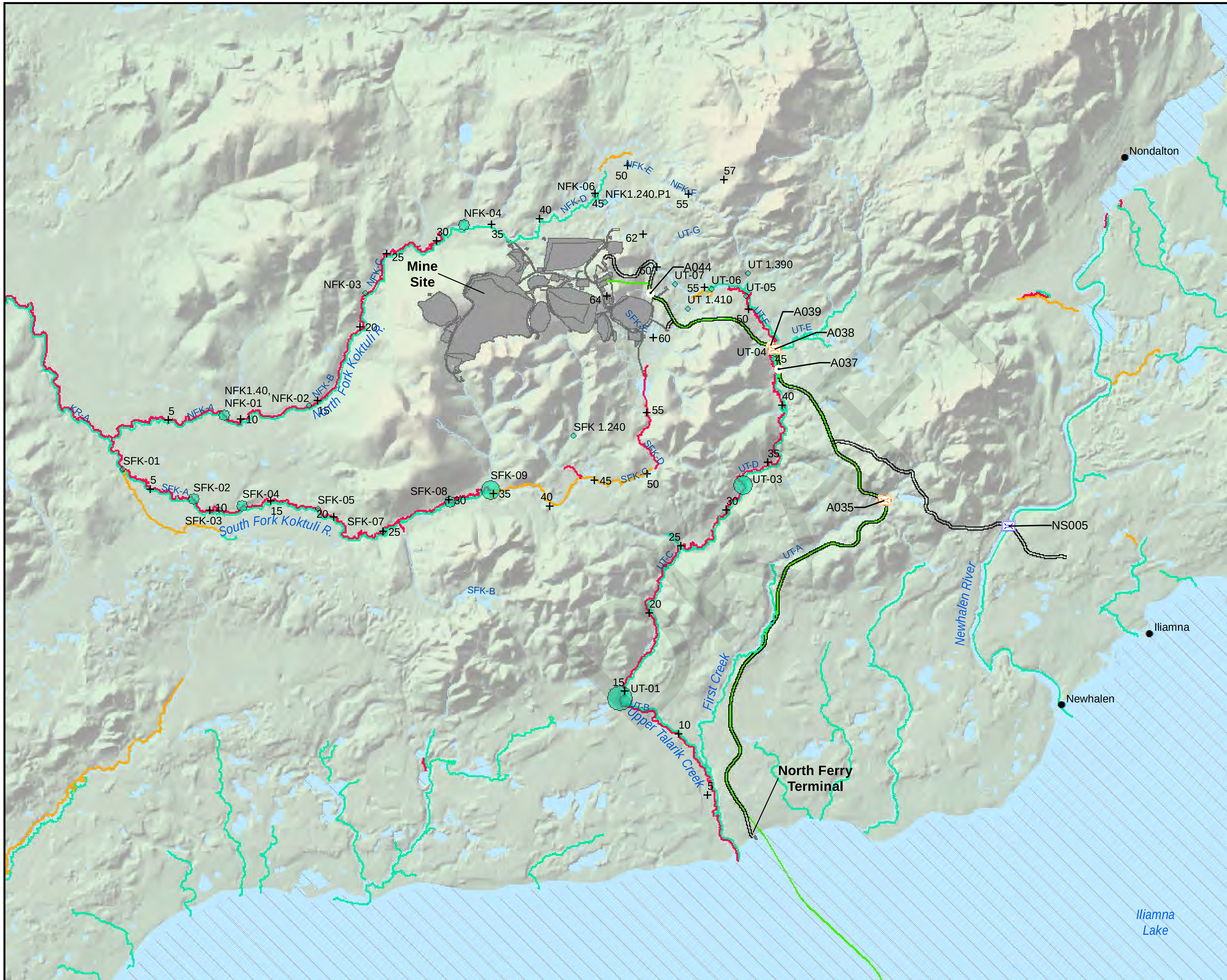
Figure:
4-5

Coho Salmon Distribution within Action Area South of Iliamna Lake

Essential Fish Habitat Assessment
Pebble Project

File: PLP073	Date: 1/14/2019
Revision: 14	Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP073.mxd



Proposed Mine Site
Proposed Access
Proposed Natural Gas Pipeline
Culvert/Pipeline
Bridge
Bridge/Pipeline

Aerial Survey Counts of Adult Sockeye Salmon, 2008

- 1 - 308
- 309 - 1435
- 1436 - 3057
- 3058 - 21554

Sockeye Salmon - Life Stage

- Present
- Rearing
- Spawning
- Early Juvenile/Adult Spawning

Miles

0 2 4 6 8 10

Scale 1:200,000

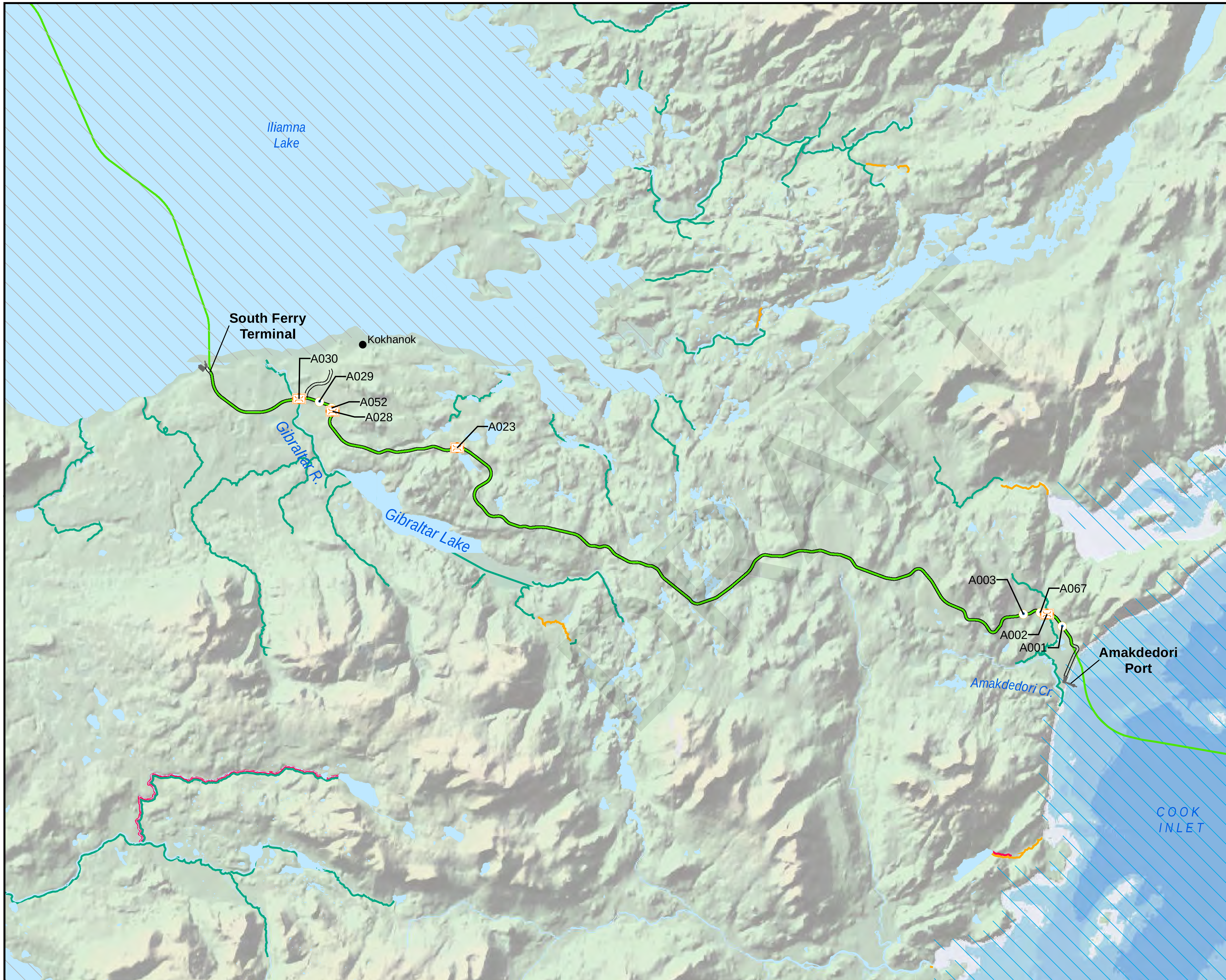
NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
4-6

Sockeye Salmon Distribution within Action Area North of Iliamna Lake

Essential Fish Habitat Assessment
Pebble Project

File: PLP069	Date: 12/21/2018
Revision: 14	Author: RC/OR



THE pebble PARTNERSHIP

- Proposed Access Road
- Proposed Natural Gas Pipeline
- Culvert/Pipeline
- Bridge/Pipeline

Sockeye Salmon - Life Stage

- Present
- Rearing
- Spawning
- Early Juvenile Rearing/Adult Spawning
- Late Juvenile/Adult

Miles

0 2 4 6 8 10

Scale 1:200,000

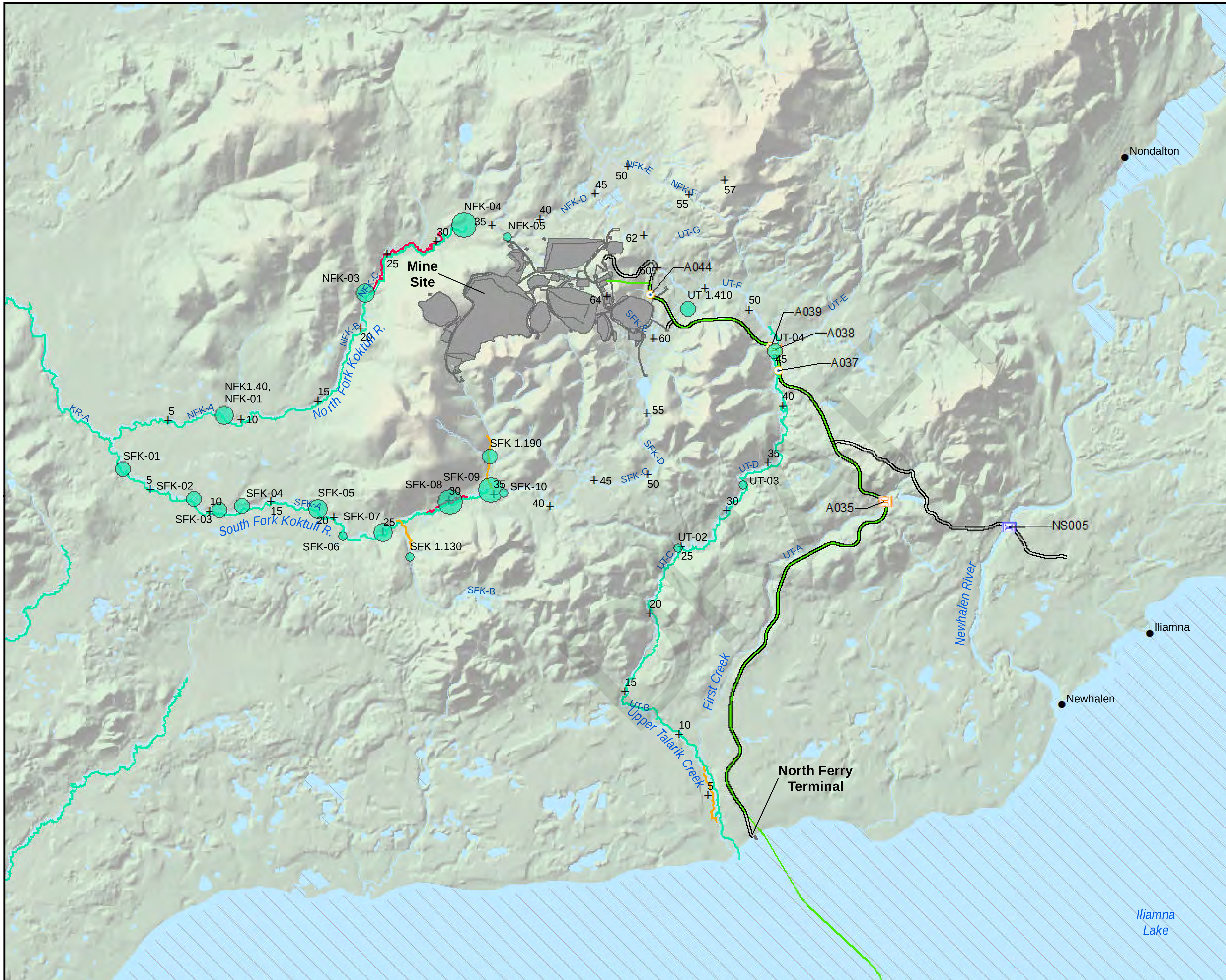
NAD 1983 StatePlane Alaska 5 FIPS 5005 Seward Meridian	Figure: **4-7**

Sockeye Salmon Distribution within Action Area South of Iliamna Lake

Essential FIsh Habitat Assessment
Pebble Project

File: PLP074	Date: 12/21/2018
Revision: 13	Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP074.mxd



THE pebble PARTNERSHIP

Proposed Mine Site
Proposed Access Road
Proposed Natural Gas Pipeline
Culvert/Pipeline
Bridge
Bridge/Pipeline

Aerial Survey Counts of Adult Chum Salmon, 2008

1 - 7
8 - 49
50 - 132
133 - 516

Chum Salmon - Life Stage

Present
Rearing
Spawning
Early Juvenile/Adult

Miles
0 2 4 6 8 10
Scale 1:200,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

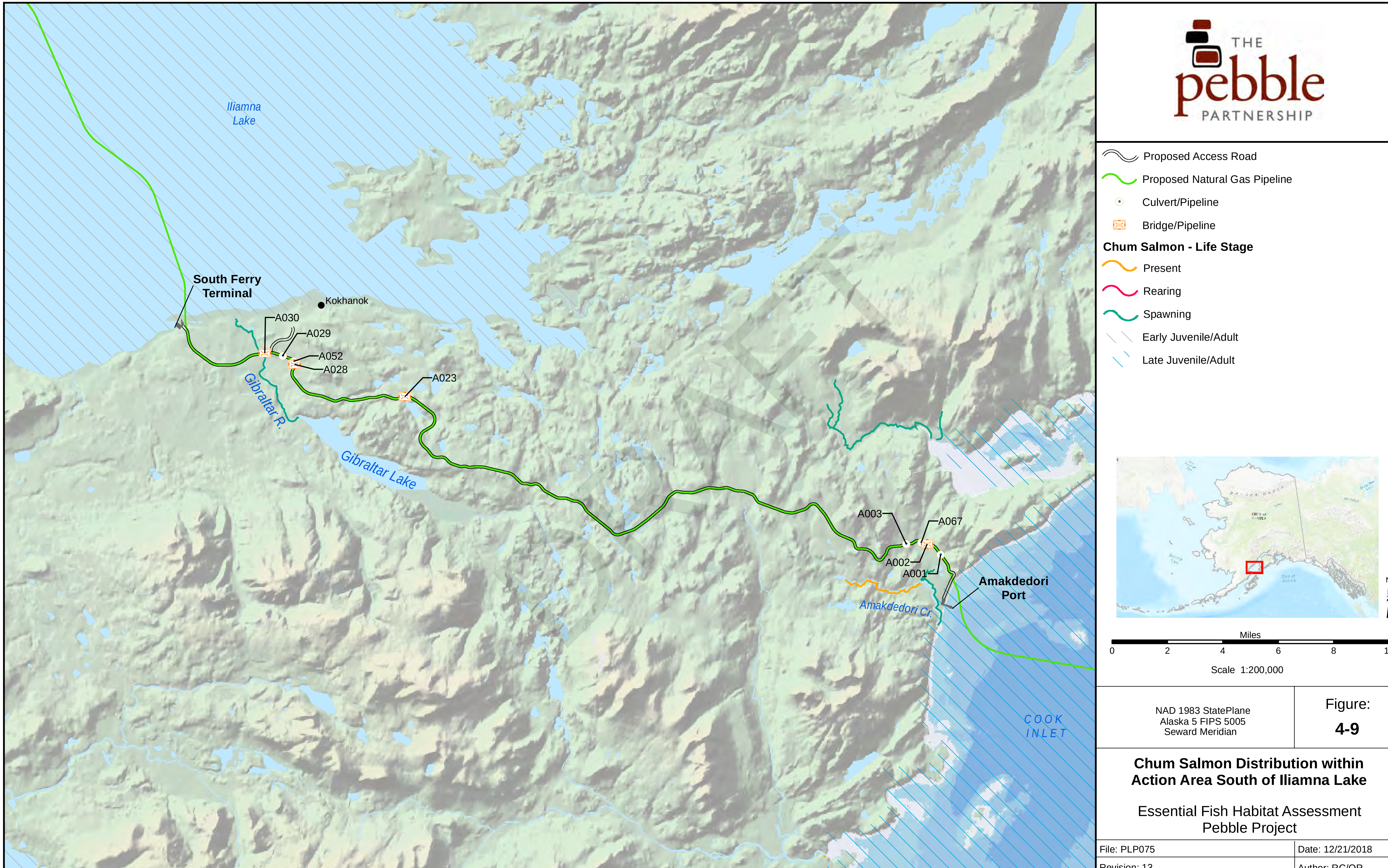
Figure:
4-8

Chum Salmon Distribution within Action Area North of Iliamna Lake

Essential Fish Habitat Assessment
Pebble Project

File: PLP070 | Date: 1/14/2019
Revision: 14 | Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP070.mxd



NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

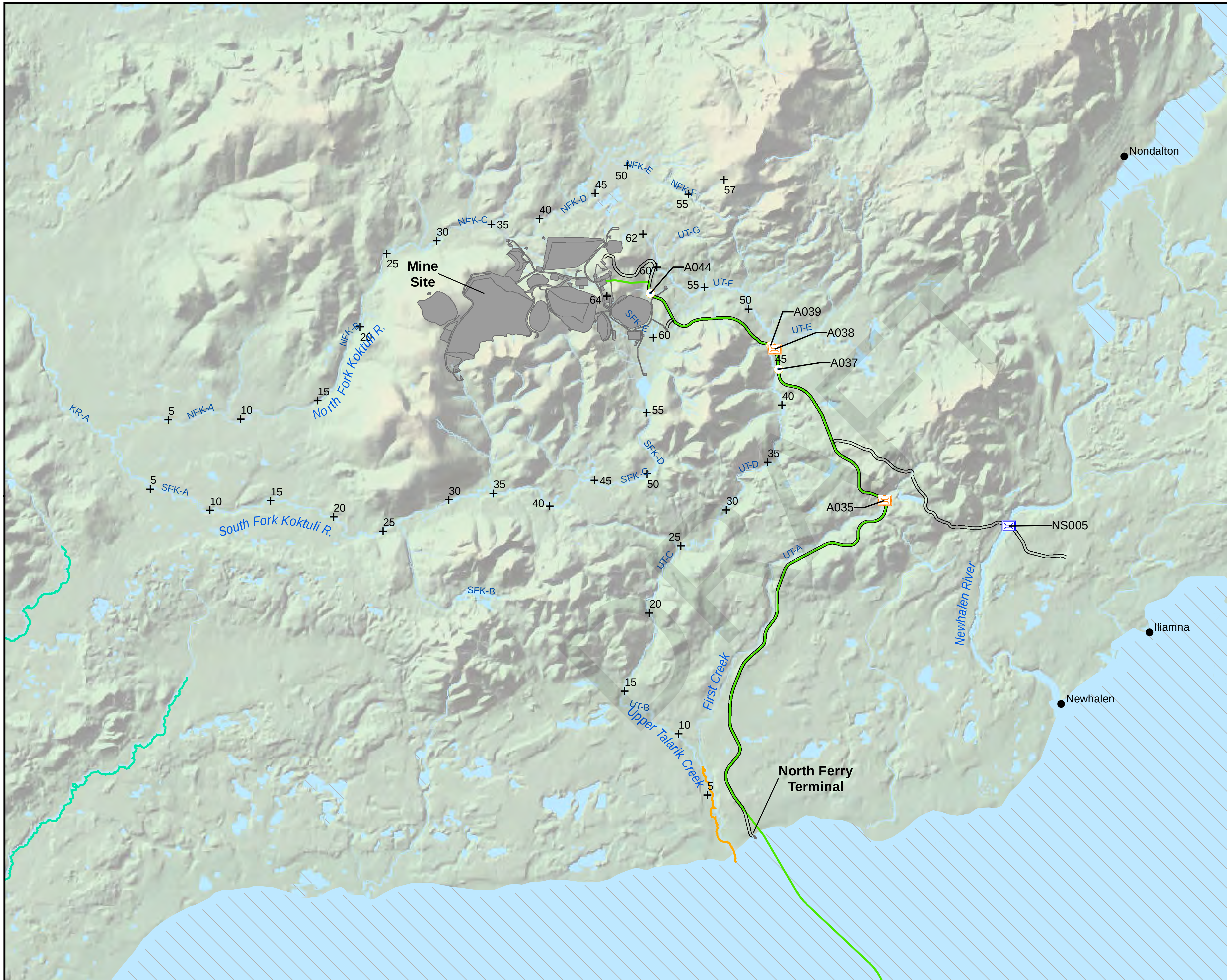
Figure:
4-9

Chum Salmon Distribution within Action Area South of Iliamna Lake

Essential Fish Habitat Assessment
Pebble Project

File: PLP075	Date: 12/21/2018
Revision: 13	Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP075.mxd



Proposed Mine Site
Proposed Access Road
Proposed Natural Gas Pipeline
Culvert/Pipeline
Bridge
Bridge/Pipeline
River Kilometer

Pink Salmon - Life Stage

Present
Rearing
Spawning
Early Juvenile/Adult

Miles

0 2 4 6 8 10

Scale 1:200,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
4-10

Pink Salmon Distribution within Action Area North of Iliamna Lake

Essential Fish Habitat Assessment
Pebble Project

File: PLP071 | Date: 1/14/2019
Revision: 14 | Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP071.mxd

THE pebble PARTNERSHIP

Proposed Access Road
Proposed Natural Gas Pipeline
Culvert/Pipeline
Bridge/Pipeline

Pink Salmon - Life Stage

Present
Rearing
Spawning
Early Juvenile/Adult
Late Juvenile/Adult

Miles
0 2 4 6 8 10
Scale 1:200,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

