APPENDIX I—EFH ASSESSMENT

Essential Fish Habitat Assessment

Pebble Project

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Appendix A

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
AHT	Anchor handling tug
APDES	Alaska Pollutant Discharge Elimination System
AWC	Anadromous Waters Catalog
BMP	Best management practices
BSAI	Bering Straits Aleutian Islands
BSEE	Bureau of Safety and Environmental Enforcement
CADoT	California Department of Transportation
CFR.	Code of Federal Regulations
CMP	Compensatory Mitigation Plan
CPUE	Catch per unit of effort
CWA	Clean Water Act
DA	Department of the Army
EBD	Environmental Baseline Document
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
FC	First Creek
FERC	Federal Energy Commission
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
KR	Koktuli River
MLLW	Mean lower low water
MSFCMA or MSA	Magnuson-Stevens Fishery Conservation and Management Act
NFK	North Fork Koktuli River
NMFS	National Marine Fisheries Service
NPFMC	North Pacific Fishery Management Council
NOAA	National Oceanographic and Atmospheric Administration
OCS	Outer Continental Shelf
OHWM	Ordinary high-water mark
PHABSIM	Physical Habitat Simulation System
PHMSA	Pipeline and Hazardous Materials Safety Administration

ABBREVIATION	DEFINITION
PLP	Pebble Limited Partnership
Project	Pebble Project
RHA	Rivers and Harbors Act
ROV	Remotely operated vehicle
ROW	Right-of-way
SEBD	Supplemental Environmental Baseline Document
SFK	South Fork Koktuli River
sp.	Species
SPCC	Spill Prevention Countermeasures and Control Plan
SWPPP	Stormwater Pollution Prevention Plan
TSF	Tailings Storage Facility
U.S.	United States
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
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
dB	Decibel
ft	Foot/feet
ha	Hectares
in	Inches
in/s	Inches per second
kg	Kilogram(s)
km	Kilometers
lb	Pound(s)
LD10	Lethal dose 10
LF	Linear foot / feet
LM	Linear meter
m	Meter(s)
m^3	Cubic meters
m^3/sec	Cubic meters per second
mi	Miles
mm	Millimeters
psi	Pounds per square inch
sec	Second
sf	Square feet
SEL	Sound exposure level
SPL	Sound pressure level
μPa	Micropascals

1 PURPOSE/SCOPE

In December 2017, the Pebble Limited Partnership (PLP) submitted an application for a Department of the Army (DA) permit to discharge fill material into waters of the United States (U.S.) and for the construction of structures and work in navigable waters of the U.S. for the purpose of developing a copper-gold-molybdenum porphyry deposit (Pebble deposit). PLP proposes to develop the Pebble deposit as an open pit mine, with associated infrastructure (Project). The Pebble deposit is in Southwest Alaska, approximately 200 miles (mi) (321.9 kilometers [km]) southwest of Anchorage and 60 mi (96.0 km) west of Cook Inlet. The closest communities are the villages of Iliamna, Newhalen, and Nondalton, each approximately 17 miles from the Pebble deposit (Figure 1-1). PLP's application includes four primary components: the mine site at the Pebble deposit location, the port site at Diamond Point on Cook Inlet, the transportation corridor connecting these two sites, and a natural gas pipeline and fiber optic cable connecting to existing infrastructure on the Kenai Peninsula. This document presents the findings of an Essential Fish Habitat (EFH) assessment of the Federal actions associated with the proposed Project to support EFH consultation under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA or MSA) of 1996. 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 on the Outer Continental Shelf (OCS) of Cook Inlet (30 CFR Part 250 Subpart J); and U.S. Coast Guard (USCG) authorization for bridges across Navigable Waters. The USCG is granted authority under the General Bridge Act of 1946, as amended, 33 U.S.C 525, and 33 CFR Parts 114-118 to review and approve locations and navigational clearances of bridges and causeways in or over navigable waters.