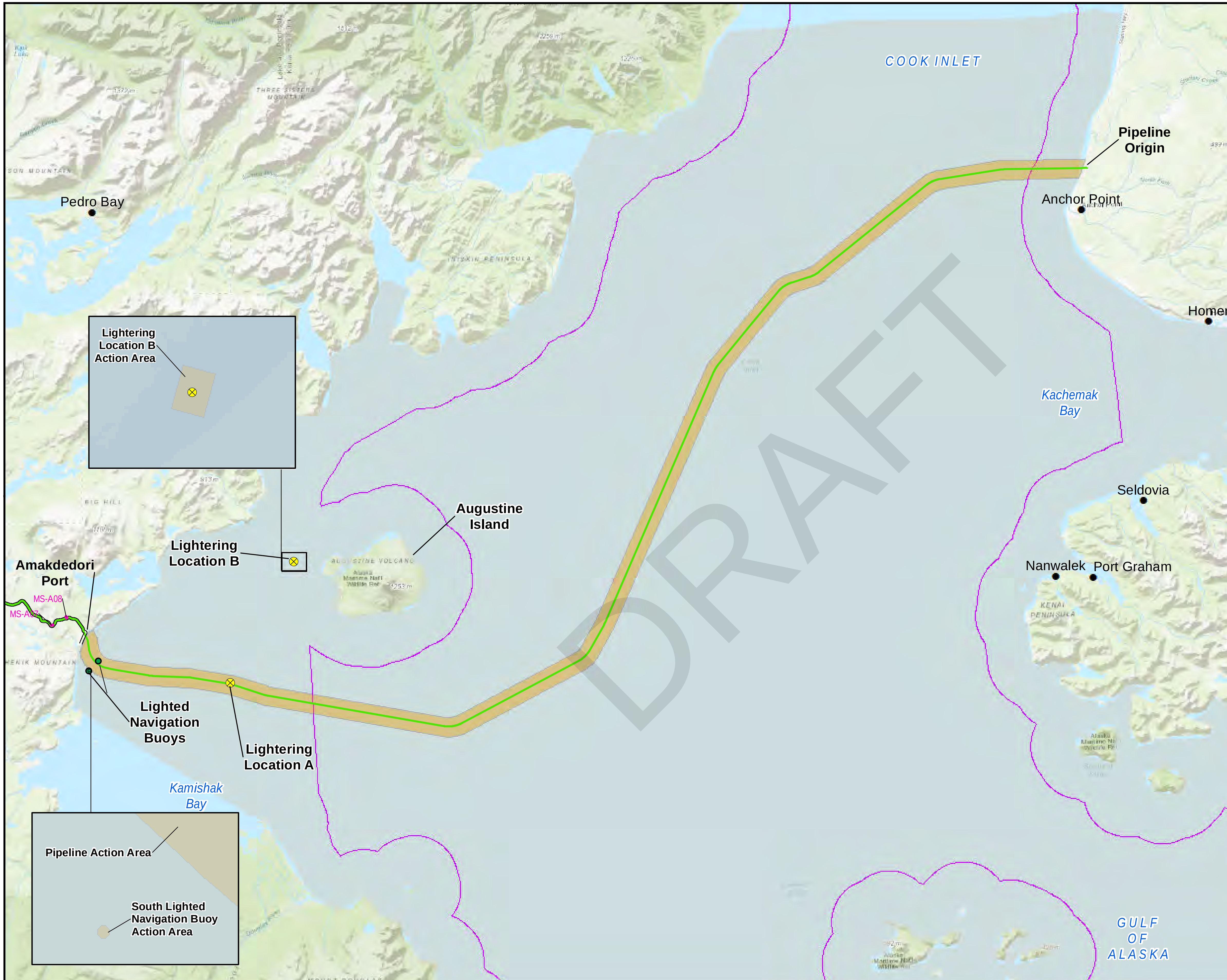
Figure:
4-11

Pink Salmon Distribution within Action Area South of Iliamna Lake

Essential Fish Habitat Assessment
Pebble Project

File: PLP076 | Date: 1/14/2019
Revision: 13 | Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP076.mxd



THE pebble PARTNERSHIP

EFH Action Area
EFH Species Lifestage
Adult
Lighted Navigation Buoys
Lightering Locations
Proposed Access Road
Proposed Natural Gas Pipeline
Outer Continental Shelf Boundary (3nm)
Material Site

Miles
0 5 10 15 20
Scale 1:500,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

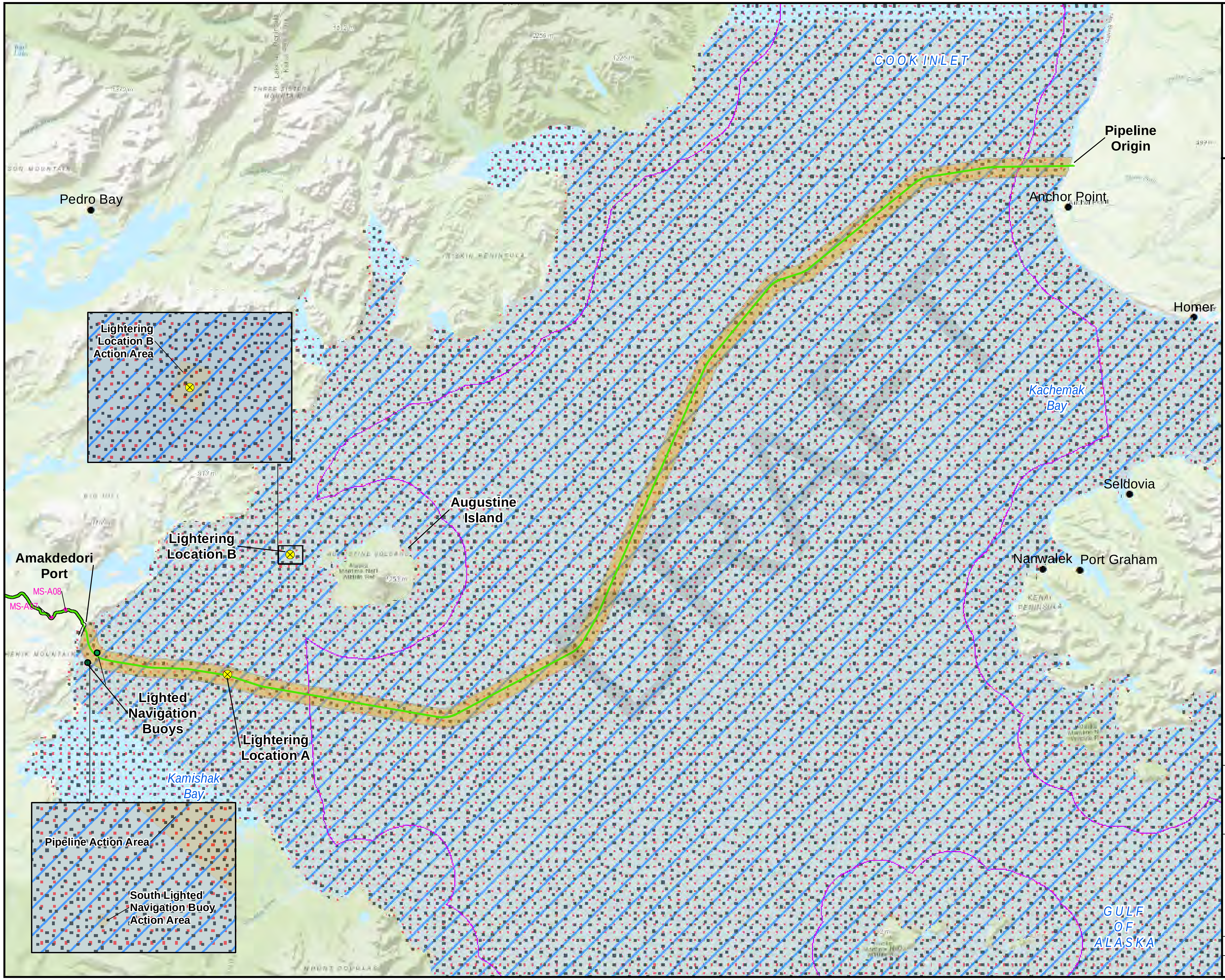
Figure:
4-12

Atka Mackerel EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLP146	Date: 1/14/2019
Revision: 00	Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP146.mxd



EFH Action Area

EFH Species Lifestage

Egg

Larvae

Juvenile

Adult

Lighted Navigation Buoys

Lightering Locations

Proposed Access Road

Proposed Natural Gas Pipeline

Outer Continental Shelf Boundary (3nm)

Material Site

Miles

0 5 10 15 20

Scale 1:500,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
4-13

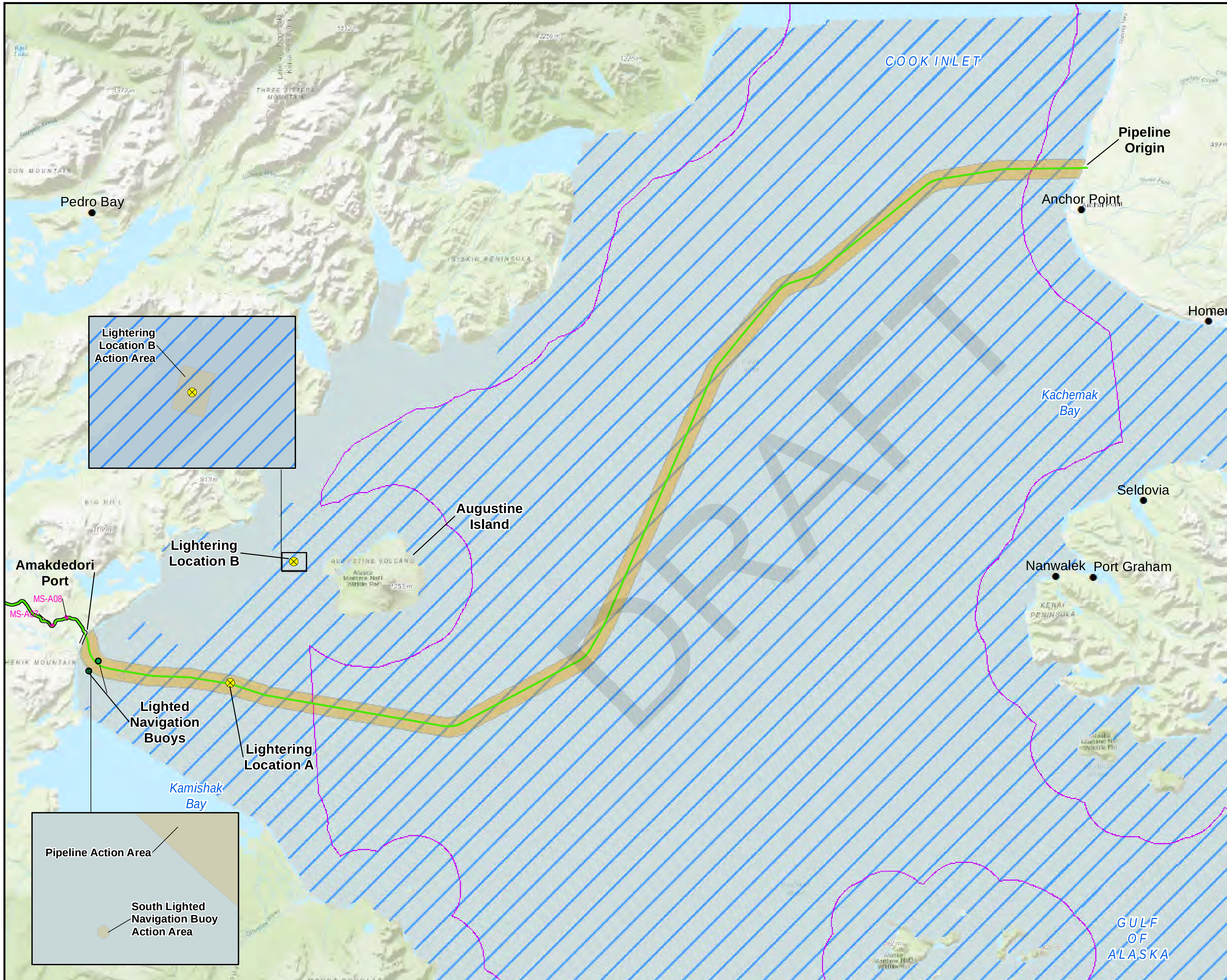
Flatfish EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLP146 | Date: 1/14/2019

Revision: 00 | Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP146.mxd



THE pebble PARTNERSHIP

EFH Action Area

EFH Species Lifestage

- Juvenile
- Adult
- Lighted Navigation Buoys
- Lightering Locations
- Proposed Access Road
- Proposed Natural Gas Pipeline
- Outer Continental Shelf Boundary (3nm)
- Material Site

Miles
0 5 10 15 20
Scale 1:500,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

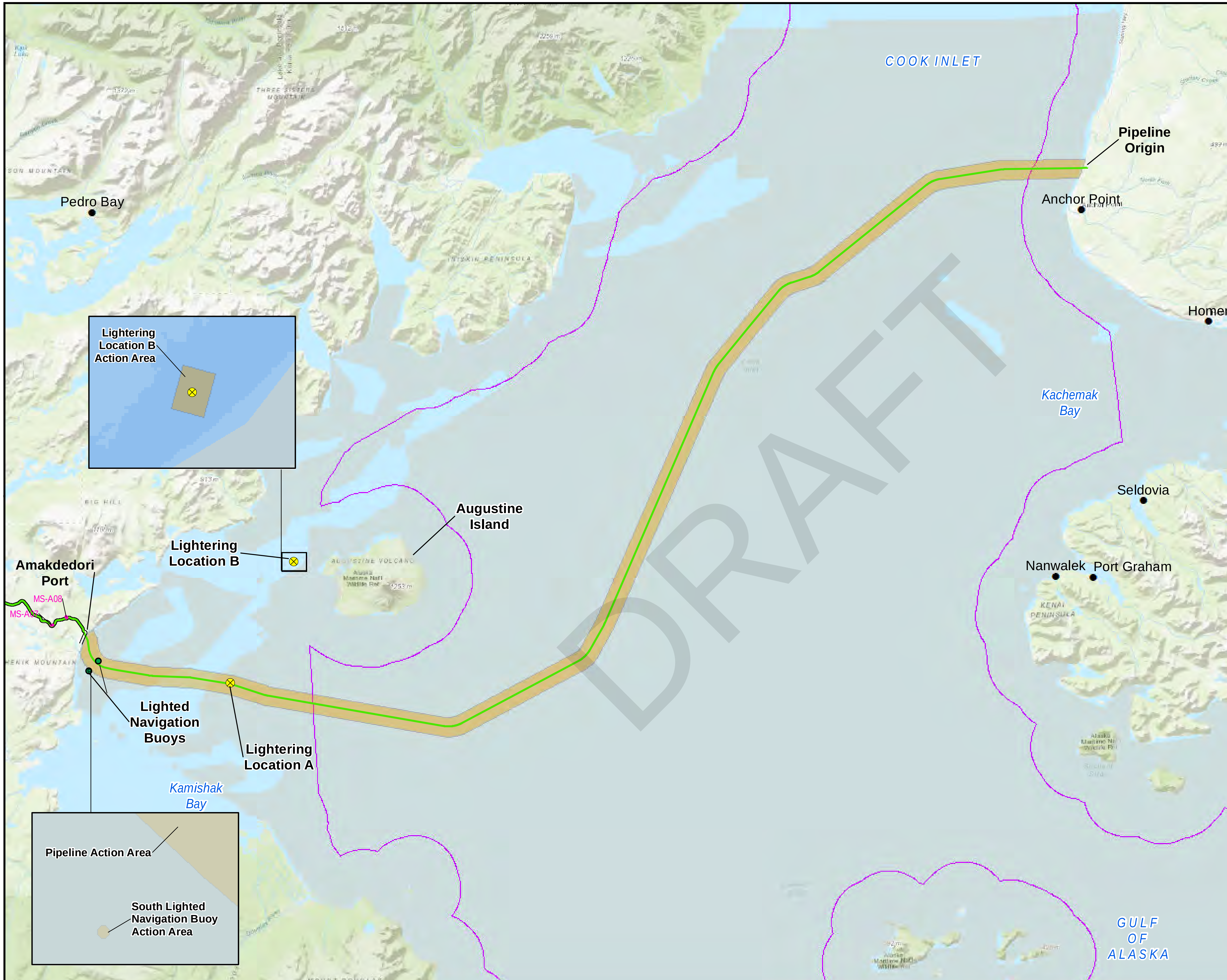
Figure: **4-14**

GOA Skates (Rajidae) EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLP146	Date: 1/14/2019
Revision: 00	Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP146.mxd



THE pebble PARTNERSHIP

EFH Action Area

EFH Species Lifestage

- Adult
- Lighted Navigation Buoys
- Lightering Locations
- Proposed Access Road
- Proposed Natural Gas Pipeline
- Outer Continental Shelf Boundary (3nm)
- Material Site

Miles

0 5 10 15 20

Scale 1:500,000

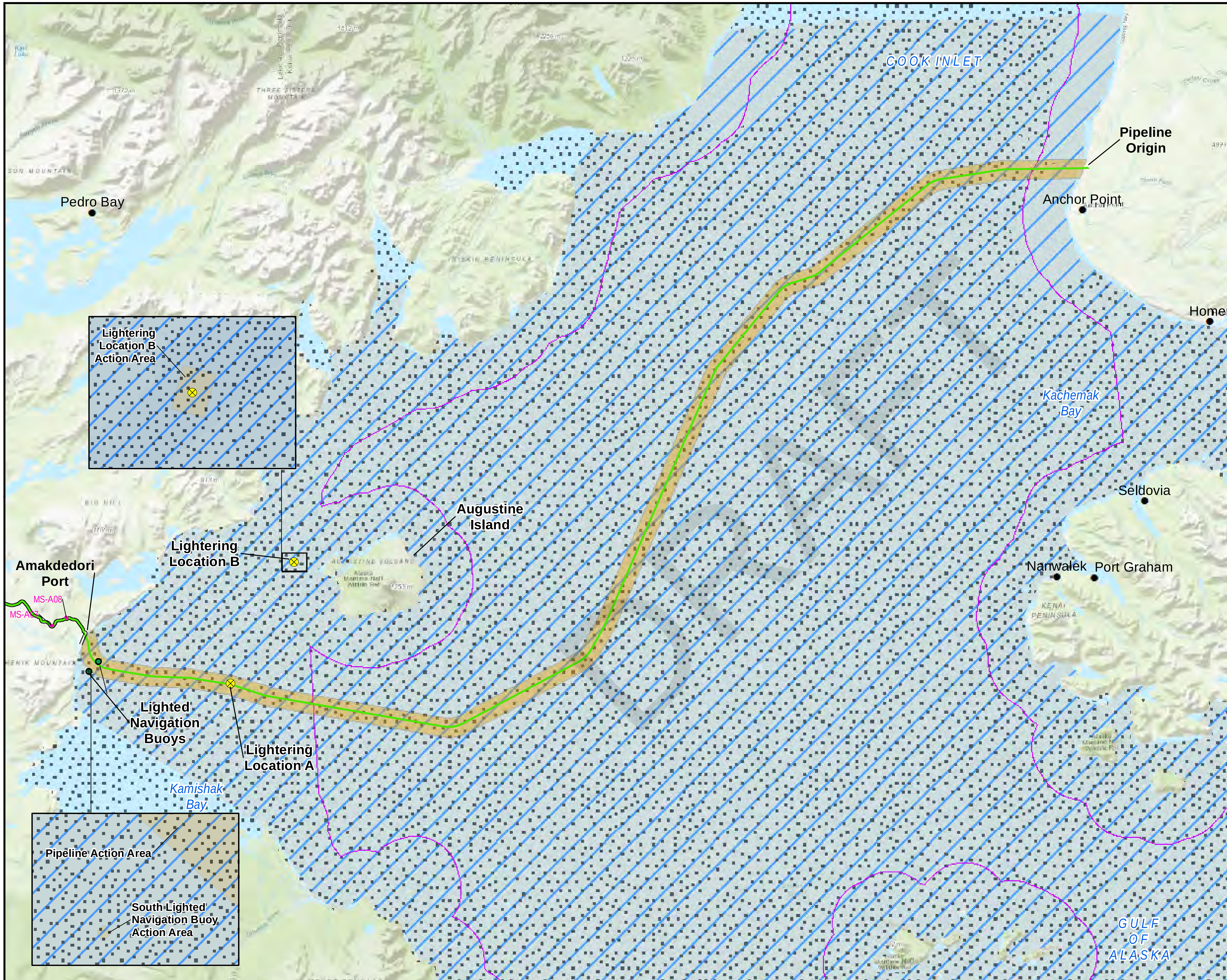
NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
4-15

Octopus EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLP146	Date: 1/14/2019
Revision: 00	Author: RC/OR



THE pebble PARTNERSHIP

EFH Action Area

EFH Species Lifestage

Larvae

Juvenile

Adult

Lighted Navigation Buoys

Lightering Locations

Proposed Access Road

Proposed Natural Gas Pipeline

Outer Continental Shelf Boundary (3nm)

Material Site

Miles

0 5 10 15 20

Scale 1:500,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

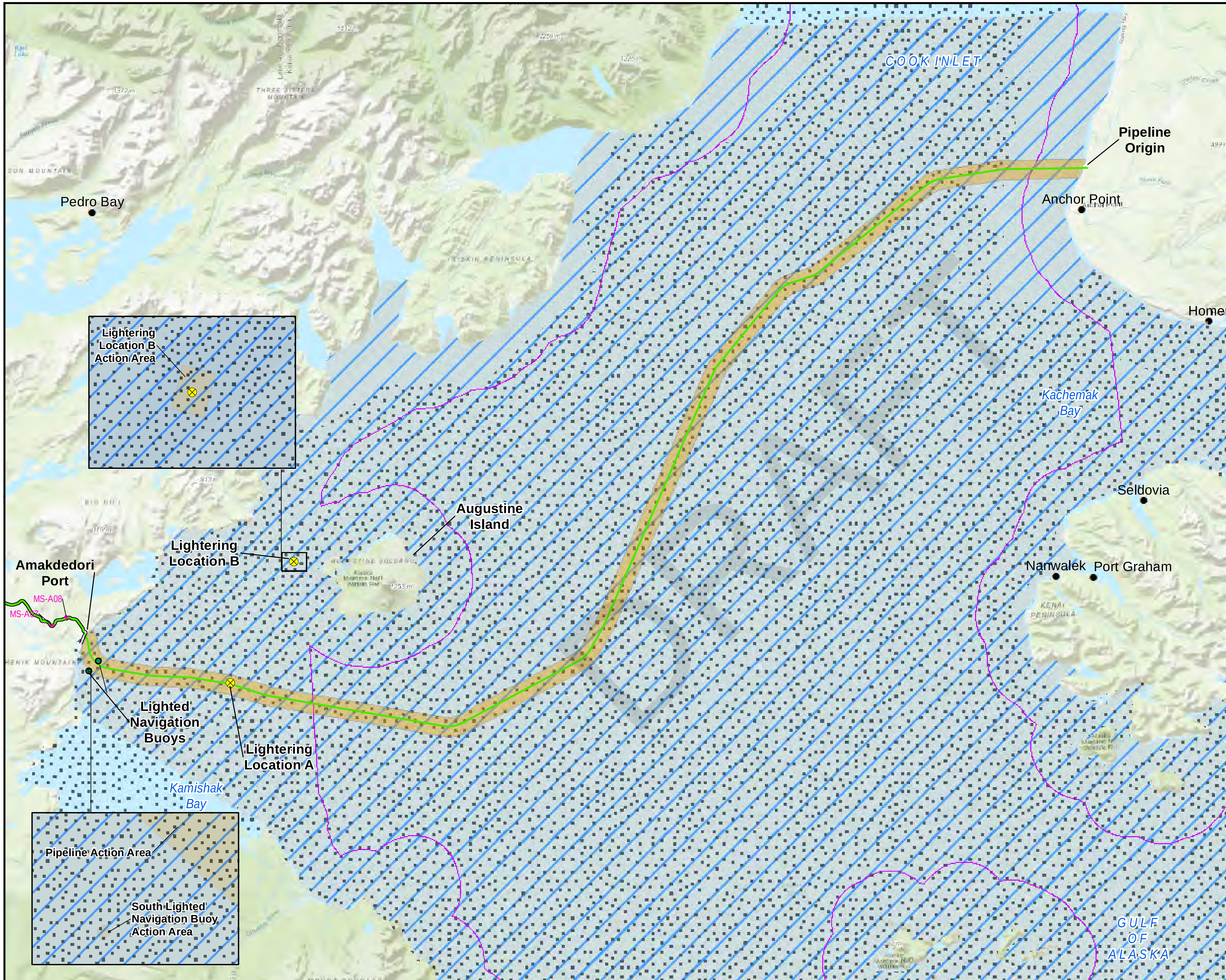
Figure:
4-16

Pacific Cod EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLP146 | Date: 1/14/2019

Revision: 00 | Author: RC/OR



THE pebble PARTNERSHIP

EFH Action Area

EFH Species Lifestage

- Larvae
- Juvenile
- Adult
- Lighted Navigation Buoys
- Lightering Locations
- Proposed Access Road
- Proposed Natural Gas Pipeline
- Outer Continental Shelf Boundary (3nm)
- Material Site

Miles
0 5 10 15 20
Scale 1:500,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

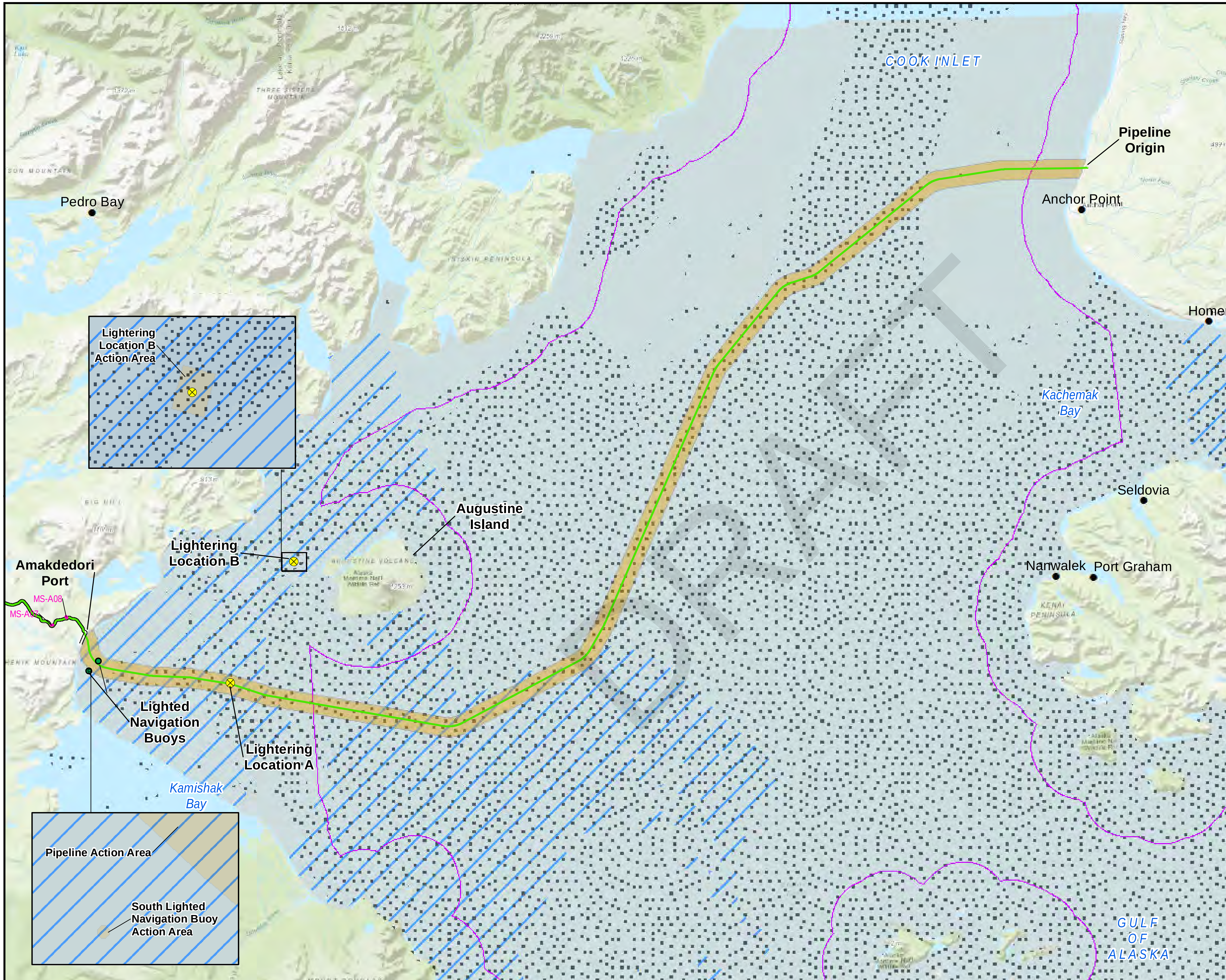
Figure:
4-17

Rockfish (Sebastes) EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLP146	Date: 1/14/2019
Revision: 00	Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP146.mxd



THE pebble PARTNERSHIP

EFH Action Area

EFH Species Lifestage

- Larvae
- Juvenile
- Adult
- Lighted Navigation Buoys
- Lightering Locations
- Proposed Access Road
- Proposed Natural Gas Pipeline
- Outer Continental Shelf Boundary (3nm)
- Material Site

Miles

0 5 10 15 20

Scale 1:500,000

NAD 1983 StatePlane Alaska 5 FIPS 5005 Seward Meridian

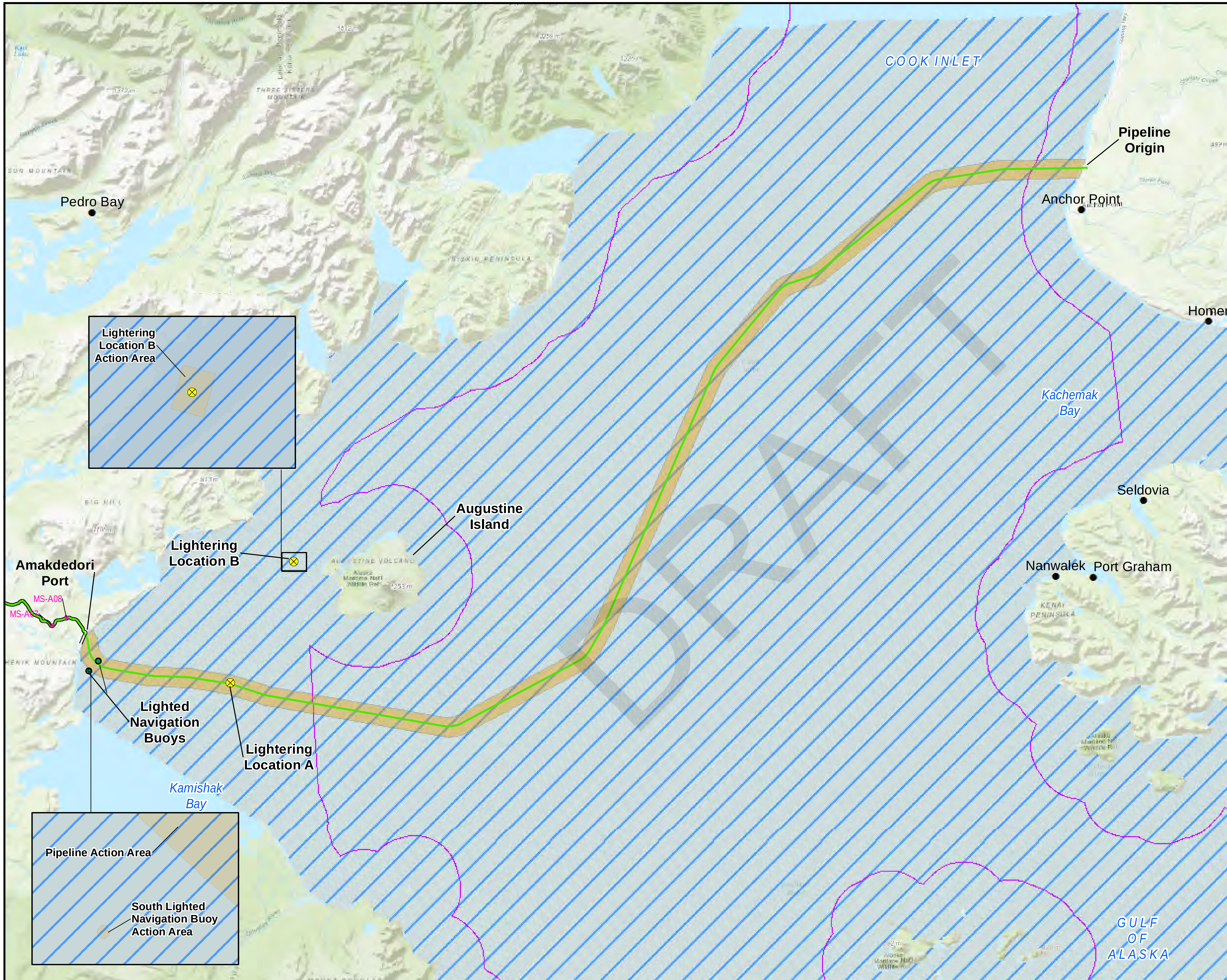
Figure: **4-18**

Sablefish EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLP146	Date: 1/14/2019
Revision: 00	Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP146.mxd



THE pebble PARTNERSHIP

EFH Action Area

EFH Species Lifestage

Juvenile

Adult

Lighted Navigation Buoys

Lightering Locations

Proposed Access Road

Proposed Natural Gas Pipeline

Outer Continental Shelf Boundary (3nm)

Material Site

Miles

0 5 10 15 20

Scale 1:500,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

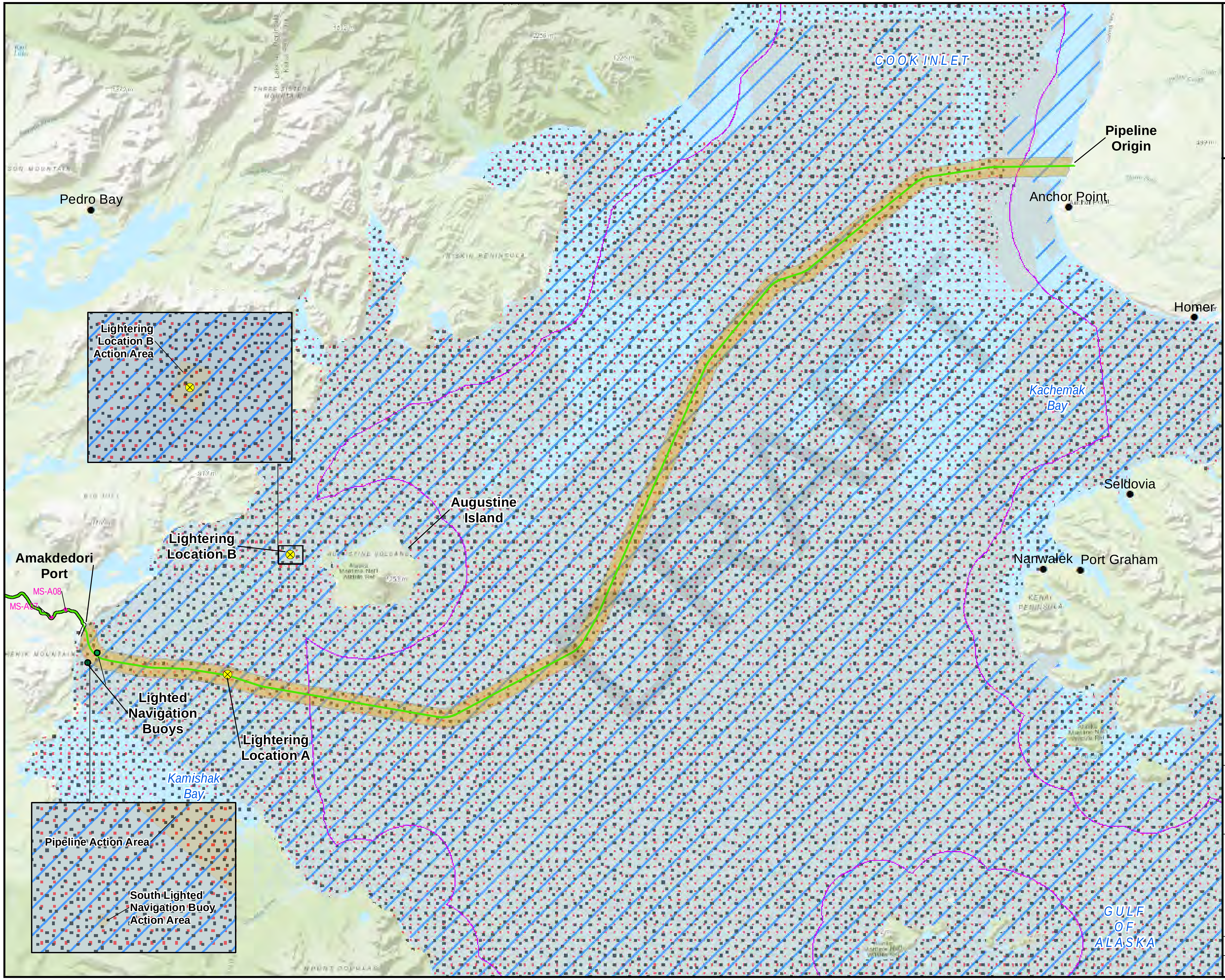
Figure:
4-19

Sculpins (Cottidae) EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLP146	Date: 1/14/2019
Revision: 00	Author: RC/OR

Document Path: G:\Pebble\ARC_Proj\MXD\PLP146.mxd



THE pebble PARTNERSHIP

EFH Action Area

EFH Species Lifestage

- Egg
- Larvae
- Juvenile
- Adult
- Lighted Navigation Buoys
- Lightering Locations
- Proposed Access Road
- Proposed Natural Gas Pipeline
- Outer Continental Shelf Boundary (3nm)
- Material Site

Miles

0 5 10 15 20

Scale 1:500,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

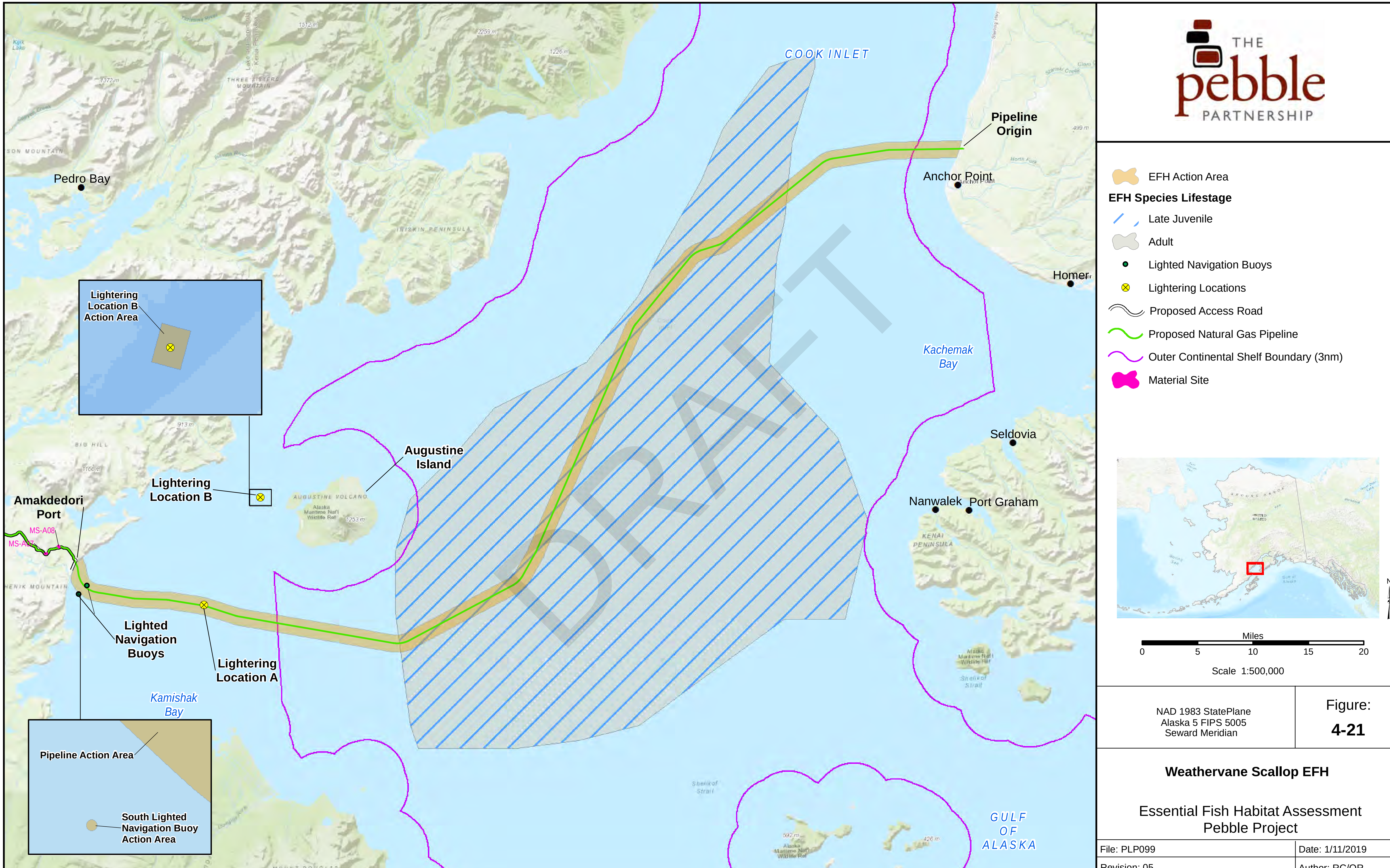
Figure: **4-20**

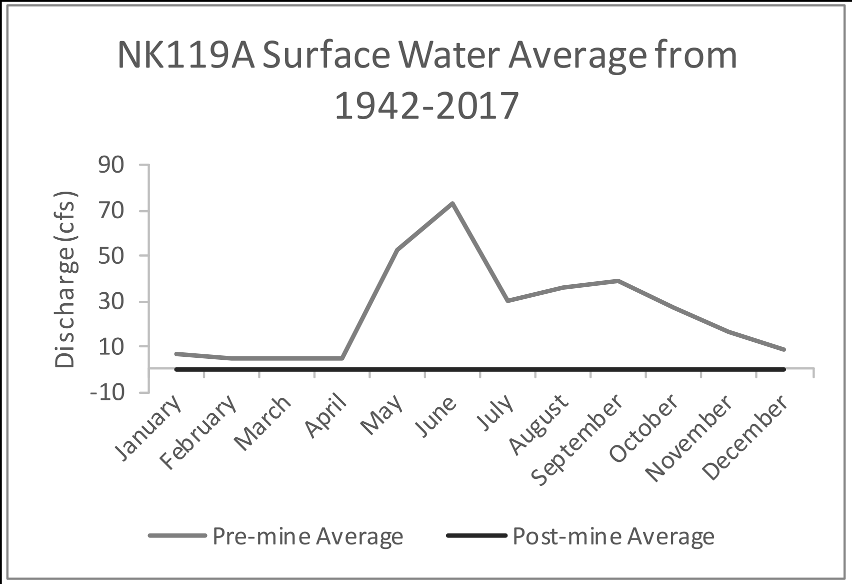
Walleye Pollock EFH

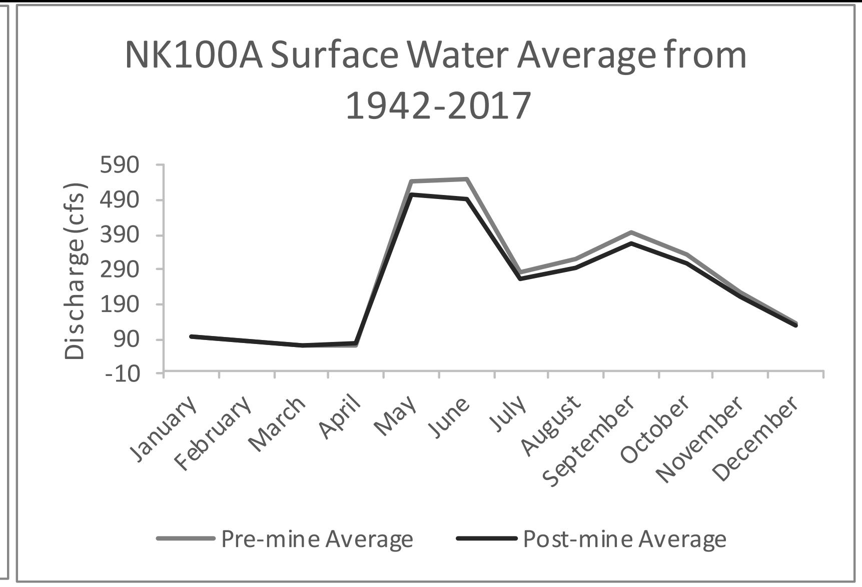
Essential Fish Habitat Assessment
Pebble Project