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) (Figure 1-2).

The EFH Guidelines are contained under 50 Code of Federal Regulations (CFR) 600.05 – 600.930, and outline procedures that federal agencies must follow to satisfy MSA consultation requirements (50 CFR 600.920). Federal agencies must consult NMFS regarding federal actions that may adversely affect EFH:

- "**Federal action** means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal agency" (50 CFR 600.910).
- "**Adverse effect** means any impact that reduces quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions" (50 CFR 600.910).
- Additional definitions are included in the MSA, 50 CFR 600.10, and 50 CFR 600.910.

For any federal action that may adversely affect EFH, federal agencies must provide NMFS with a written assessment of the effects of that action on EFH (50 CFR 600.920 (e)(1)). The EFH assessment must contain the following: 1) A description of the action, 2) An analysis of the potential adverse effects of the action on EFH and the managed species, 3) The federal agency's conclusions regarding the effects of the action on EFH, and 4) Proposed mitigation, if applicable (50 CFR 600.920(e)). The level of detail in an EFH Assessment should be commensurate with the complexity and magnitude of the potential adverse effects of the action (50 CFR 600.920 (e)(2)).

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.
- 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).
- "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.
- 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 2014, NPFMC 2018, NPFMC 2019). Species identified in the FMP are generally referred to in this EFH assessment as “managed species”.

3 DESCRIPTION OF THE ACTION

PLP's proposed actions requiring consultation pursuant to section 305(b)(2) of the MSA include those that would be authorized, or proposed to be authorized, by the DA, BSEE, and USCG that may adversely affect EFH. PLP's proposed activities that require DA authorization under Section 404 of the Clean Water Act (CWA) include the temporary and permanent discharge of dredged or fill material into waters of the U.S. necessary to construct:

- A mine site at the Pebble deposit.
- A port site and dredged access channel near Diamond Point (Diamond Point port).
- A road connecting the mine site and Diamond Point port along the north side of Iliamna Lake.
- Material sites adjacent to the road.
- A natural gas pipeline and fiber optic cable between Kenai Peninsula and the mine site.
- Concentrate and return water pipelines between the mine site and Diamond Point port.

Structures and work that require DA authorization under Section 10 of the Rivers and Harbors Act (RHA) include:

- Structures and work in tidal waters below the mean-high water (MHW) of Cook Inlet:
    - Constructing the Diamond Point port causeway/wharf, and access roads (Iliamna Bay only).
    - Dredging the port site approach channel out to a water depth for barge passage.
    - Installing one spread anchor mooring system at an offshore lightering station in Iniskin Bay.
    - Installing a natural gas pipeline and fiber optic cable across Cook Inlet.

Additional required federal authorizations for the Project include

- Bureau of Safety and Environmental Enforcement (BSEE) authorization for the pipeline right-of-way in Federal waters on the OCS of Cook Inlet.
- U.S. Coast Guard (USCG) authorization for bridges across the Newhalen River and Iliamna River under Title 33 Navigation and Navigable Waters, Subchapter J, Bridges (33 Code of Federal Regulations [CFR] Parts 114 through 118) (Figure 1-1). The USCG is granted authority under the General Bridge Act of 1946, as amended, 33 U.S.C 525, and 33 CFR Parts 114-118 to review and approve locations and navigational clearances of bridges and causeways in or over navigable waters.

A description of the actions are presented in Sections 3.1 through 3.4, and are grouped by project component: the mine site at the Pebble deposit location; the Diamond Point port on the western shore of Iliamna Bay; the transportation corridor consisting of an access road connecting the port and mine sites, and; a natural gas pipeline and fiber optic cable corridor connecting the mine site to existing infrastructure on the Kenai Peninsula (Figure 1-1). Additional Project details, including descriptions of actions not requiring federal consultation pursuant section 305(b)(2) of the MSA and therefore outside of the scope of analysis of this EFH are described in The Pebble Project: Project Description (PLP 2020) and in the Pebble Project Preliminary Final Environmental Impact Statement (PFEIS), section 2.2.7, Alternative 3–North Road Only (USACE 2020).

3.1 Mine Site

The proposed mine site (Figure 3-1) 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 (WMP) (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 (Upper Talarik [UT] Creek, North Fork Koktuli [NFK]River, South Fork Koktuli [SFK] River); a 270 megawatt power plant; and, on-site roads.

The Federal action includes earthwork activities associated with discharges of dredged and fill material into waters of the U.S., including wetlands, associated with the construction of the proposed mine. Earthwork activities include excavation (cuts) and embankments (fill) for road and pad construction, open pit development, rock quarrying for construction materials, structural foundations, utility installations, and preparation of material storage areas including associated earthen dams (i.e., WMPs, TSFs, and seepage collection systems) (Figure 3-1). Earthworks would require the use of heavy construction equipment such as loaders, dump trucks, graders, bulldozers, backhoes, or dragline excavators. Drilling and blasting may be required to break rock for excavation.

Construction of the mine site is expected to last approximately 4 years. Some earthwork activities, such as the open pit expansion and tailings dam lifts would take place throughout the twenty year mine operating life. Earthwork activities at the mine site will commence with those necessary for establishing the process and power plant sites, the open pit WMP, the main WMP, the pyritic TSF, and the bulk TSF. Laydown areas and access roads for construction will be placed within the future footprint of the facilities to minimize impacts. In the later construction years, the bulk TSF main embankment will be completed and pyritic TSF foundation and liner installed. The initial open pit development will commence. A major activity during the final year of construction will be completion of the open pit pre-production phase mining infrastructure and remaining embankments in the TSF.

3.1.1 Embankment Construction and Water Management

Embankment construction will require diversion and temporary impoundment of water with ongoing release of that water back into the affected streams downstream of the mine site. Construction of all the embankments will commence with the installation of sediment control measures including diversion ditches, runoff collection ditches, sediment control ponds, and other best management practices (BMPs) as required.

Construction will be initiated with the bulk TSF seepage collection pond (SCP) embankment. This will be followed by the bulk TSF main embankment and the main WMP followed by the remaining tailings embankments. The open pit WMP is in the South Fork Koktuli River drainage and can be constructed independently of construction of the other water management facilities. Its timing will be coordinated with the open pit dewatering program and pre-production mining to ensure that the open pit water treatment facilities are operational when required.

3.1.1.1 Bulk TSF SCP Embankment

The footprint of the bulk TSF SCP embankment will be excavated to bedrock. This work will require complete diversion of water around the footprint. This diversion is proposed to be accomplished as follows:

- Construct a diversion channel above the west bank of the SCP to divert runoff from this area downstream of the SCP. The diversion channel will remain in place post construction to continue to divert runoff from undisturbed areas downstream during operations.
- Construct a bulk TSF main embankment cofferdam upstream of the bulk TSF main embankment. This cofferdam will collect the majority of the runoff from the catchment upstream of the Bulk TSF SCP. Water collected at this location will be pumped to the diversion channel and released to the North Fork Koktuli, downstream of the Bulk TSF SCP and upstream of station NK100B.
- Construct a bulk TSF SCP cofferdam between the bulk TSF SCP and the bulk TSF main embankment excavation. Water collected at this location will be pumped to a location downstream of all construction activities and released between stations NK100B and NK100C. This cofferdam will be removed following completion of the bulk TSF SCP embankment.

3.1.1.2 Main WMP Embankment

The main WMP embankment will be founded on bedrock. Excavation to bedrock will commence on the northern limb of the embankment with embankment fill progressing behind the excavation. Depending on the timing of the project, construction may advance in more than one location. Flows across the northern limb are expected to be minor and will be diverted locally as required. Water collected in the embankment excavation will be pumped to temporary sediment ponds within the impoundment prior to release downstream of the construction area.