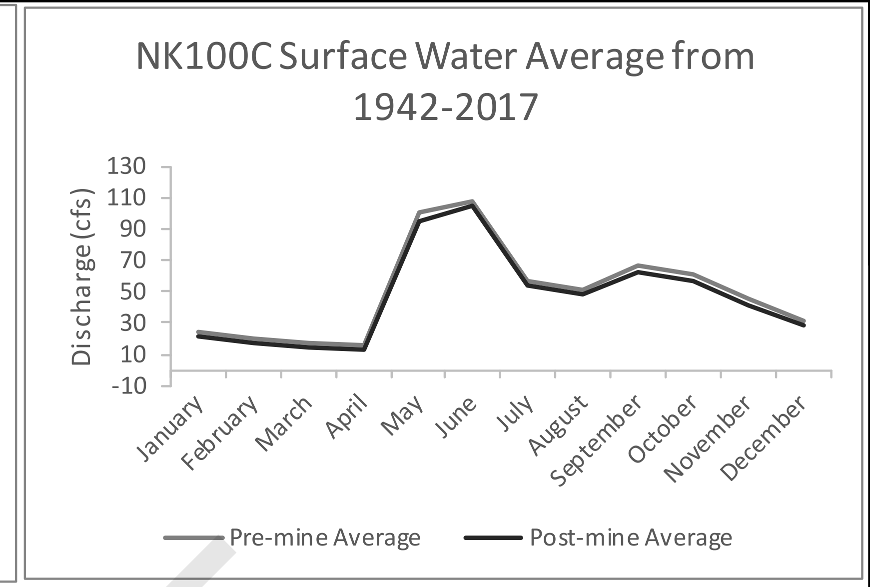
File: PLP146	Date: 1/14/2019
Revision: 00	Author: RC/OR

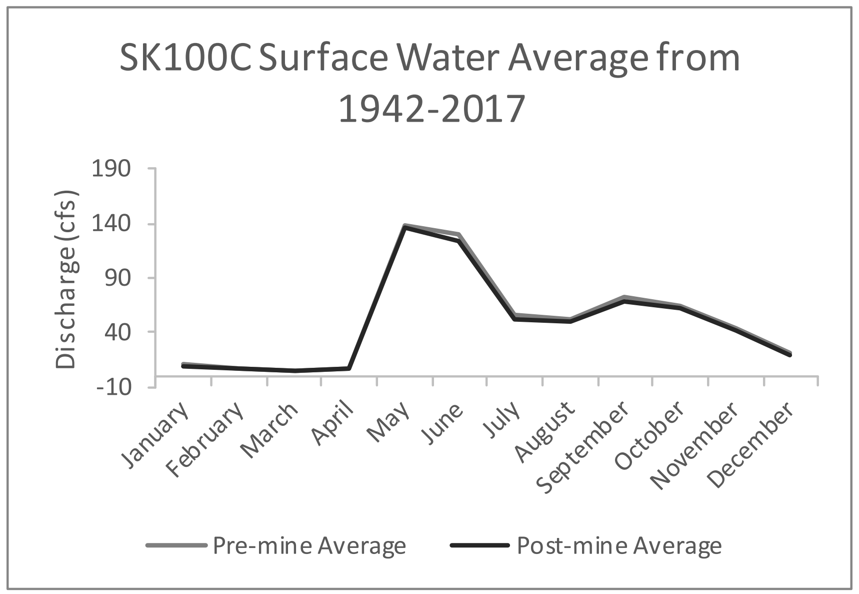
Document Path: G:\Pebble\ARC_Proj\MXD\PLP146.mxd

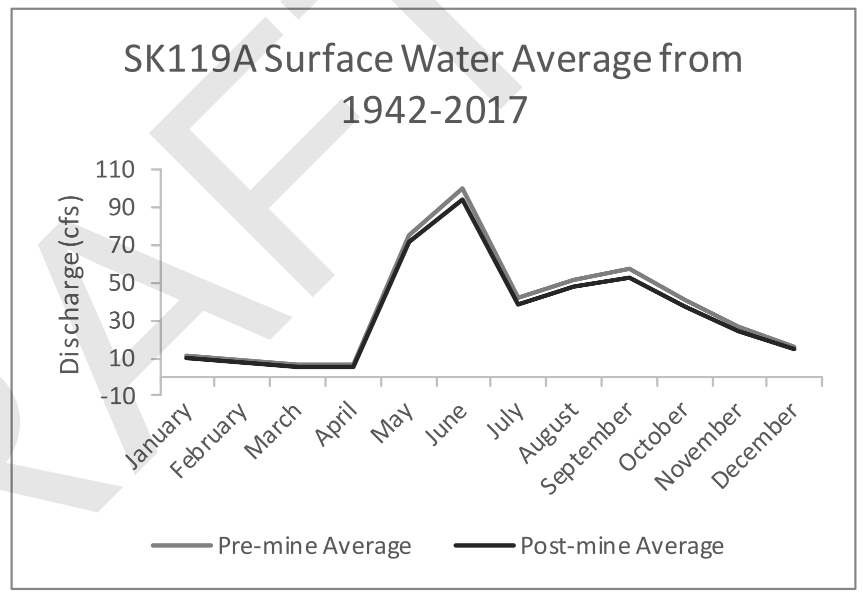

COOK INLET
Pipeline Origin
Anchor Point
Homer
Pedro Bay
Kachemak Bay
Seldovia
Nanwalek
Port Graham
Augustine Island
Lightering Location B
Lightering Location B Action Area
Amakdedori Port
MS-A08
MS-A07
Lighted Navigation Buoys
Lightering Location A
Kamishak Bay
Pipeline Action Area
South Lighted Navigation Buoy Action Area
GULF OF ALASKA
DRAFT
THE pebble PARTNERSHIP
EFH Action Area
EFH Species Lifestage
Late Juvenile
Adult
Lighted Navigation Buoys
Lightering Locations
Proposed Access Road
Proposed Natural Gas Pipeline
Outer Continental Shelf Boundary (3nm)
Material Site
Miles
0 5 10 15 20
Scale 1:500,000
NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian
Figure:
4-21
Weathervane Scallop EFH
Essential Fish Habitat Assessment
Pebble Project
File: PLP099
Date: 1/11/2019
Revision: 05
Author: RC/OR

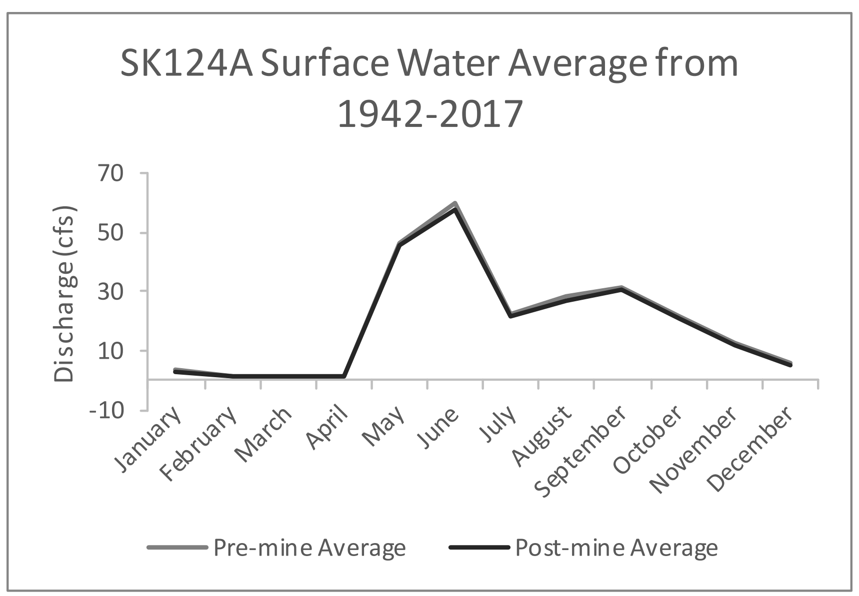


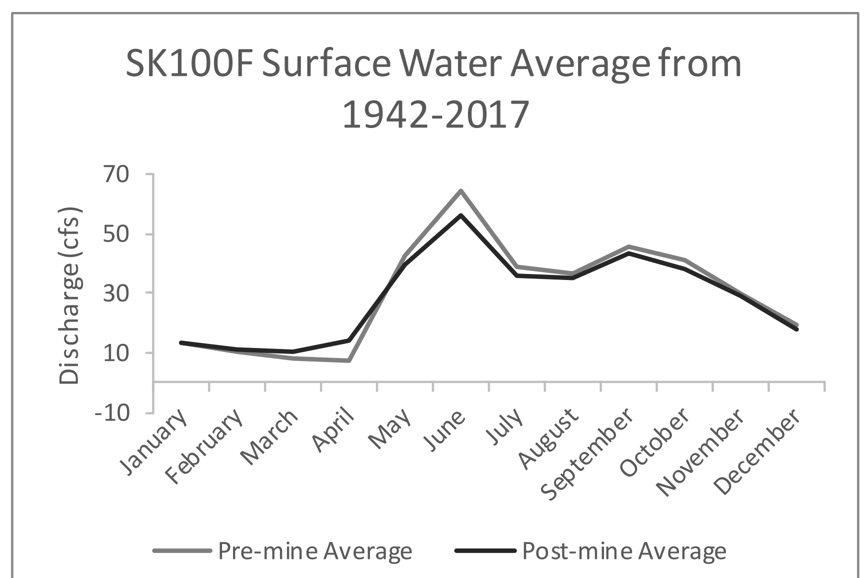












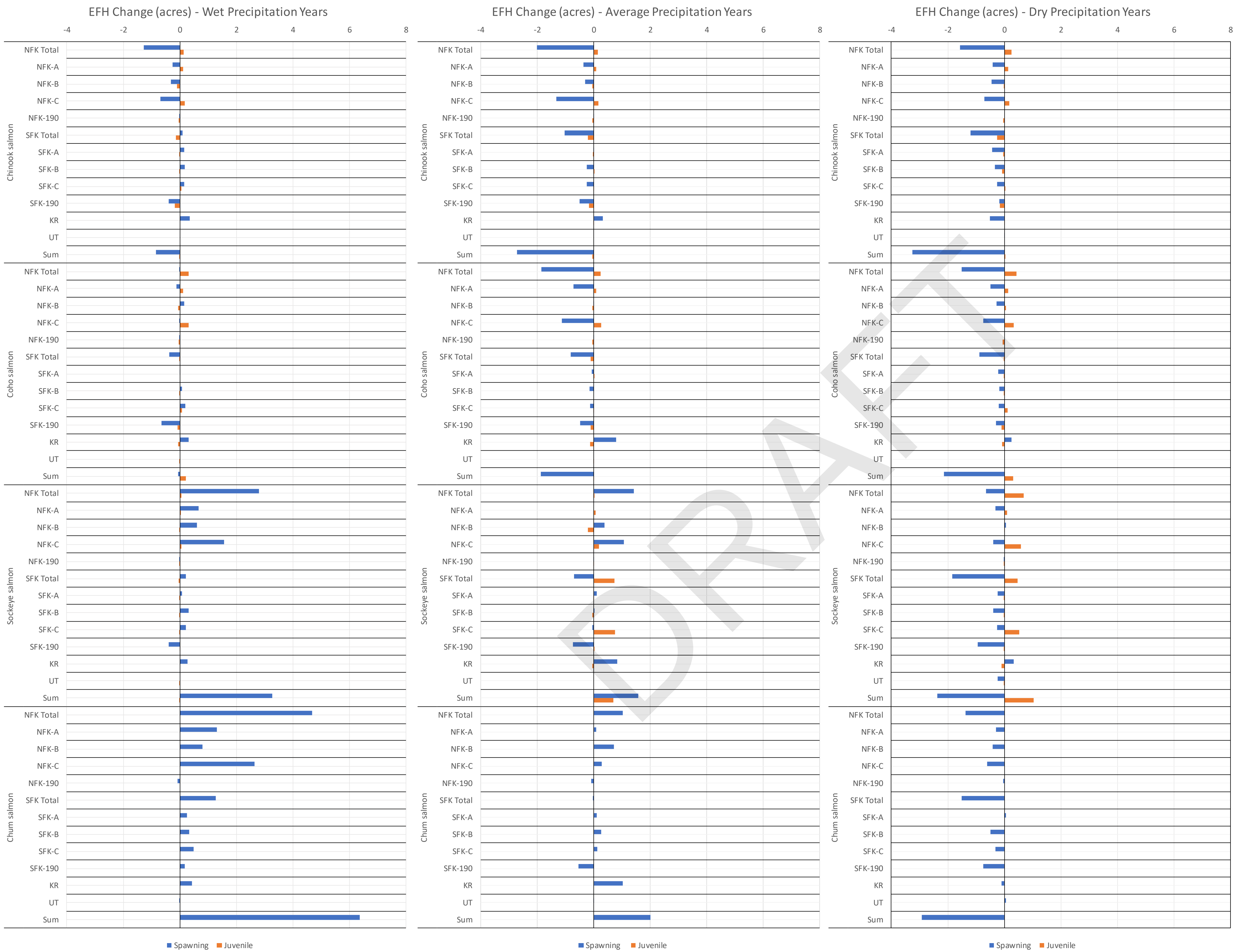
THE pebble PARTNERSHIP

Figure:
5-1

NFK AND SFK FULL FLOW SERIES FOR SELECTED SITES

Essential Fish Habitat Assessment
Pebble Project

File: PLP_Fig5_2.vsdx	Date: 12/21/2018
Revision: 01	Author: RC/OR



Change in Pacific salmon spawning and juvenile rearing habitat modeled for wet, average, and dry precipitation years (pre-mine and after release of treated surplus water).

Refer to Table 5-3 for acreage values.

Figure:

5-2

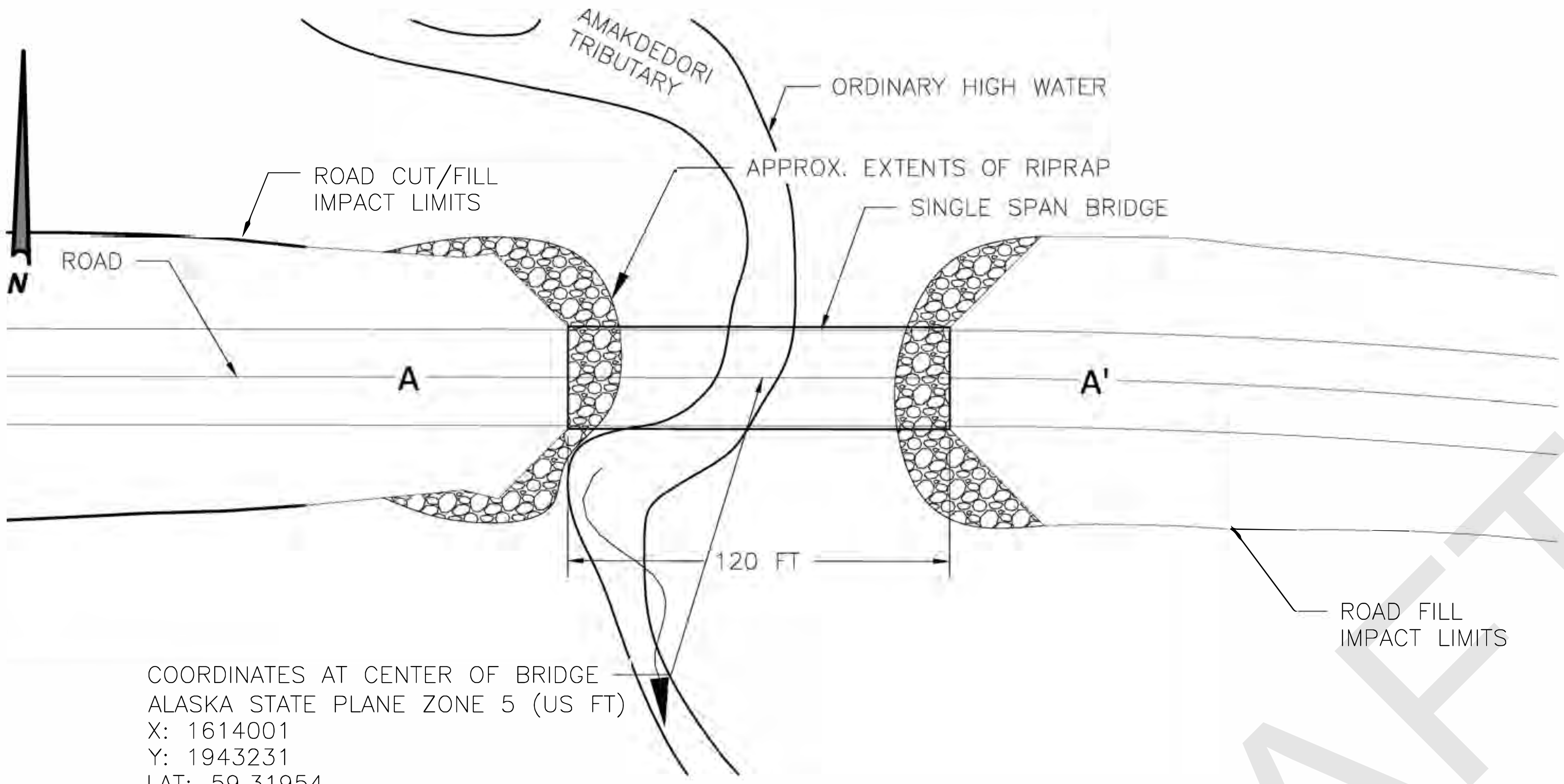
Preliminary Watershed Modeling Results of Estimated Change

Essential Fish Habitat Assessment
Pebble Project

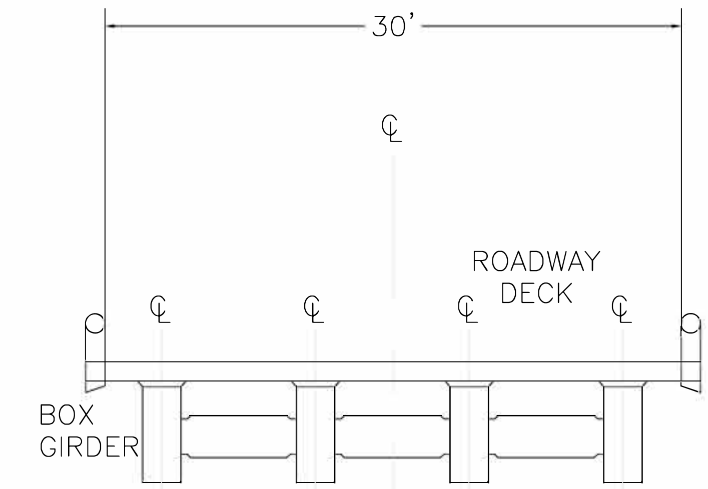
File: PLP114	Date: 11/16/2018
Revision: 02	Author: RC/OR

APPENDIX A
CONCEPTUAL BRIDGE AND CULVERT DESIGNS

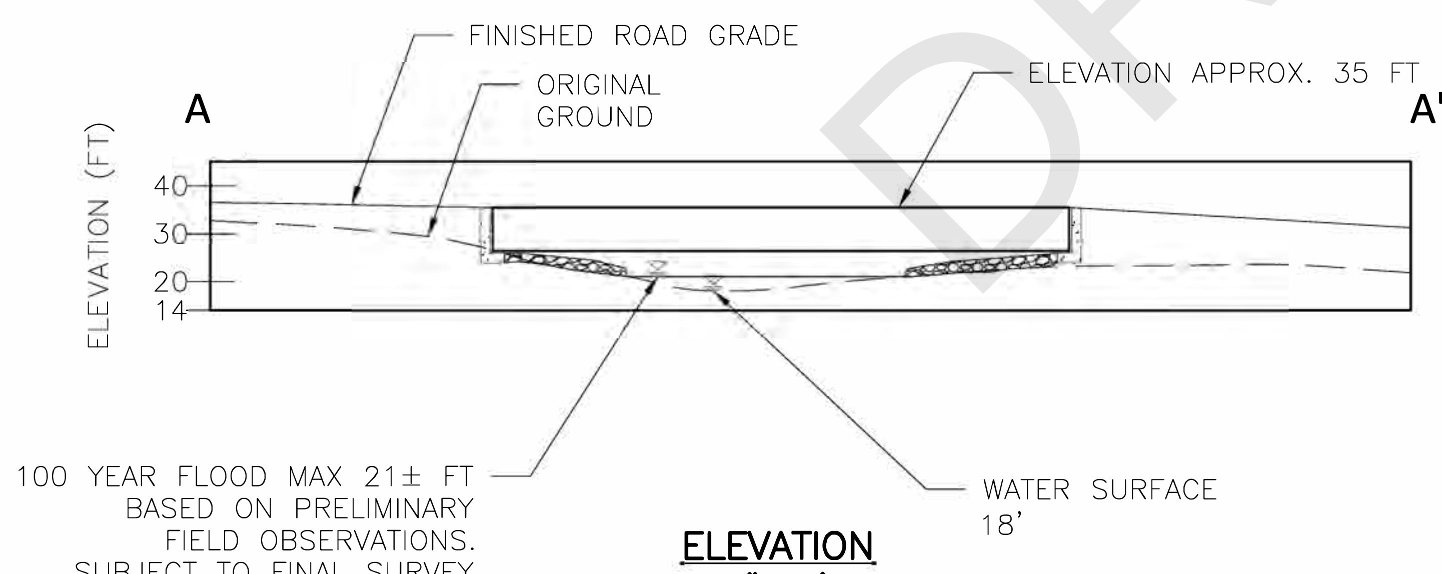
APPENDIX A - CONCEPTUAL BRIDGE AND CULVERT DESIGNS



PLAN
1":50'



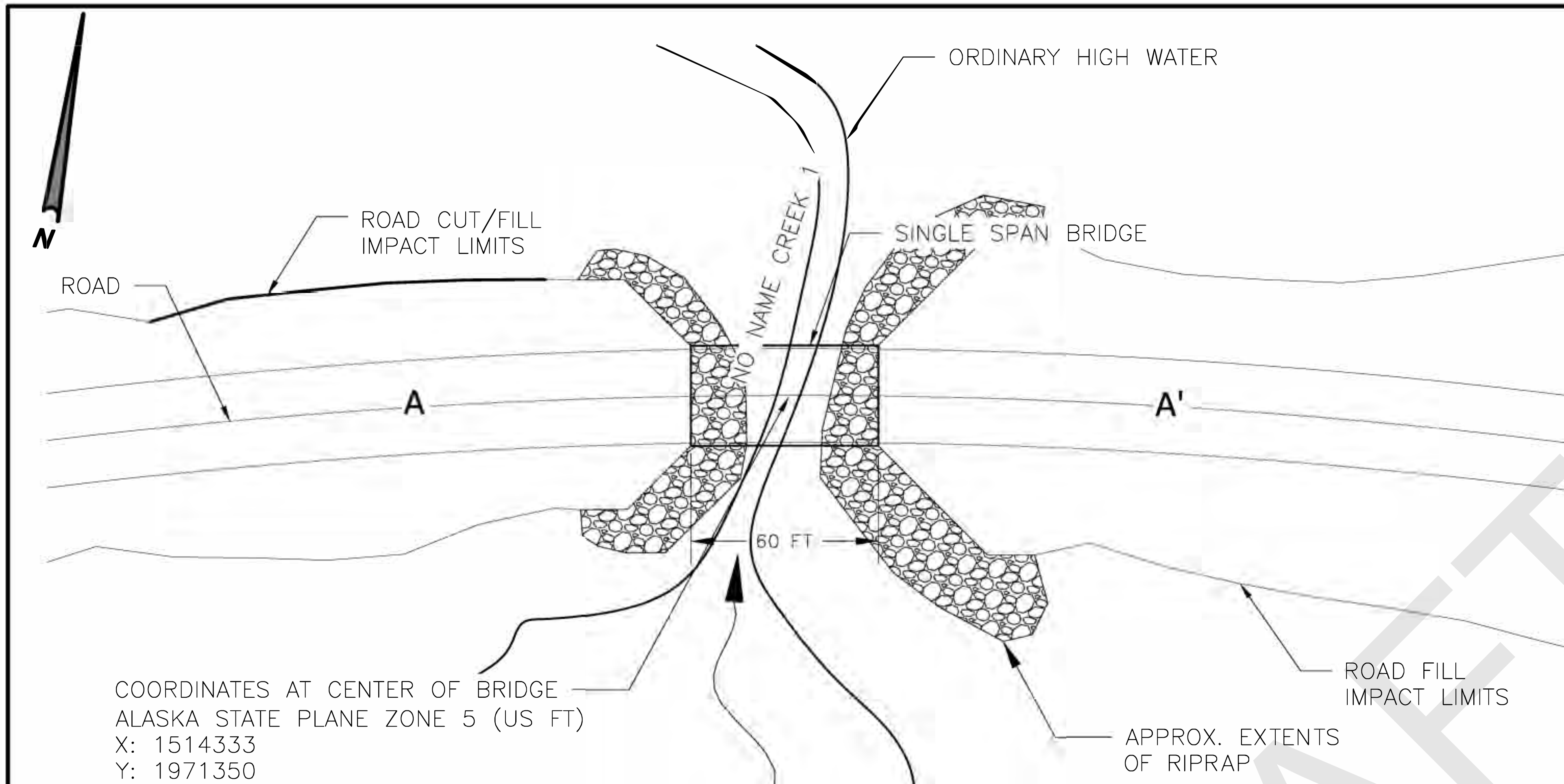
TYPICAL SECTION
1":10'



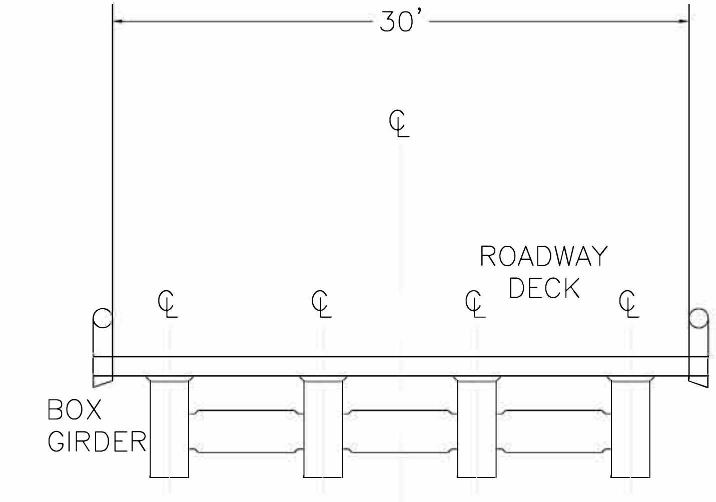
ELEVATION
1"=40'

CONCEPTUAL PLANS SHOW PRELIMINARY INTERPRETATION OF HYDROLOGY & TERRAIN. AS SHOWN HEREON, THE PLAN REASONABLY REPRESENTS CROSSING SITE CHARACTERISTICS.

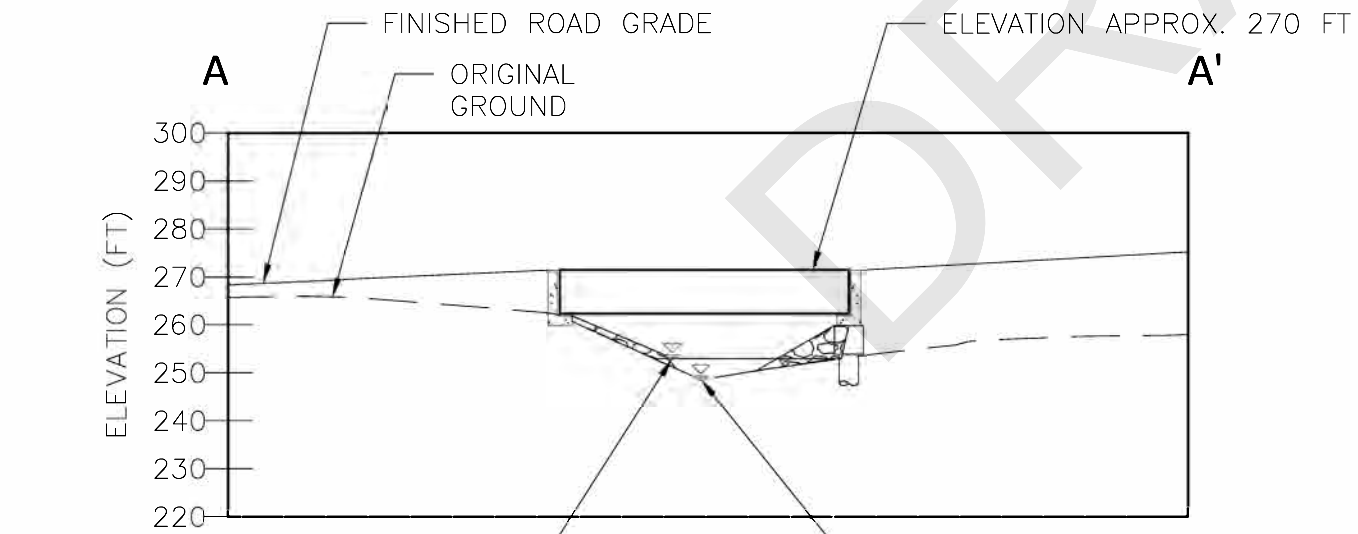
APPLICANT: PEBBLE LIMITED PARTNERSHIP	PEBBLE PROJECT AMAKDEDORI TRIBUTATY BRIDGE (A002) PLAN, PROFILE AND TYPICAL SECTION	SHEET NO. 1 OF 9
ADDRESS: 3201 C STREET, SUITE 604 ANCHORAGE, AK 99503		
WATERWAY: AMAKDEDORI TRIBUTARY		
	11" X 17" December 19, 2018	



PLAN
1":50'



TYPICAL SECTION
1":10'



ELEVATION
1"=40'

CONCEPTUAL PLANS SHOW PRELIMINARY INTERPRETATION OF HYDROLOGY & TERRAIN. AS SHOWN HEREON, THE PLAN REASONABLY REPRESENTS CROSSING SITE CHARACTERISTICS.

APPLICANT: PEBBLE LIMITED PARTNERSHIP

ADDRESS: 3201 C STREET, SUITE 604 ANCHORAGE, AK 99503

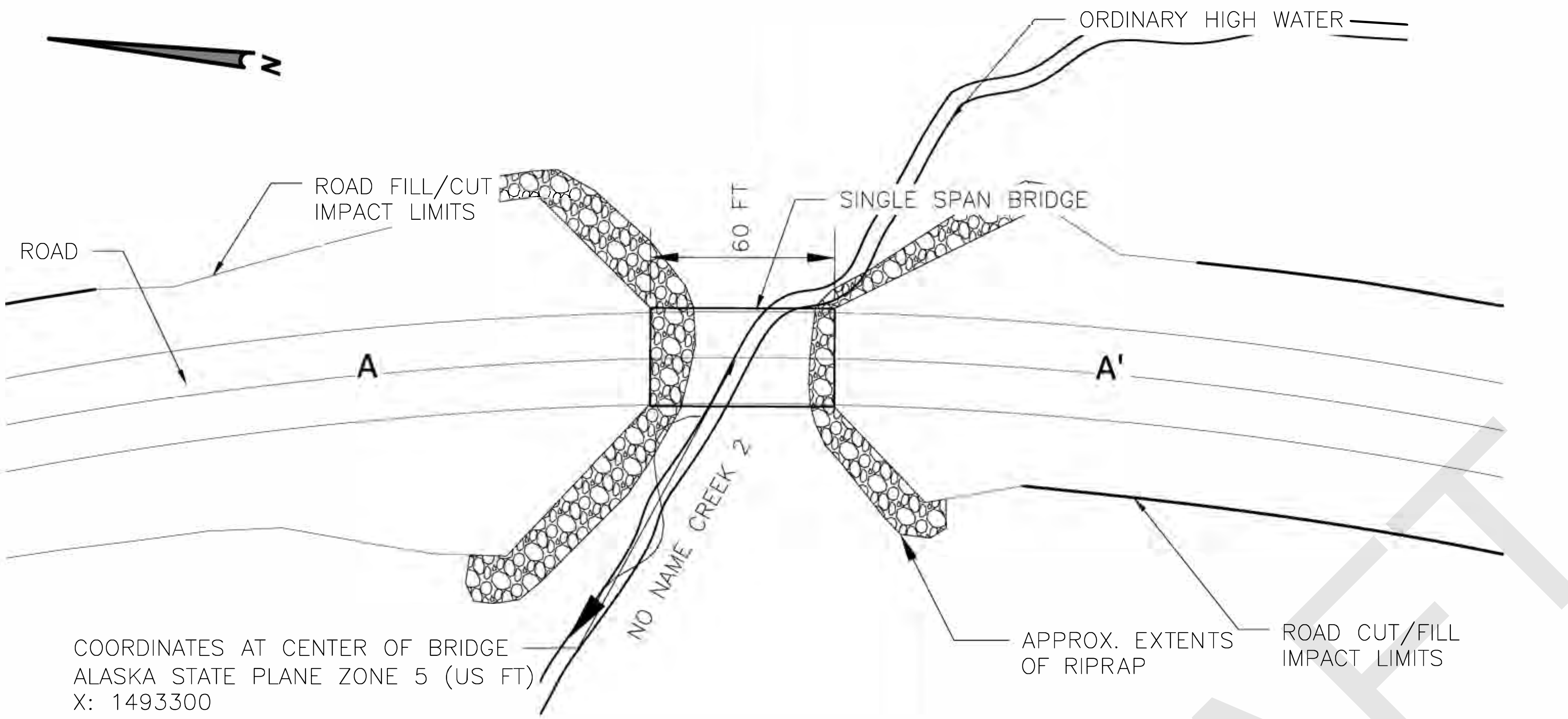
WATERWAY: NO NAME CREEK 1

PEBBLE PROJECT
NO NAME CREEK 1 BRIDGE (A023)
PLAN, PROFILE AND TYPICAL SECTION

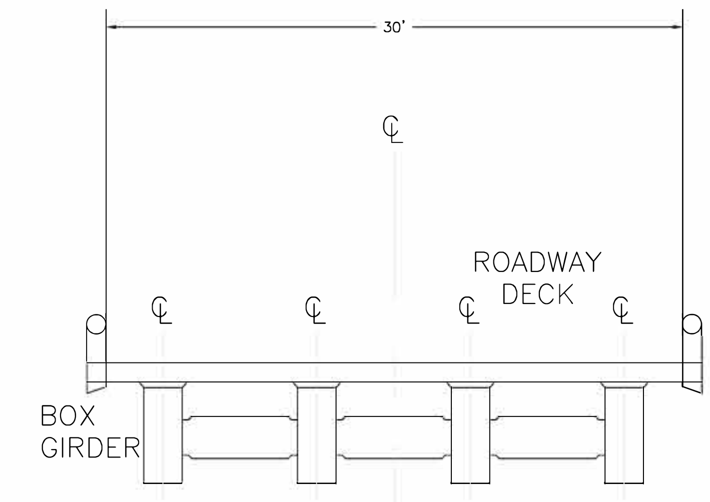
11" X 17"

December 19, 2018

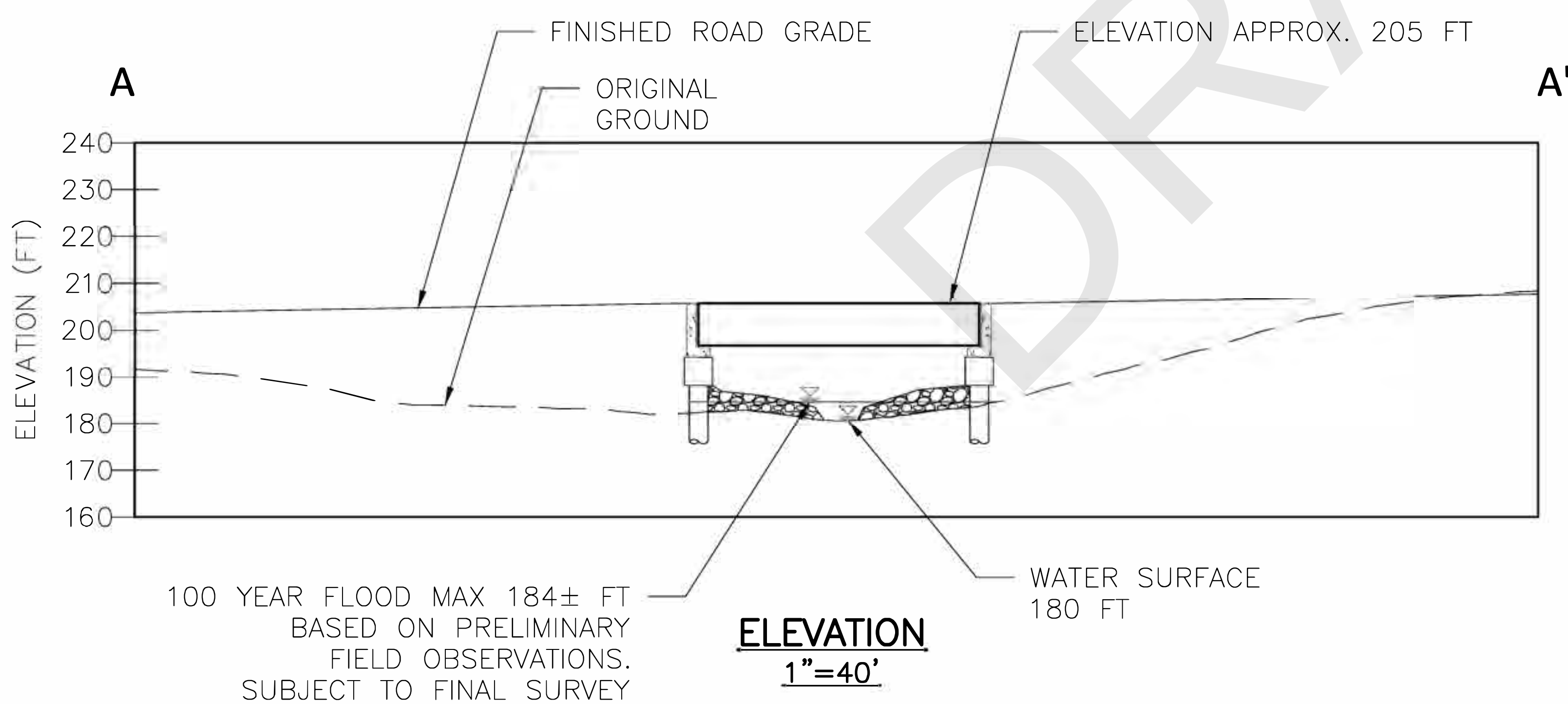
ACAD FILE: 4_No Name 1 Bridge 404_181218.dwg



PLAN
1":50'



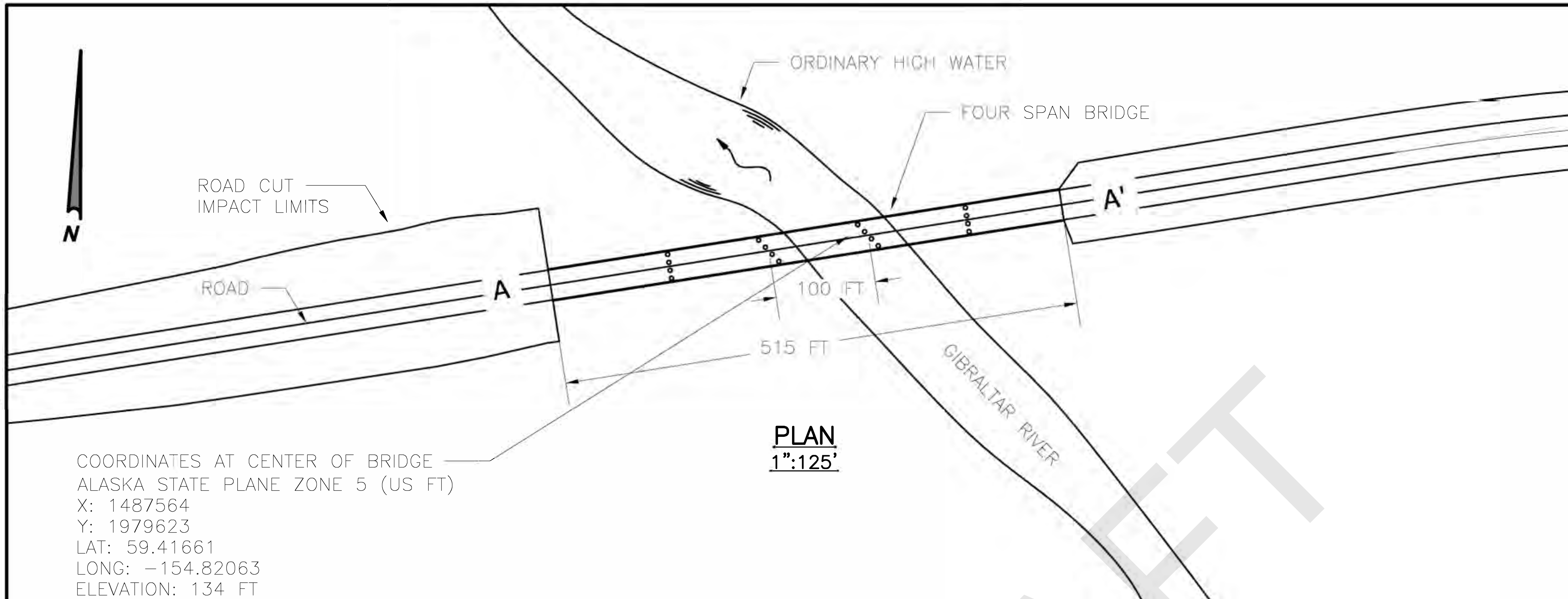
TYPICAL SECTION
1":10'



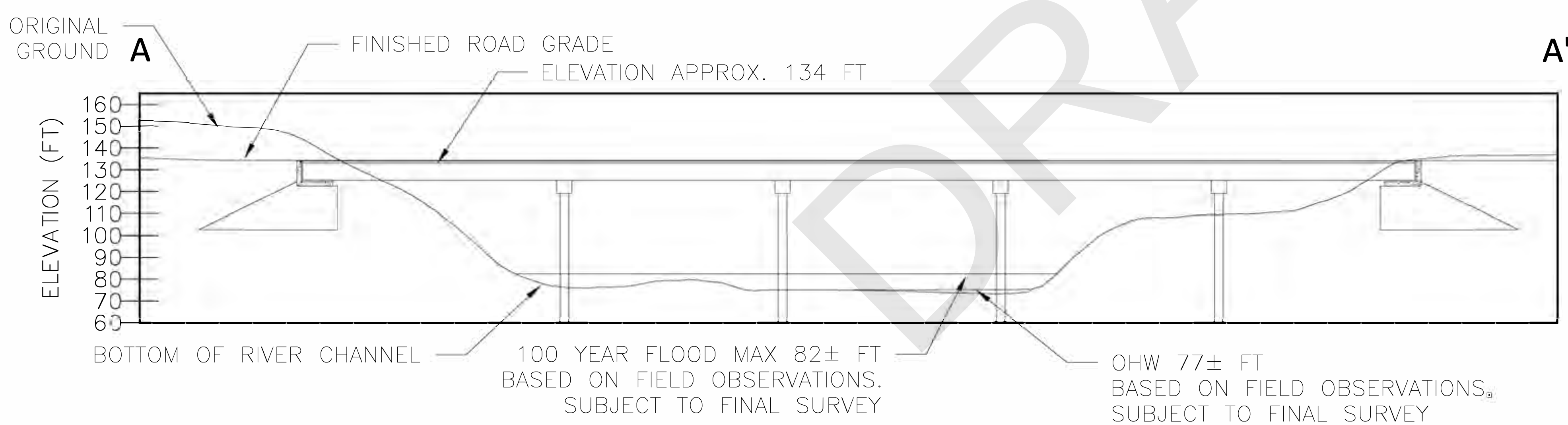
ELEVATION
1"=40'

CONCEPTUAL PLANS SHOW PRELIMINARY INTERPRETATION OF HYDROLOGY & TERRAIN. AS SHOWN HEREON, THE PLAN REASONABLY REPRESENTS CROSSING SITE CHARACTERISTICS.