Two streams intersect the western limb of the main WMP embankment. Managing runoff from these streams will include the construction of diversion ditches to divert upstream flows and the construction of two small cofferdams near the excavation. Water collected behind the northern cofferdam will be pumped downstream of all construction activities and released into a tributary upstream of the main stem of the North Fork Koktuli River. Water collected behind the south cofferdam will be pumped and released between stations NK100B and NK100C. A liner will be installed along the face of the embankment and within the impoundment. The impoundment grading plan will direct runoff to defined low points where the water will be collected and treated if required, prior to being pumped downstream of all construction activities to tributaries feeding the main stem of the North Fork Koktuli River.

3.1.1.3 Bulk TSF Main Embankment

The bulk TSF main embankment will be founded on bedrock. The cofferdam installed upstream of the bulk TSF during construction of the bulk TSF SCP will remain in place during excavation and construction of the main embankment starter dam. Water collected behind the cofferdam will be pumped around the excavation and discharged to the North Fork Koktuli River via the diversion channel constructed west of the SCP.

The cofferdam will be breached following completion of the starter embankment. The main embankment is designed as a flow-through structure. Seepage through the embankment will be captured in the SCP prior to being discharged to the North Fork Koktuli River during the time period prior to commencement of operations.

3.1.1.4 Bulk TSF South Embankment

The bulk TSF south starter embankment, founded on bedrock, is required for year two of operations. The embankment straddles the drainage break between the South Fork and North Fork Koktuli rivers and it is expected that only direct catchment and groundwater inflows will be encountered during the excavation. Water collected within the excavation will be pumped back to the main WMP via the bulk TSF pond.

3.1.1.5 Pyritic Tailings Storage Facility

The pyritic TSF embankment, founded on bedrock, has three limbs. The north limb, the first to be constructed, will require the construction of a cofferdam upstream of the embankment to manage runoff during the excavation and construction. Cofferdams are not required for the east and south limbs of the pyritic TSF which are located on catchment boundaries. Water collected behind the pyritic TSF cofferdam will be pumped to a temporary sediment pond, from which it will flow into the tributary upstream of station NK100B. The cofferdam will be removed upon completion of the north embankment starter dam and the site regraded for installation of the liner system.

3.1.1.6 Open Pit Water Management Pond

The open pit WMP must be in place and operational prior to open pit dewatering (i.e., two years prior to mine start up). The embankments are founded on bedrock and will require excavation. A diversion channel will direct flow from upstream around the facility.

3.1.2 Construction Stream Flow

All water diverted around embankment construction footprints and water collected in upstream cofferdams and pumped around construction footprints would be returned to the same tributaries below the construction footprints. As such, no measurable reductions in streamflow in the NFK, SFK, and UTC main stems would result from the construction activity (Knight Piésold 2019).

3.2 Diamond Point Port and Lightering Location

The Diamond Point port (Figure 1-1) would be located north of Diamond Point in Iliamna Bay on the western shore of Cook Inlet, approximately 165 mi (266 km) southwest of Anchorage and approximately 75 mi (121 km) west of Homer. The port (21.7 acres [ac], 8.8 hectare [ha]) would be operated year-round and would include shore-based and maritime facilities for the shipment of concentrate, freight, and fuel for the project (Figure 3-2). One offshore lightering station near the entrance to Iniskin Bay would be used to) lighter the concentrate to moored Handysize bulk carriers.

The shore-based facilities (15.5 ac [6.3 ha]) include the port site with separate facilities for the receipt and storage of containerized freight, and an elevated conveyor for the loading of concentrate. Other facilities at the port site would include fuel storage and transfer facilities, natural gas power generation and distribution facilities, a concentrate dewatering plant, a communication tower, maintenance facilities, break bulk storage for large equipment or other non-containerized supplies (e.g., large truck tires), a container storage area, a specialized storage facility for hazardous materials as required to maintain compliance with all applicable regulations, employee accommodations, parking, offices, and a domestic wastewater treatment plant for the employee accommodations. The wastewater would be treated and discharged to a subsurface leach field. An offtake from the natural gas pipeline (discussed below) would distribute natural gas to the port power generation facility. Dredge spoils will be stored in two bermed facilities located in uplands adjacent to the mine access road (Figure 3-2). Runoff water from the dredge spoils will pass through settling ponds and then into a drainage ditch paralleling the access road before discharging into Iliamna Bay. The shore-based complex would be constructed on an engineered fill pad at an elevation of 40 feet (ft) (12.2 meters [m]) to address tidal surge from major storms and potential tsunamis. The communications tower on the onshore pad would be approximately 100 to 150 ft (30.5 m to 45.7 m) tall and constructed in a monopole tower arrangement. The tower would not be guyed to minimize potential collision risk to avian species. In accordance with FAA and USFWS guidelines, the tower would be marked with high visibility paint bands and may include flashing red lights at the top if required. Navigational aids for the port approach will include shore-based range structures on the jetty and road and electronically transmitted (virtual) aids to navigation.

The marine component (6.2 ac [2.5 ha]) includes a caisson-supported access causeway, marine jetty, and concentrate bulk transfer barge loader. The shallow approach to the port site would require dredging to create a navigation channel and a turning/mooring basin (71.4 ac [28.9 ha]) to ensure year-round access by supply barges. The concentrate loader includes a series of three caissons will be placed within the dredged basin to provide mooring and loading for the concentrate lighter barges. A gantry will support an enclosed conveyor from the jetty to a barge loader mounted on the caissons.

The natural gas pipeline and fiber optic cable join the transportation corridor at the Diamond Point port, where offtakes would provide natural gas for power generation and data connectivity. From there the natural gas pipeline and fiber optic cable, along with a concentrate slurry pipeline and a return water pipeline, follow the access road to the mine site. The 6.25-inch (in) (15.9-centimeter [cm]) diameter concentrate slurry pipeline would transport a mixture of 55 percent concentrate and 45 percent water by mass from the mine site to the port. At the Diamond Point port, the concentrate slurry would be dewatered, and the water returned to the mine site via an 8-in (20.3-cm) diameter return water pipeline.

The proposed dredge channel and port facility is located to the west of the existing fiber optic cable and Williamsport access channel (Figure A-1, Figure A-2). Barges accessing Williamsport follow a naturally incised channel north towards the head of Iliamna Bay before turning west towards the dredged Williamsport landing basin. Dimond Point port construction and maintenance dredging operations will not impede access to the Williamsport facility. Activities would also be located north of the access corridor to the existing Cottonwood Bay gravel mining operation and would not impede access to that facility. Marine vessels not in active use for construction and dredging would be anchored in deeper water west of the main passage into the bay or moved offsite to avoid impeding access.

Design and operation of the Diamond Point port would comply with all applicable federal and State of Alaska regulations. Key regulatory requirements include:

- Vessel inspections, mariner training, safety equipment, and other shipping requirements in Title 46 of the CFR.
- Requirements for facilities and vessels that engage in oil (e.g., diesel fuel) and hazardous material transfers and spill response measures in Title 33 CFR parts 154–158.
- Provisions for handling of dangerous cargo at ports in Title 33 CFR part 126, including the general provisions specific to Ammonium Nitrate in Part 126.28.
- Hazardous materials transport requirements including packing and container requirements, emergency response, training, and security plans in Title 49 CFR parts 171–180.
- Hazardous waste disposal and transport requirements including waste tracking, emergency response and personnel training requirements in Title 40 CFR parts 260–265.
- Pipeline safety requirements in Title 49 CFR parts 186–189.
- Spill prevention control measures including requirements for the preparation of Spill Prevention Control and Countermeasure (SPCC) Plans detailing tank inspections, personnel training, and oil spill response requirements in Title 40 CFR part 112.
- Spill prevention and response requirements for fuel storage facilities in Title 18 of the Alaska Administrative Code (AAC) 75 that require preparation of Oil Discharge Prevention Contingency Plans (ODPC) for the port bulk fuel storage tanks and certain tank and non-tank vessels.
- Wastewater disposal regulations Title 18 AAC 72 would require wastewater discharges at the port to obtain an Alaska Pollutant Discharge Elimination System (APDES) permit, in agreement with the water quality standards in Title 18 AAC 70, and wastewater operator training requirements in Title 18 AAC 74.