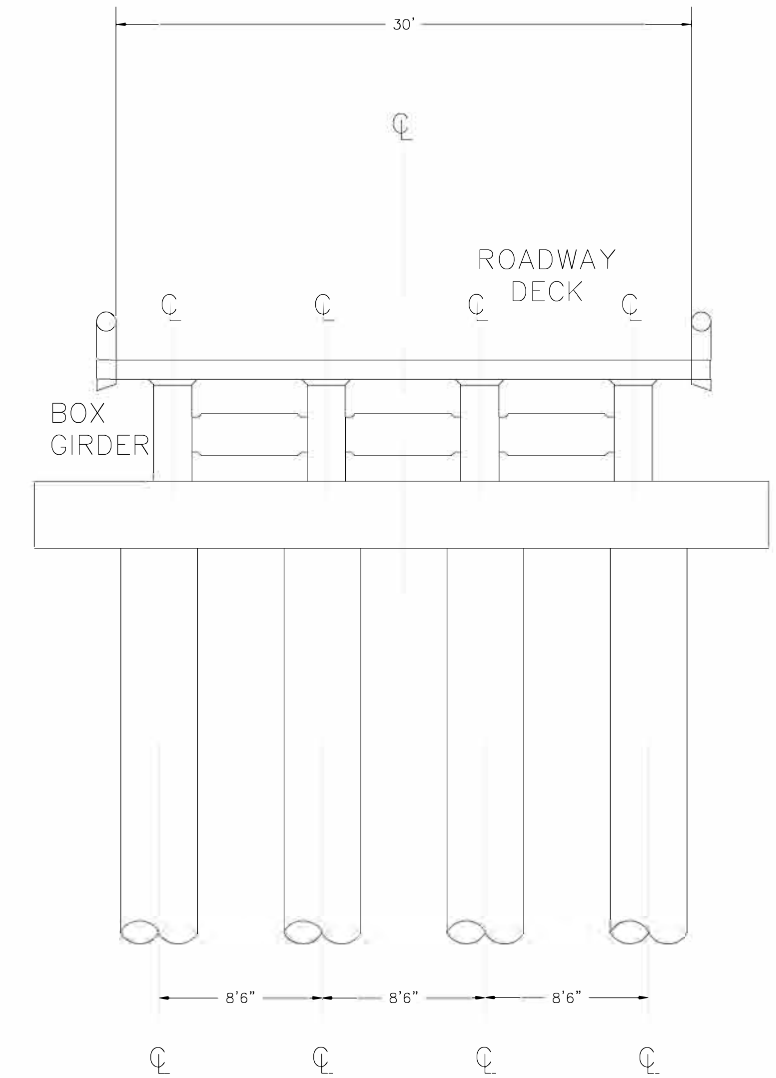
APPLICANT: PEBBLE LIMITED PARTNERSHIP ADDRESS: 3201 C STREET, SUITE 604 ANCHORAGE, AK 99503 WATERWAY: NO NAME CREEK 2	PEBBLE PROJECT NO NAME CREEK 2 BRIDGE (A028) PLAN, PROFILE AND TYPICAL SECTION 11" X 17" December 19, 2018		SHEET NO. 5 OF 9



PLAN
1":125'



ELEVATION
1":70'



TYPICAL SECTION
1":20'

CONCEPTUAL PLANS SHOW PRELIMINARY INTERPRETATION OF HYDROLOGY & TERRAIN. AS SHOWN HEREON, THE PLAN REASONABLY REPRESENTS CROSSING SITE CHARACTERISTICS.

APPLICANT: PEBBLE LIMITED PARTNERSHIP

ADDRESS: 3201 C STREET, SUITE 604 ANCHORAGE, AK 99503

WATERWAY: GILBRALTAR RIVER

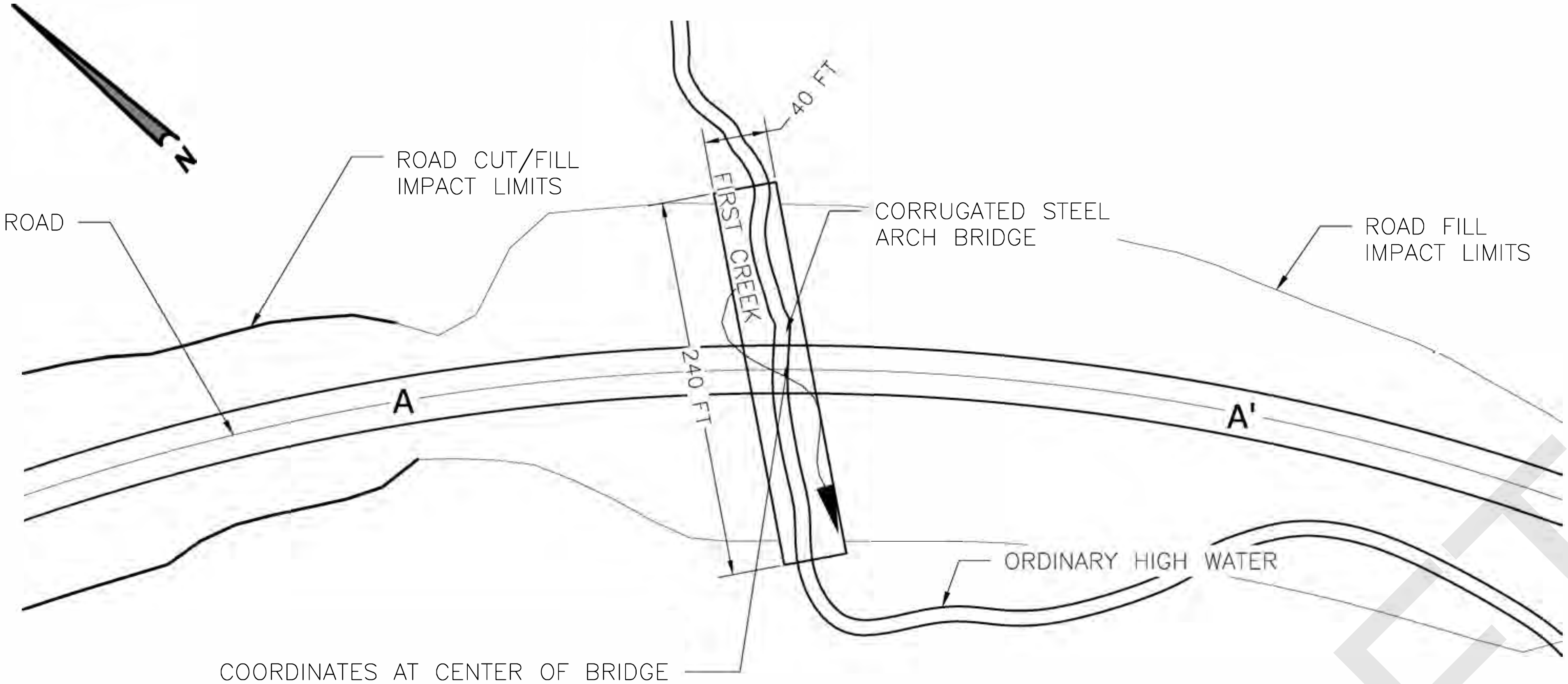
DRAWN BY: IJR

PEBBLE PROJECT
GILBRALTAR BRIDGE (A030)
PLAN, PROFILE AND TYPICAL SECTION

11" X 17"

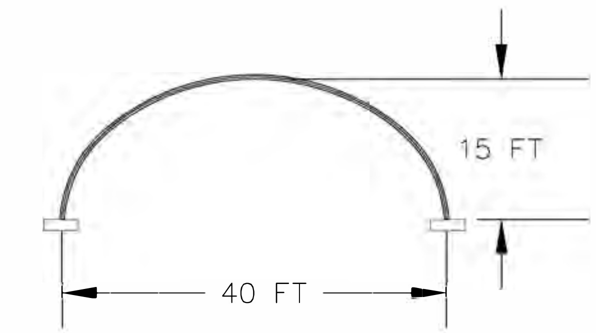
December 17, 2018

SHEET NO.
6 OF 9

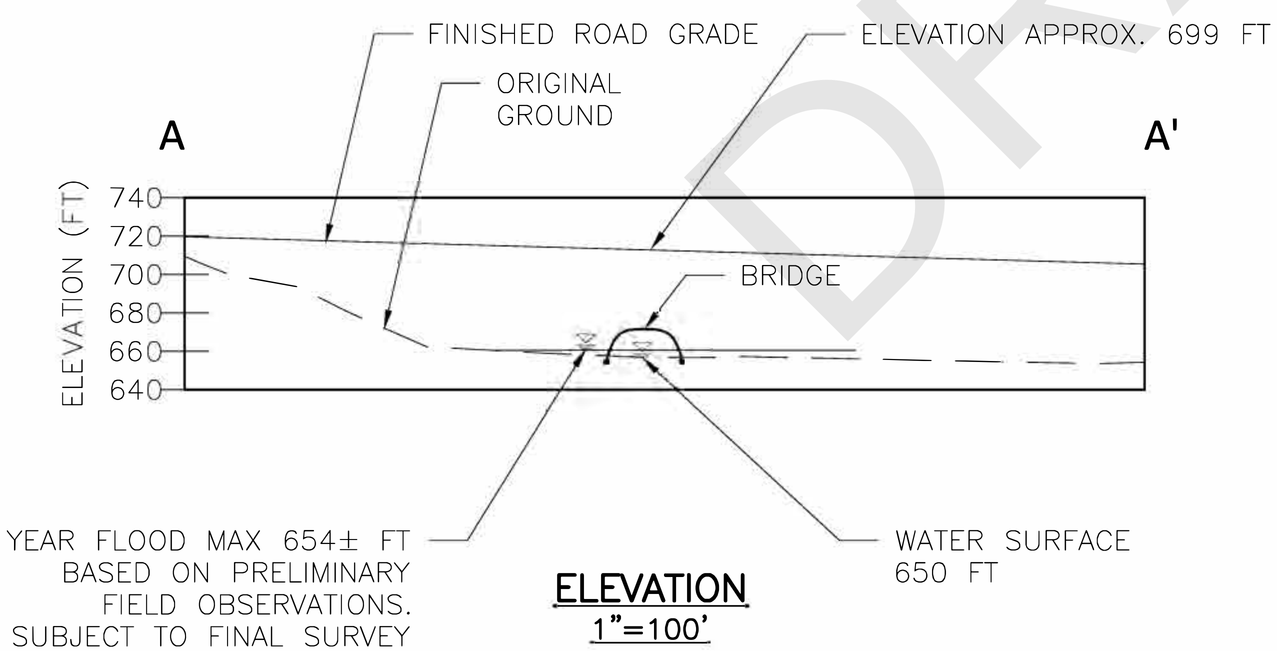


COORDINATES AT CENTER OF BRIDGE
ALASKA STATE PLANE ZONE 5 (US FT)
X: 1444456
Y: 2124949
LAT: 59.81253
LONG: −154.06453
ELEVATION: 699 FT

PLAN
1":100'



TYPICAL SECTION
1":20'

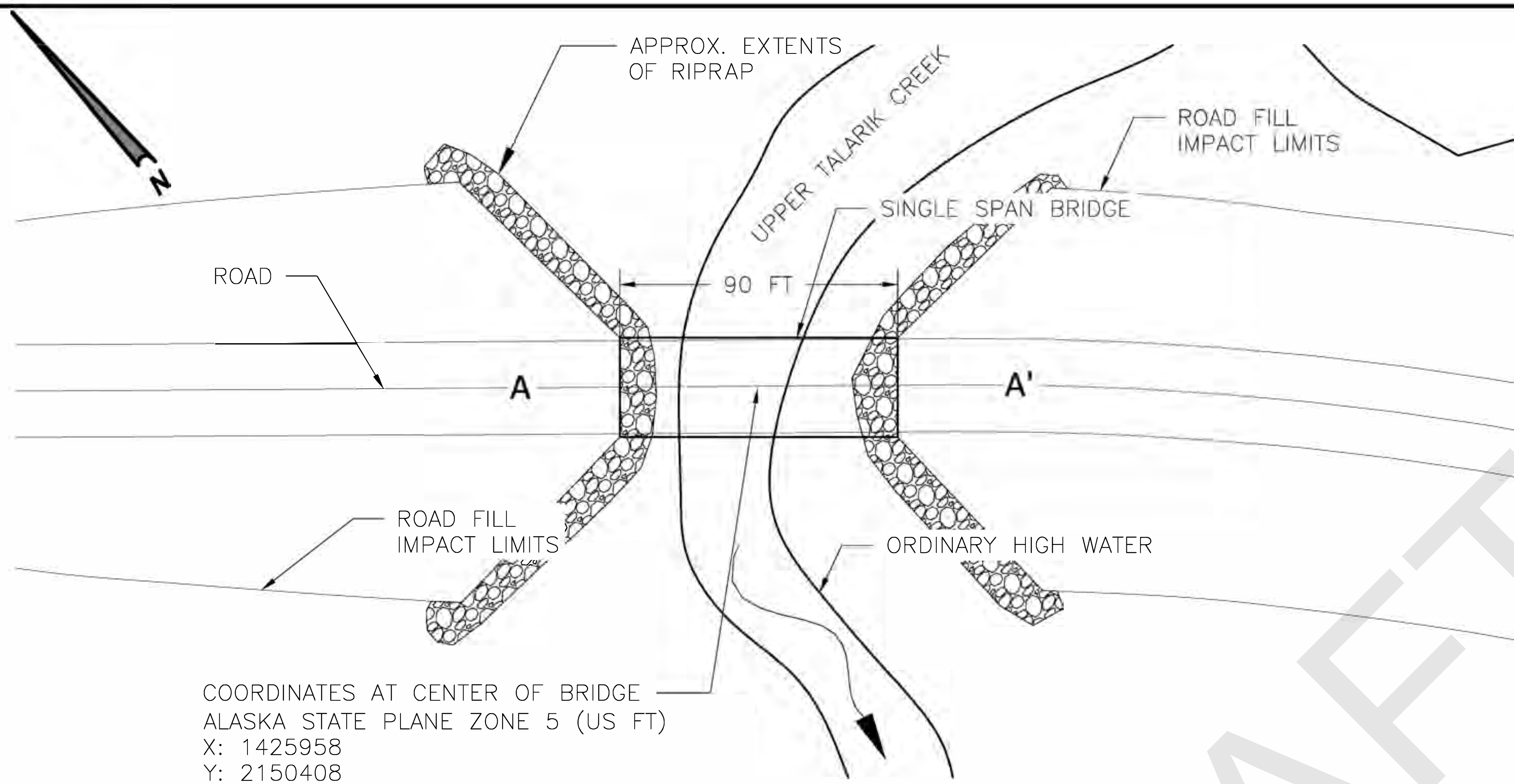


ELEVATION
1"=100'

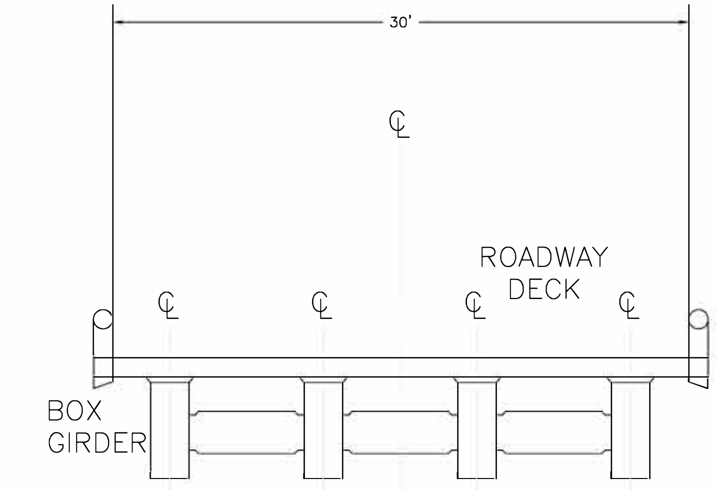
DRAFT

CONCEPTUAL PLANS SHOW PRELIMINARY INTERPRETATION OF HYDROLOGY & TERRAIN. AS SHOWN HEREON, THE PLAN REASONABLY REPRESENTS CROSSING SITE CHARACTERISTICS.

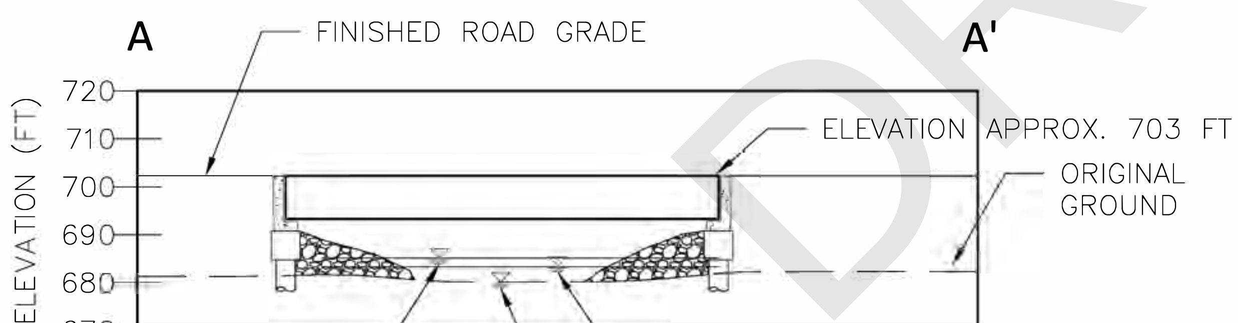
APPLICANT: PEBBLE LIMITED PARTNERSHIP	PEBBLE PROJECT FIRST CREEK BRIDGE (A035) PLAN, PROFILE AND TYPICAL SECTION		SHEET NO. 7 OF 9
ADDRESS: 3201 C STREET, SUITE 604 ANCHORAGE, AK 99503			
WATERWAY: FIRST CREEK			
	11" X 17" December 19, 2018		ACAD FILE: 7_First Crk Bridge 404_181219.dwg



PLAN
1":50'



TYPICAL SECTION
1":10'



ELEVATION
1":70'

CONCEPTUAL PLANS SHOW PRELIMINARY INTERPRETATION OF HYDROLOGY & TERRAIN. AS SHOWN HEREON, THE PLAN REASONABLY REPRESENTS CROSSING SITE CHARACTERISTICS.

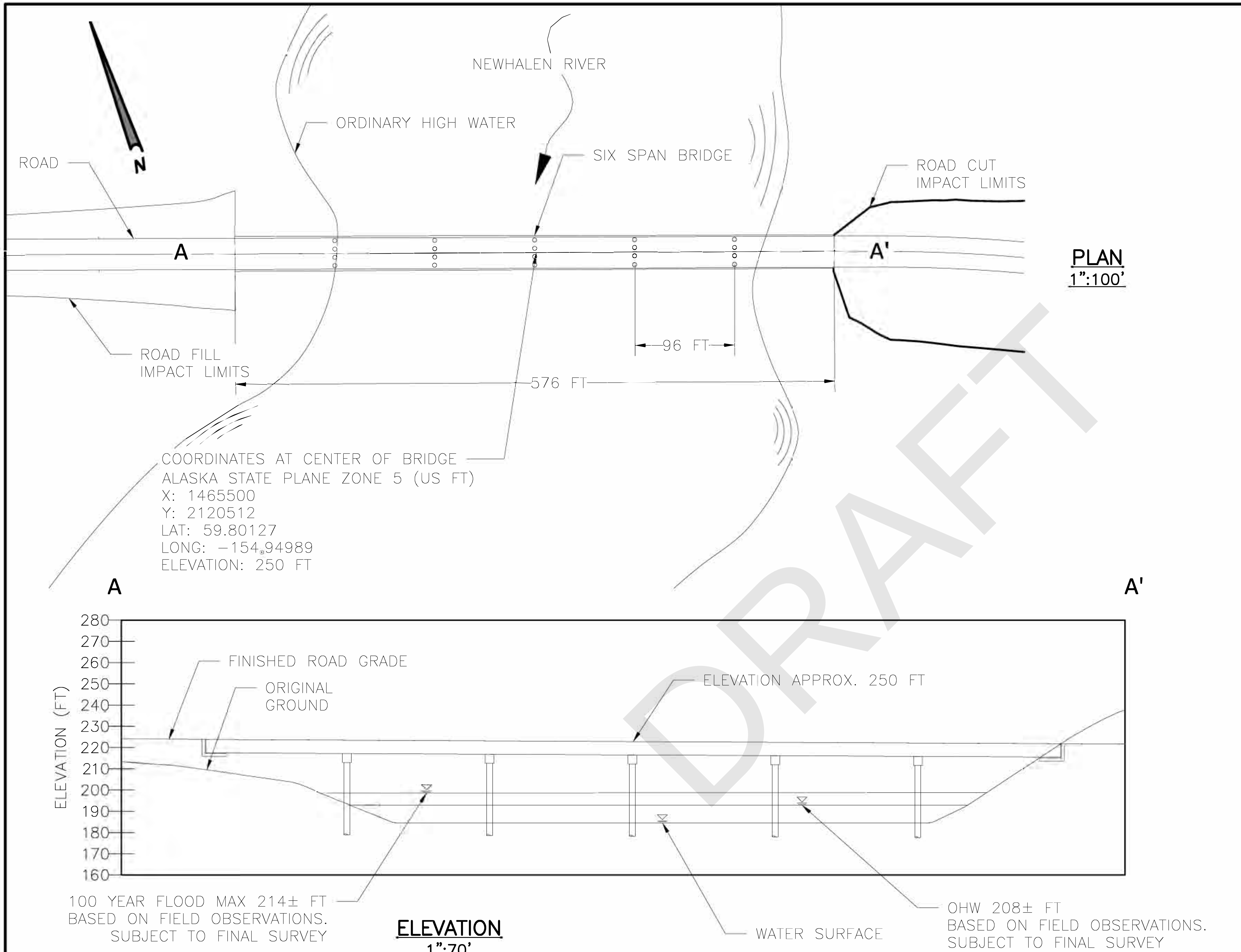
APPLICANT: PEBBLE LIMITED PARTNERSHIP
ADDRESS: 3201 C STREET, SUITE 604 ANCHORAGE, AK 99503
WATERWAY: UPPER TALARIK CREEK