Consistent with the above and other applicable regulatory requirements, which may include international standards and regulations, the Project would implement systems for proper screening, acceptance, storage, and transport of dangerous cargo that require:

- Validating dangerous goods manifests for hazardous materials whether in transit, loading or unloading to and from ships, including proper shipping name, hazard class, United Nations number, and packing group.
- Training port staff in relevant aspects of dangerous goods management, including screening, acceptance, and handling/transfer/storage/emergency response of dangerous goods at the port.
- Establishing segregated and access-controlled storage areas for dangerous goods with emergency response procedures and equipment to ensure collection and/or containment of accidental releases.

A list of permit authorizations that would be required by the Pebble Project is included in Appendix E of the PFEIS, Table E-1 (USACE 2020).

3.2.1 Navigation Channel and Basin

The shallow approach to the Diamond Point port site would require dredging for construction of a navigation channel and turning basin (71.4 ac [28.9 ha]). The channel will be approximately 2.9 mi (4.7 km) long and 300 ft (91.4 m) wide (3 times the maximum expected barge width), while the basin will incorporate an area of approximately 1,100 by 800 feet (Figure 3-2). The channel and basin would be dredged to -18 ft (-5.5 m) mean lower low water (MLLW) to ensure year-round access under all tidal conditions by supply barges and other vessels requiring 15 ft (4.6 m) of draft (Figure A-2). The target depth also provides for accumulated sedimentation between forecast maintenance dredging (estimated at 20 inches over 5 years) and over depth excavation.

A 1994 USACE dredging study was completed for the evaluation of a dredged access channel and port facility at Williamsport. PLP completed a bathymetric survey of the Iliamna Bay area in 2008. The information from the USACE report and the bathymetric survey data were used to inform the dredge planning and design. Based on available geophysical data, bedrock in the vicinity of the dredged channel and basin occurs at depths greater than 100 ft (30.5 m), well below the proposed dredge depth. Sediments are expected to be composed of greater than 70 percent fines, with the remainder consisting of sand and gravel. Dredge slopes of 4H:1V are proposed to address sediment stability and the potential for seismic induced slumping.

Dredging would be done using a barge mounted cutterhead suction dredge. The total dredge volume would be 1,100,000 yd^3 (841,010 m^3). The dredged material would be pumped directly to shore from the dredge barge or placed on barges and transported to shore for storage in the bermed facilities (Figure 3-2) on uplands. Consolidation and runoff water from the dredge material stockpiles would be channeled into a sediment pond and suspended sediments would be allowed to settle before discharge to Iliamna Bay via a drainage ditch paralleling the access road. Boulders encountered during dredging would be removed using a grab bucket or a cable net placed by divers and transported to shore for placement in the stockpiles or used in construction. Dredging operations are expected to commence in May of the second year of construction (CY2) and would last approximately 4 to 6 months.

Dredged channels are prone to sedimentation and the Diamond Point port navigation channel and basin would require maintenance dredging to ensure uninterrupted year-round access by supply barges and other vessels. Maintenance dredging (estimated at 20 in [50.8 cm]) is estimated to be required every 5 years and is expected to total 700,000 yd^3 (535,188 m^3) over twenty years (four times). Maintenance dredging would be completed using the same techniques and sediment storage locations used for construction of the channel. Maintenance dredging operations would be conducted during the early summer and are expected to last 3 to 4 weeks.