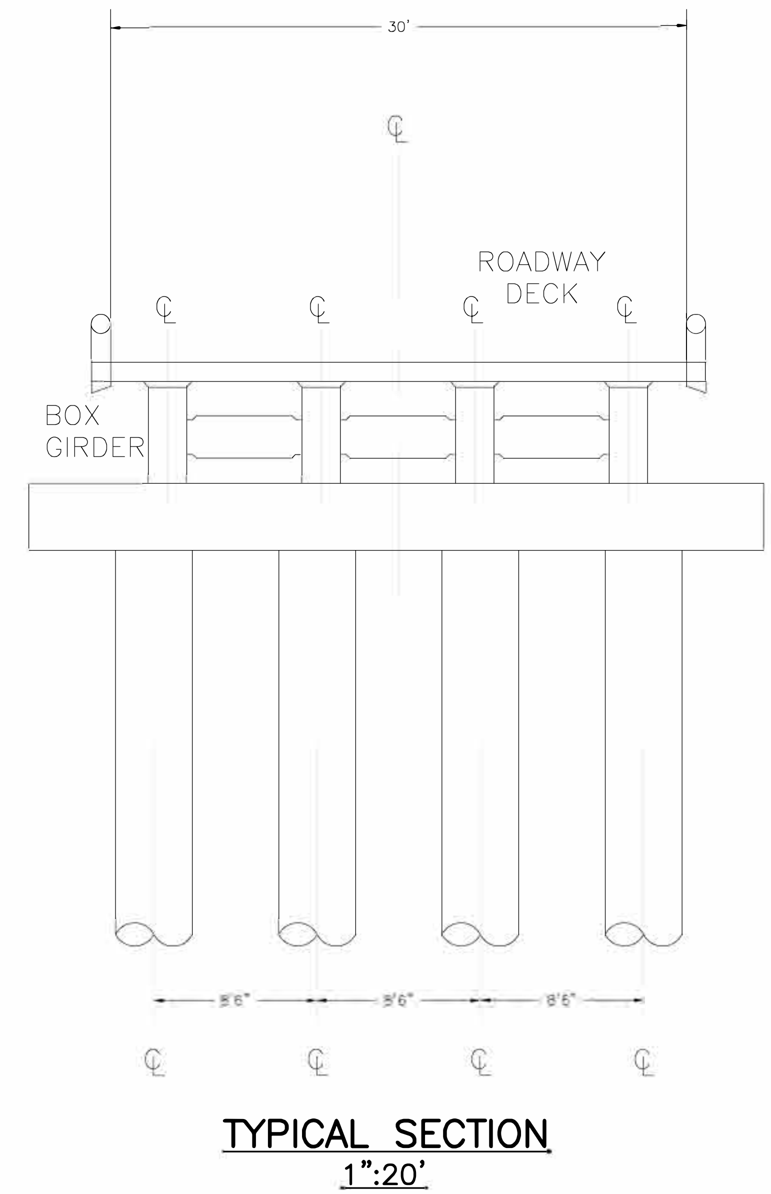
PEBBLE PROJECT
UPPER TALARIK CREEK BRIDGE (A038)
PLAN, PROFILE AND TYPICAL SECTION

11" X 17"
December 19, 2018

SHEET NO.
9 OF 9

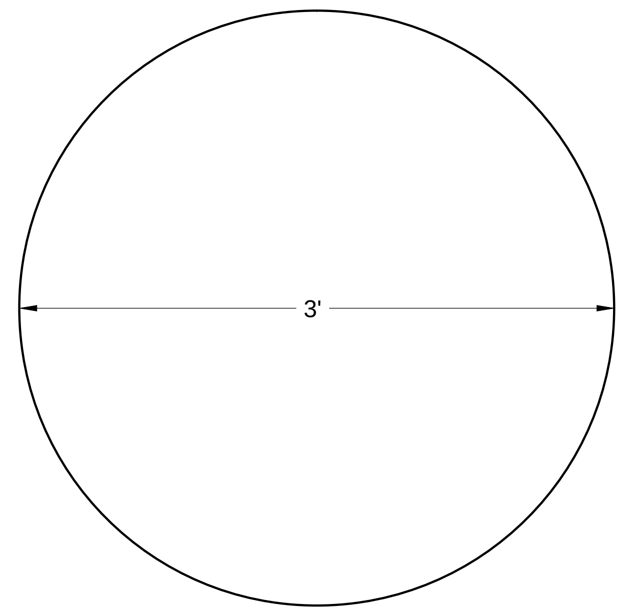
ACAD FILE: 9_Upper Talarik Bridge 404_181219.dwg



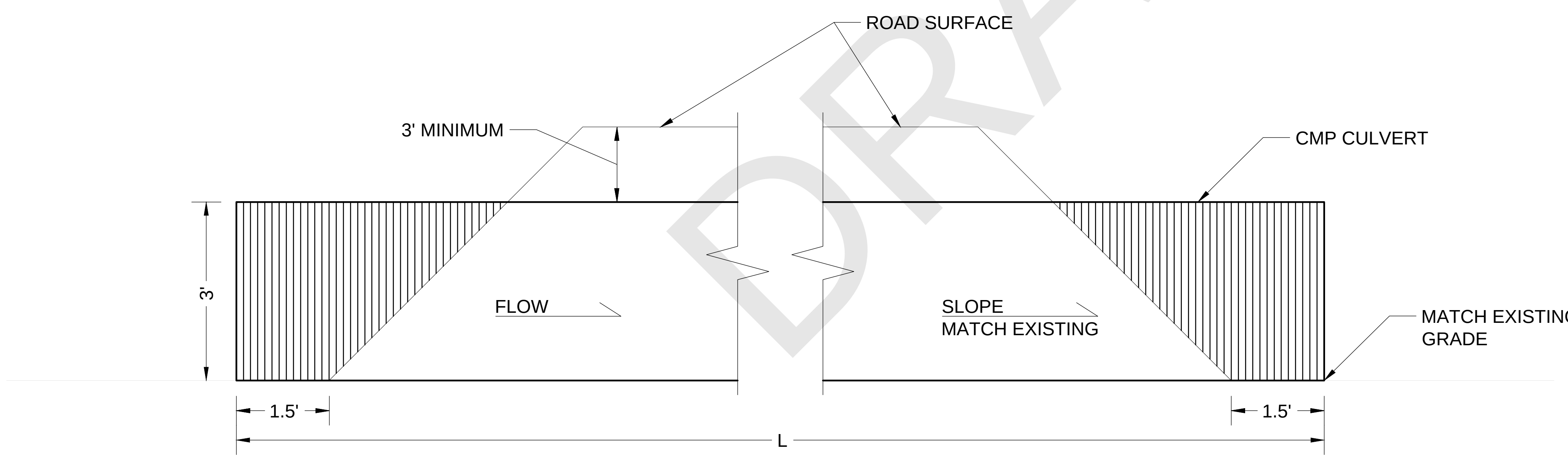


CONCEPTUAL PLANS SHOW PRELIMINARY INTERPRETATION OF HYDROLOGY & TERRAIN. AS SHOWN HEREON, THE PLAN REASONABLY REPRESENTS CROSSING SITE CHARACTERISTICS.

APPLICANT: PEBBLE LIMITED PARTNERSHIP	PEBBLE PROJECT NEWHALEN BRIDGE (NS005) PLAN, PROFILE AND TYPICAL SECTION		SHEET NO. 8 OF 9
ADDRESS: 3201 C STREET, SUITE 604 ANCHORAGE, AK 99503			
WATERWAY: NEWHALEN RIVER			
DRAWN BY: DVD	11" X 17" December 17, 2018		



TYPICAL SECTION
NTS



TYPICAL PROFILE
NTS

NOTES:

CATEGORY 1 CULVERTS SHALL BE INSTALLED AS NEEDED DURING ROAD CONSTRUCTION FOR CROSS DRAINAGE. CULVERTS SHALL NOT BE USED ON MAPPED STREAMS.

CULVERTS SHALL SPAN ENTIRE TOE OF FILL WIDTH PLUS ONE HALF CULVERT DIAMETER BEYOND TOE OF FILL.

DIAMETER SHALL BE 3'.

FILL DEPTH WILL BE DETERMINED BASED ON EQUIPMENT LOADING AND CMP DESIGN.

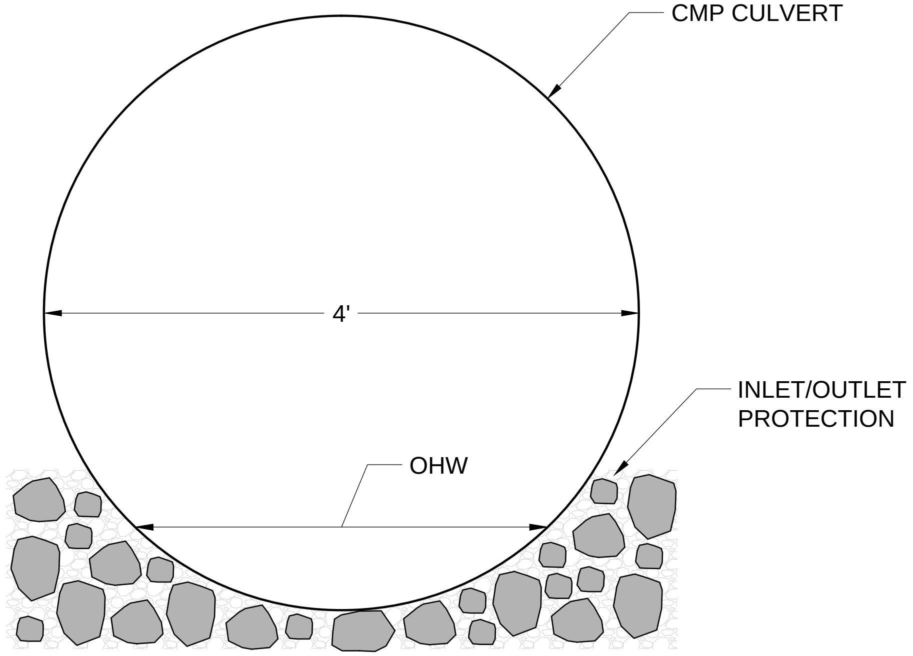
PEBBLE PROJECT

APPLICANT: **PEBBLE LIMITED PARTNERSHIP**

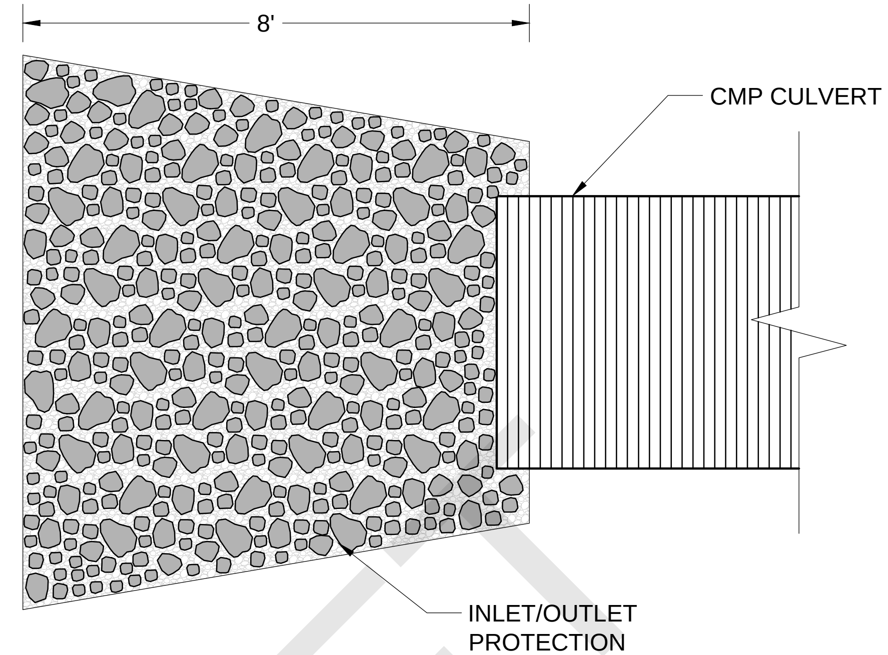
LAT., LONG. OF MINE **59°53'51.29"N 155°18'2.83"W**	PROPOSED ACTIVITY: **MINERAL DEVELOPMENT**
WATERWAY: **VARIOUS**	FILE NO. **POA-2017-271**

DRAWING TITLE:
CULVERT DESIGN CATEGORY 1

DATE:	FIGURE NO.
DECEMBER 2017	**CX-001**



TYPICAL SECTION
NTS



TYPICAL INLET/OUTLET PROTECTION
NTS

NOTES:

CATEGORY 2 CULVERTS SHALL BE INSTALLED ON MAPPED STREAMS THAT HAVE A STREAM WIDTH OF UP TO 2' AT THE ORDINARY HIGH WATER (OHW) MARK.

CULVERTS SHALL SPAN ENTIRE TOE OF FILL WIDTH PLUS ONE HALF CULVERT DIAMETER BEYOND TOE OF FILL.

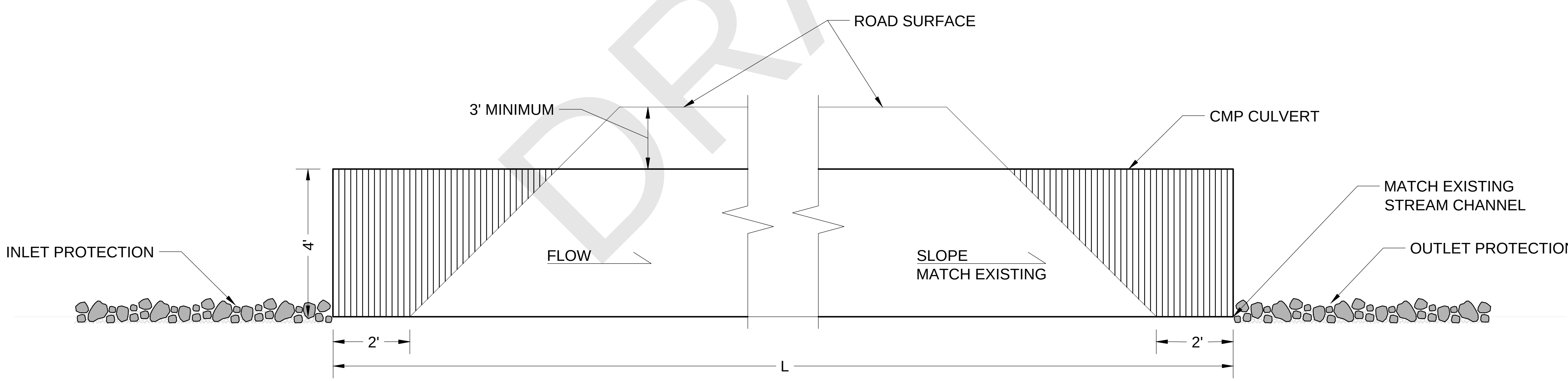
DIAMETER SHALL BE 4'.

STREAM IMPACT AREA EQUALS STREAM WIDTH TIMES CULVERT LENGTH PLUS THE AREA ASSOCIATED WITH INLET/OUTLET PROTECTION.

STREAM BED SLOPE THROUGH CULVERT SHALL MATCH STREAM SLOPE TO MAXIMUM EXTENT PRACTICABLE.

FILL DEPTH WILL BE DETERMINED BASED ON EQUIPMENT LOADING AND CMP DESIGN.

INLET/OUTLET PROTECTION SHALL BE CONSTRUCTED PER ALASKA DOT HIGHWAY DRAINAGE MANUAL.



TYPICAL PROFILE
NTS

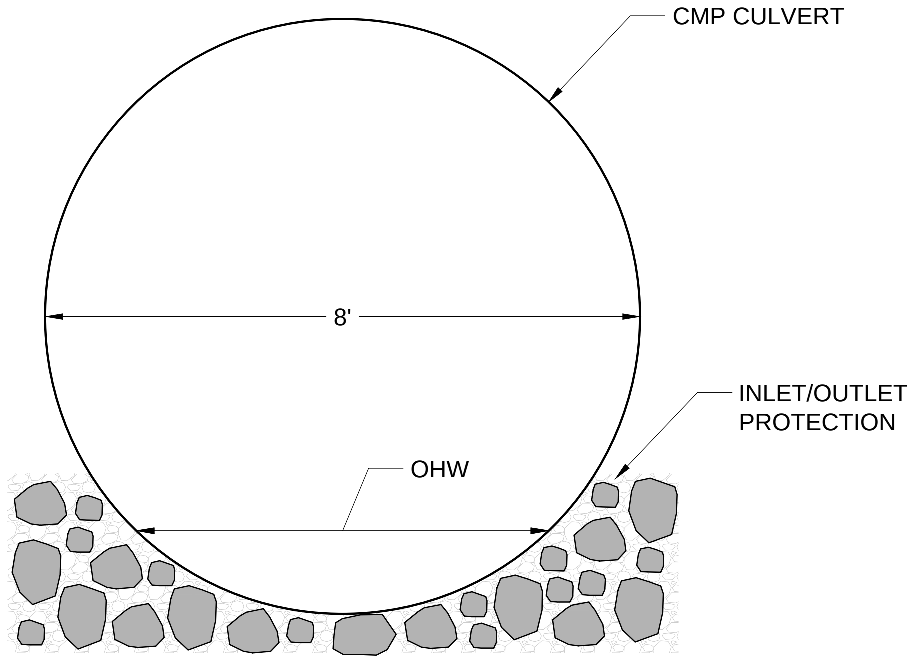
PEBBLE PROJECT

APPLICANT: **PEBBLE LIMITED PARTNERSHIP**

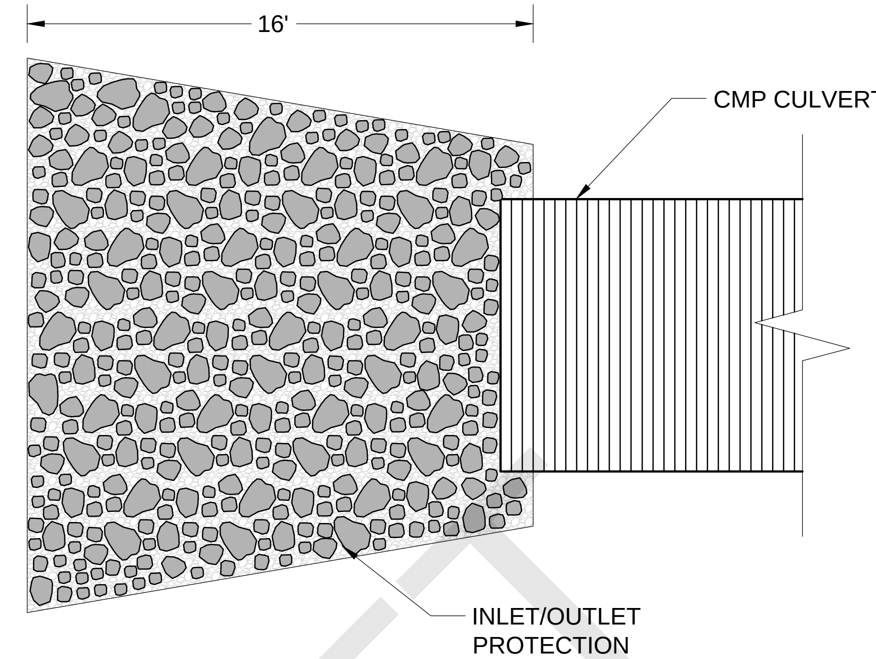
LAT., LONG. OF MINE **59°53'51.29"N 155°18'2.83"W**	PROPOSED ACTIVITY: **MINERAL DEVELOPMENT**
WATERWAYS: **VARIOUS**	FILE NO. **POA-2017-271**

DRAWING TITLE:
CULVERT DESIGN CATEGORY 2

DATE: **DECEMBER 2017**	FIGURE NO. **CX-002**



TYPICAL SECTION
NTS



TYPICAL INLET/OUTLET PROTECTION
NTS

NOTES:

CATEGORY 3 CULVERTS SHALL BE INSTALLED ON MAPPED STREAMS THAT HAVE A STREAM WIDTH GREATER THAN 2' TO 6' AT THE ORDINARY WATER (OHW) MARK.

CULVERTS SHALL SPAN ENTIRE TOE OF FILL WIDTH PLUS ONE HALF CULVERT DIAMETER BEYOND TOE OF FILL.

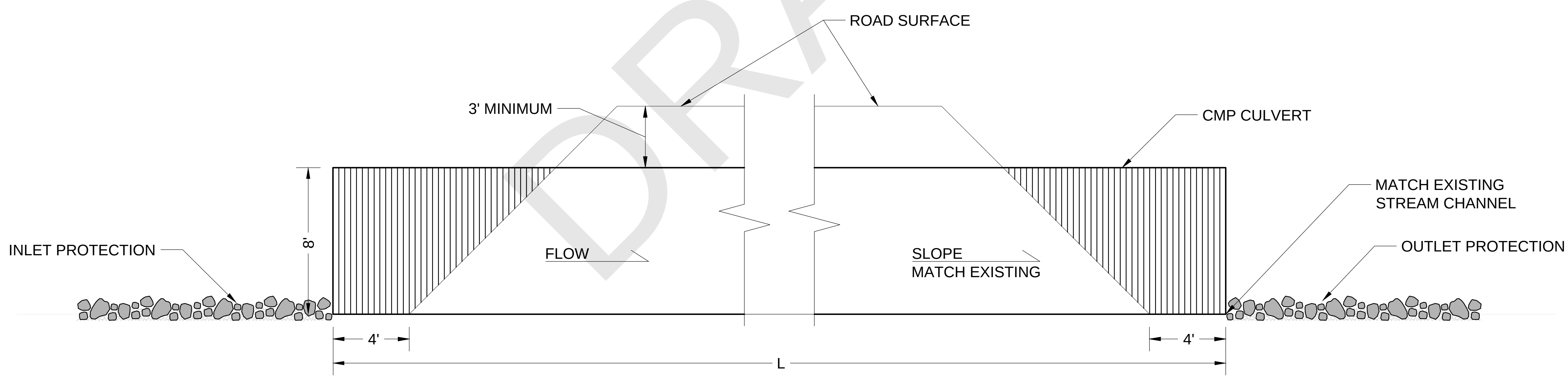
DIAMETER SHALL BE 8'.