3.2.2 Diamond Point Port Marine Components Construction

The marine components include a causeway extending out to a marine jetty located in the 18-foot deep dredged basin. The access causeway, marine jetty, and concentrate bulk loader design include the use of caissons for support (Figure A-1). Caissons are pre-cast concrete open-top rectangular prisms with a flat bottom (60 ft x 60 ft and 120 ft x 60 ft [18.3 m x 18.3 m and 36.6 m x 18.3 m]) that would be lowered onto the seabed and then filled with quarried material to act as supports for the causeway and jetty. The use of caissons allows for the unimpeded flow of water through and around the structures. The jetty will be constructed along the northern and western limits of the basin and consist of 120 x 60-foot concrete caissons 58 ft (17.7 m) high that would be separated by 60 ft (18.3 m). The marine jetty caissons will be covered with a concrete deck. Fuel and freight barges will be moored to the jetty for loading and unloading.

In addition to the jetty, a series of three caissons (60 ft x 60 ft [18.3 m x 18.3 m]) will be placed within the dredged basin to provide mooring and loading for the concentrate lighter barges. A gantry will support an enclosed conveyor from the jetty to a barge loader mounted on the caissons. A floating dock, on the jetty but separate from the cargo handling berths, will be provided for ice-breaking tug moorage. The causeway will also be constructed with concrete caissons (60 ft x 60 ft [18.3 m x 18.3 m]) to support a concrete deck.

The causeway, marine jetty, and bulk loader cover an area of 6.2 ac (2.5 ha) (Figure 4-21). This includes approximately 3.4 ac (1.4 ha) of permanent fill below the MHW from installation of the caissons, and 2.8 ac (1.1 ha) of over-water structures. The footprint for the jetty structures would be dredged to -18 ft (-5.5 m) MLLW coincident with the dredging of the navigation channel and basin, bringing the total dredged area for construction to 78.8 ac (31.9 ha).

Caisson installation requires excavating the footprint up to 5 ft (1.5 m) below the dredged basin and leveling the seabed before caisson placement. Once the footprint is prepared, caissons would be floated into place with a tugboat at high tide and then seated on the prepared seabed on the falling tide or slowly lowered by pumping water into the caisson. Cranes may be used to place caissons in shallower water. Once set in place, the caissons would be filled with coarse material from the dredging and additional quarried material of a size that would achieve proper compaction when filled to avoid settlement over time. The additional fill material would be sourced from onshore material sites. Fill would be transported from shore to the caissons using a barge. Initially, only enough fill would be placed into the caisson to achieve proper seating, avoiding displacement and overflow of any water within the caisson. Fill materials would be stored temporarily on a barge moored adjacent to the construction area. Any water accumulated within the caisson would be pumped out to avoid saturation in the top fill layers and, if necessary, run through tanks on a barge for sediment settlement before discharge into the marine environment.

Pre-cast bridge beams (T-sections) would be placed on the caissons to create the main service deck and the access trestle. These pre-cast beams would then be tied together with rebar and topped with a cast-in-place concrete deck for the final surface. The caissons at the jetty area would be placed on the dredged seabed at depths of approximately -23 ft (-7 m) MLLW and extend to an elevation of +35 ft (+10.5 m) MLLW, or 58 ft (17.7 m) in total height. Caissons would be progressively shorter closer to shore. The concentrate conveyor on the marine facility would have a maximum height of 68 ft (20.7 m) MLLW (Figure A-1). For the shore transition, concrete pedestals would be constructed from shore to support the final bridge beams leading to the causeway. At the dock area, the caissons would be used to mount the fendering system and barge ramp equipment for the marine operations. Dredged areas between the caissons would be allowed to fill naturally over time.

Construction of the dock and causeway would take place following completion of the dredging and would occur in the summer/fall of Y2 of construction. The conveyor and fuel unloading pipeline would be constructed on the causeway and dock deck.