STREAM IMPACT AREA EQUALS STREAM WIDTH TIMES CULVERT LENGTH PLUS THE AREA ASSOCIATED WITH INLET/OUTLET PROTECTION.

STREAM BED SLOPE THROUGH CULVERT SHALL MATCH STREAM SLOPE TO MAXIMUM EXTENT PRACTICABLE.

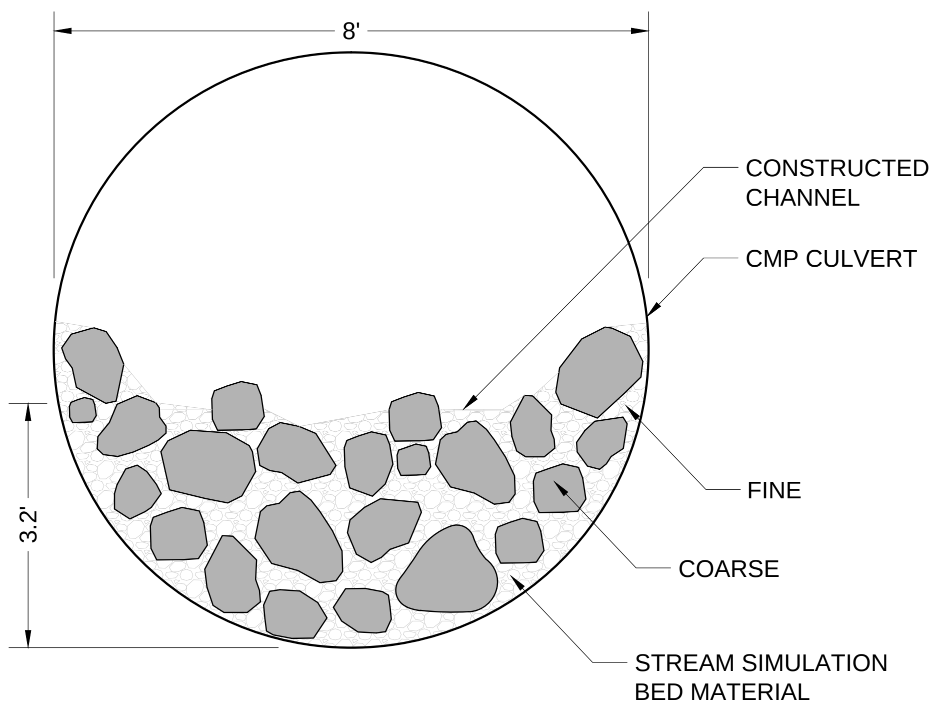
FILL DEPTH WILL BE DETERMINED BASED ON EQUIPMENT LOADING AND CMP DESIGN.

INLET/OUTLET PROTECTION SHALL BE CONSTRUCTED PER ALASKA DOT HIGHWAY DRAINAGE MANUAL.

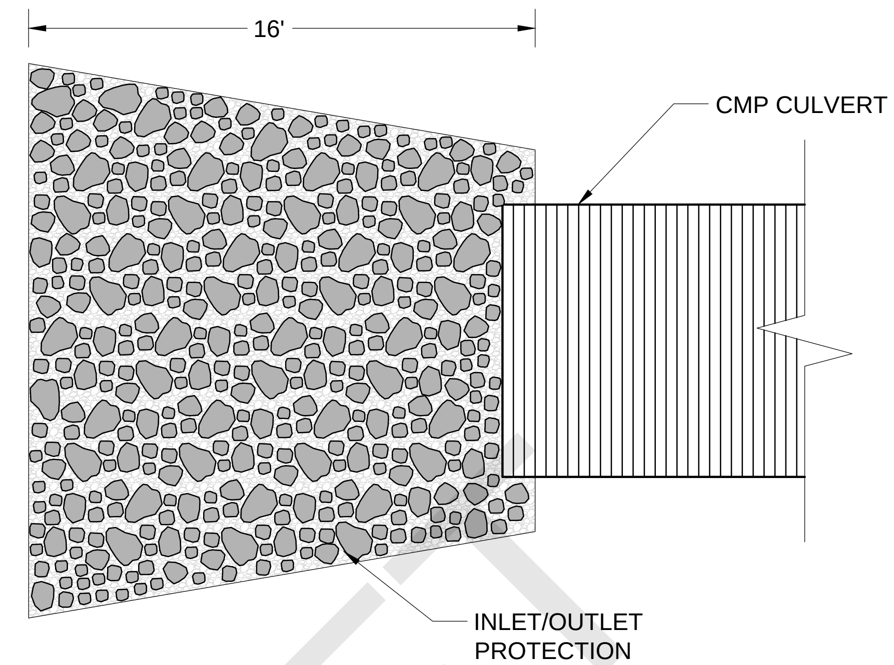


TYPICAL PROFILE
NTS

PEBBLE PROJECT APPLICANT: PEBBLE LIMITED PARTNERSHIP	DRAWING TITLE: CULVERT DESIGN CATEGORY 3
LAT., LONG. OF MINE: 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: MINERAL DEVELOPMENT
WATERWAY: VARIOUS	FILE NO. POA-2017-271
DATE: DECEMBER 2017	FIGURE NO. CX-003



TYPICAL SECTION
NTS



TYPICAL INLET/OUTLET PROTECTION
NTS

NOTES:

CATEGORY 4 CULVERTS SHALL BE INSTALLED IN MAPPED STREAMS WHERE FISH PASSAGE IS REQUIRED AND THAT HAVE A STREAM WIDTH UP TO 6' AT THE ORDINARY HIGH WATER (OHW) MARK.

CULVERTS SHALL SPAN ENTIRE TOE OF FILL WIDTH PLUS ONE HALF CULVERT DIAMETER BEYOND TOE OF FILL.

DIAMETER SHALL BE 8'. CULVERT INVERT BURIAL SHALL BE EQUAL TO 0.4*D.

STREAM IMPACT AREA EQUALS STREAM WIDTH TIMES CULVERT LENGTH PLUS THE AREA ASSOCIATED WITH INLET/OUTLET PROTECTION.

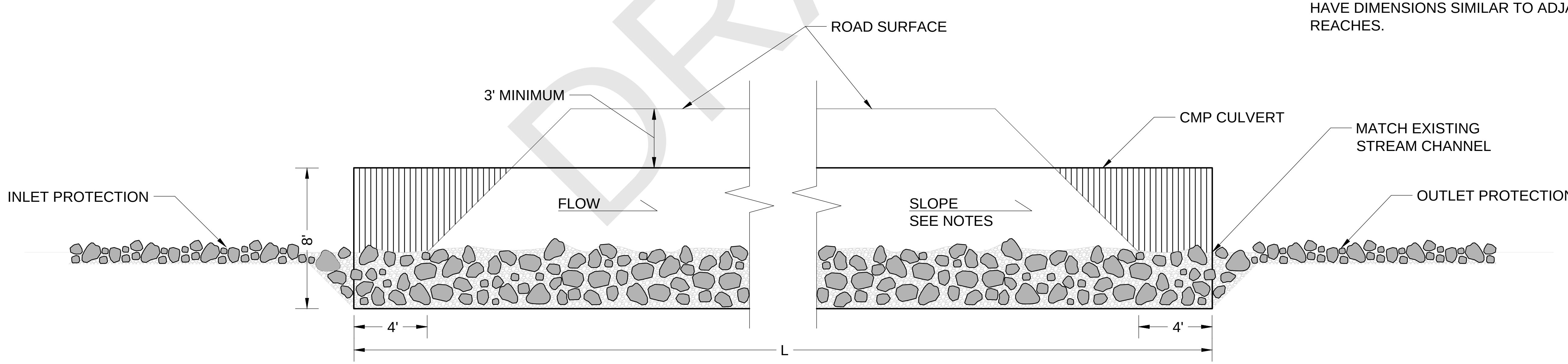
STREAM BED SLOPE THROUGH CULVERT SHALL MATCH CHANNEL BED SLOPE TO MAXIMUM EXTENT PRACTICABLE, BUT NO GREATER THAN CHANNEL BED SLOPE +1%.

FILL DEPTH WILL BE DETERMINED BASED ON EQUIPMENT LOADING AND CMP DESIGN.

SUBSTRATE DESIGNED PER MEMORANDUM OF AGREEMENT STREAM SIMULATION DESIGN REQUIREMENTS.

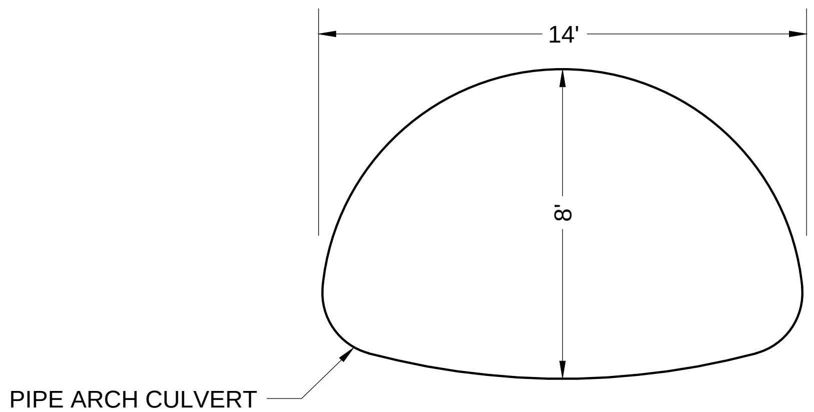
INLET/OUTLET PROTECTION SHALL MATCH STREAM SIMULATION BED MATERIAL PLACED INSIDE CULVERT.

CONSTRUCTED CHANNEL INSIDE CULVERT TO HAVE DIMENSIONS SIMILAR TO ADJACENT CHANNEL REACHES.

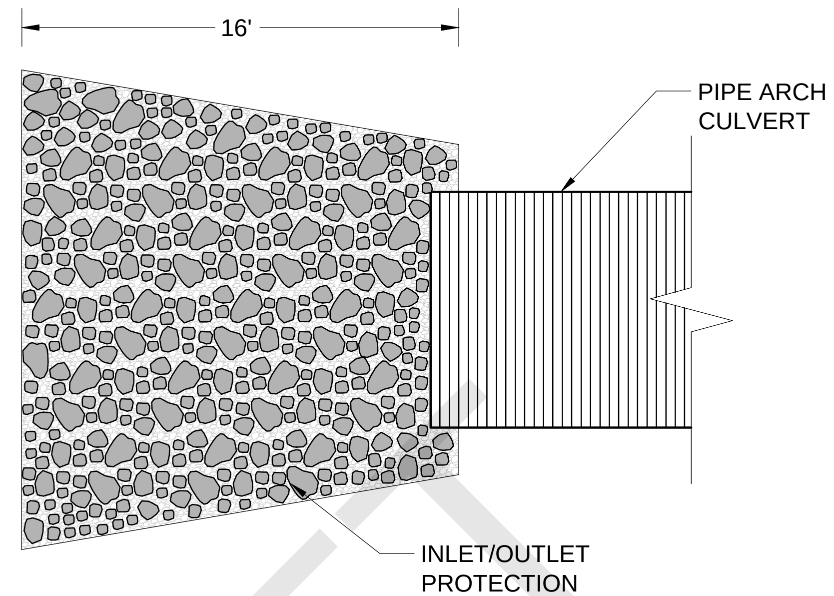


TYPICAL PROFILE
NTS

PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **CULVERT DESIGN CATEGORY 4**
LAT., LONG. OF MINE **59°53'51.29"N 155°18'2.83"W**	PROPOSED ACTIVITY: **MINERAL DEVELOPMENT**	
WATERWAY: **VARIOUS**	FILE NO. **POA-2017-271**	DATE: **DECEMBER 2017**
		FIGURE NO. **CX-004**



TYPICAL SECTION
NTS



TYPICAL INLET/OUTLET PROTECTION
NTS

NOTES:

CATEGORY 5 CULVERTS SHALL BE INSTALLED IN MAPPED STREAMS THAT HAVE A STREAM WIDTH BETWEEN 6' & 10' AT THE ORDINARY HIGH WATER (OHW) MARK. CATEGORY 5 SHALL NOT BE USED FOR FISH PASSAGE.

CULVERTS SHALL SPAN ENTIRE TOE OF FILL WIDTH PLUS ONE HALF CULVERT DIAMETER BEYOND TOE OF FILL.

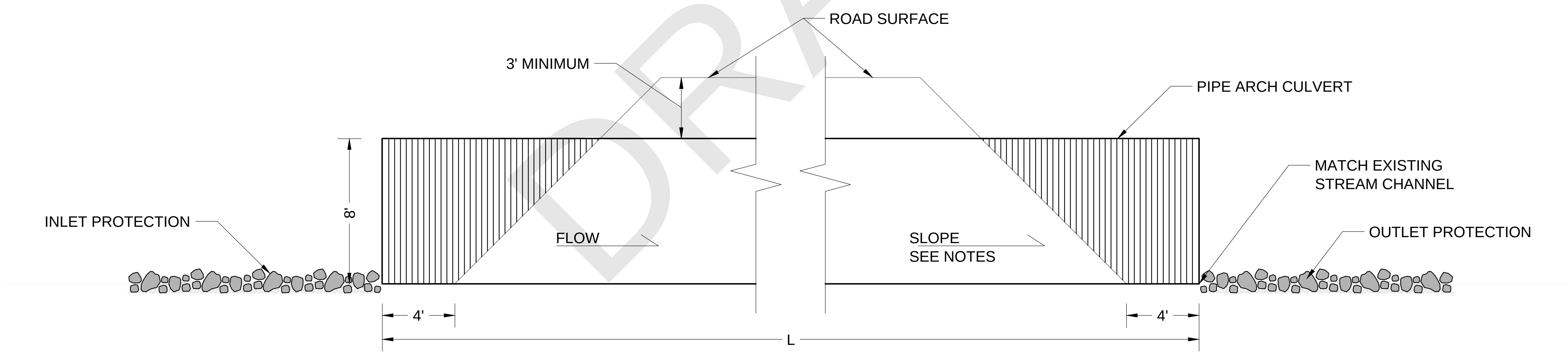
CULVERT SHALL BE PIPE ARCH THAT IS 8' TALL BY 14' WIDE.

STREAM IMPACT AREA EQUALS STREAM WIDTH TIMES CULVERT LENGTH.

STREAM BED SLOPE THROUGH CULVERT SHALL MATCH CHANNEL BED SLOPE TO MAXIMUM EXTENT PRACTICABLE.

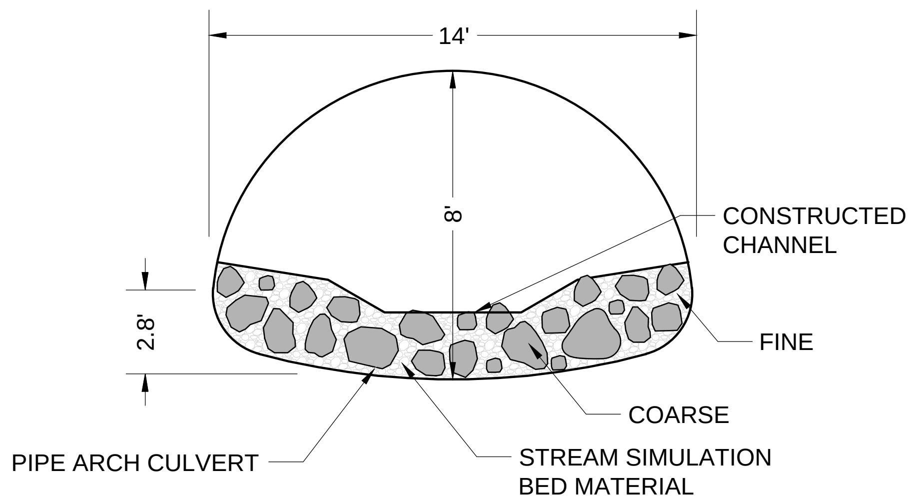
FILL DEPTH WILL BE DETERMINED BASED ON EQUIPMENT LOADING AND CMP DESIGN.

INLET/OUTLET PROTECTION SHALL BE CONSTRUCTED PER ALASKA DOT HIGHWAY DRAINAGE MANUAL.

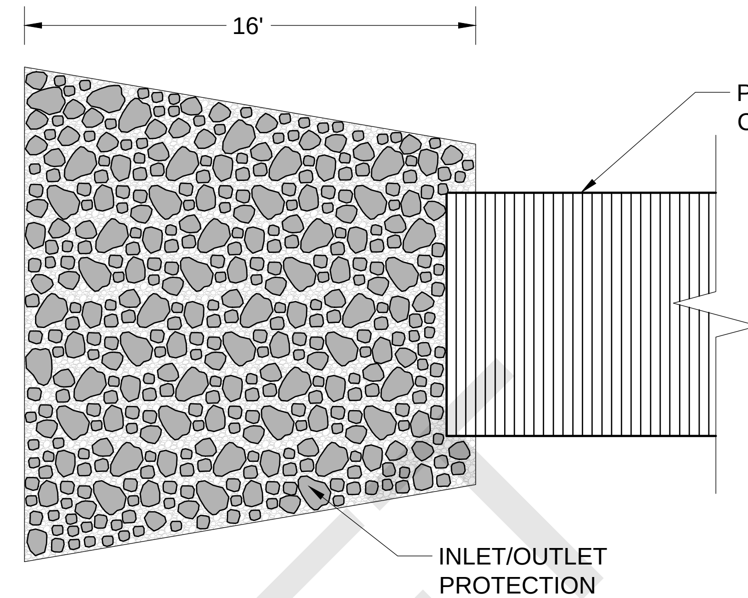


TYPICAL PROFILE
NTS

PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **CULVERT DESIGN CATEGORY 5**
LAT., LONG. OF MINE **59°53'51.29"N 155°18'2.83"W**	PROPOSED ACTIVITY: **MINERAL DEVELOPMENT**	
WATERWAY: **VARIOUS**	FILE NO. **POA-2017-271**	DATE: **DECEMBER 2017** / FIGURE NO. **CX-005**



TYPICAL SECTION
NTS



TYPICAL INLET/OUTLET PROTECTION
NTS

NOTES:

CATEGORY 6 CULVERTS SHALL BE INSTALLED IN MAPPED STREAMS WHERE FISH PASSAGE IS REQUIRED AND THAT HAVE A STREAM WIDTH BETWEEN 6' & 10' AT THE ORDINARY HIGH WATER (OHW) MARK.

CULVERTS SHALL SPAN ENTIRE TOE OF FILL WIDTH PLUS ONE HALF CULVERT DIAMETER BEYOND TOE OF FILL.

CULVERT SHALL BE PIPE ARCH THAT IS 8' TALL BY 14' WIDE.

STREAM IMPACT AREA EQUALS STREAM WIDTH TIMES CULVERT LENGTH.

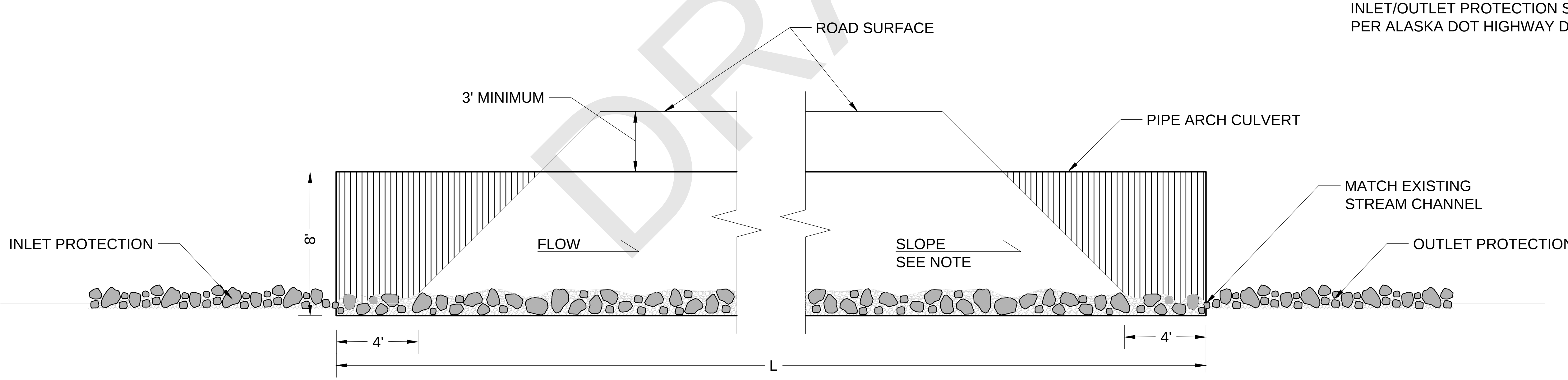
STREAM BED SLOPE THROUGH CULVERT SHALL MATCH CHANNEL BED SLOPE TO MAXIMUM EXTENT PRACTICABLE, BUT NO GREATER THAN CHANNEL BED SLOPE +1%.

FILL DEPTH WILL BE DETERMINED BASED ON EQUIPMENT LOADING AND CMP DESIGN.

CONSTRUCTED CHANNEL INSIDE CULVERT TO HAVE DIMENSIONS SIMILAR TO ADJACENT CHANNEL REACHES.

SUBSTRATE DESIGNED PER MEMORANDUM OF AGREEMENT STREAM SIMULATION DESIGN REQUIREMENTS.

INLET/OUTLET PROTECTION SHALL BE CONSTRUCTED PER ALASKA DOT HIGHWAY DRAINAGE MANUAL.



TYPICAL PROFILE
NTS

PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **CULVERT DESIGN CATEGORY 6**
LAT., LONG. OF MINE 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: MINERAL DEVELOPMENT	
WATERWAY: VARIOUS	FILE NO. POA-2017-271	DATE: DECEMBER 2017 / FIGURE NO. CX-006