3.2.3 Lightering Station

One offshore lightering station near the entrance to Iniskin Bay would be used to lighter the concentrate to moored bulk carriers (Figure 3-2). The lightering location in Iniskin Bay is protected from wave action reducing the heave of anchored vessels.

Installation of the lightering station would require the placement of anchors for mooring bulk carriers. The proposed mooring structure, which requires DA authorization, includes a 2,300 ft x 1,700 ft (700 m x 520 m) spread anchor mooring system in approximately 50 ft to 70 ft (15.2 m to 21.4 m) of water, consisting of 10 anchors and 6 mooring buoys (Figure A-3). To prevent excessive drag and swinging of the anchor chains, an arrangement similar to that shown in Figure A-3 would be utilized. A positioning (sinker mass) anchor would be set on the seafloor with only enough slack in the chain to allow the buoy to move closer to the main anchor and minimize sagging of the main anchor chain (PLP 2018b).

Each 10-ft (3.0-m) diameter mooring buoy would be tethered by lengths of 2-in (5.1-cm) diameter chain attached to three gravity anchors; first to a station keeping mass anchor, typically a 3.3 ft x 3.3 ft x 3.3 ft (1 m x 1 m x 1 m) concrete block, and secondly to two large mass anchors connected by chain equalizers (Figure A-3). The anchor chain length would be approximately 500 ft (152 m). The typical sinker mass would be cast with steel punchings, or other heavy scrap to increase the density. The typical large mass anchor is a rock and concrete filled 40 ft x 8 ft x 8 ft (12.2 m x 2.4 m x 2.4 m) shipping container that is lowered to the sea floor. The 40-ft (12.1-m) shipping container is a sacrificial form that is used to cast the solid concrete/graded rock block that serves as the anchor weight. The anchor chain would be deeply imbedded into the cast concrete and not attached to the container itself. If the final design criteria call for additional mass, additional dense material would be cast into the block in a similar fashion to the mass sinker. Placement of the anchors would result in less than 0.1 ac (<0.1 ha) of fill at the lightering station (PLP 2018b).

Construction of each anchor would require approximately 1 day of work at the site. It would take 10 to 12 days to establish all ten anchors at the lightering station. The work would be performed from a barge with support tugs and a supply vessel. Placement of the mass anchors onto the seafloor is not expected to require modification of the bottom surface; re-suspension of sediments would therefore be minimal.

3.3 Transportation Corridor

The transportation corridor would connect the mine site to the Diamond Point port on Cook Inlet, and consists of a private, unpaved two-lane road heading 82 mi (132 km) east from the mine site to the Diamond Point port in Iliamna Bay with three pipelines buried in a corridor next the road (Figure 3-3). The State of Alaska operates an existing road between Williamsport on Iliamna Bay and Pile Bay on Iliamna Lake. The proposed road will parallel that existing road for approximately 4.5 mi (7.2 km) from Williamsport and will then replace the existing road for approximately 6.5 mi (10.5 km) from that point until the existing road turns toward Pile Bay. The proposed road to the mine also intersects the existing road network for the villages of Iliamna and Newhalen.

3.3.1 Mine Access Road

The mine access road (Figure 3-3) will be a private 30-foot-wide gravel road, which will enable two-way traffic, and will be capable of supporting anticipated development and operational activities during construction and supply truck haulage from the port to the mine site.

The typical two-lane road section includes a 30 ft (9.1 m) wide travel surface design with 2:1 side slopes, a minimum 36 inches (91.4 cm) of structural fill at the road center, and 60 ft (18.3 m) wide clearing limits. Earthwork would require the use of heavy construction equipment such as loaders, dump trucks, graders, bulldozers, and backhoes. Drilling and blasting will be required to break rock for excavation.

Drainage connectivity across 132 waterbody crossings would be provided through the installation of bridges (17) and culverts (115) (Figure 3-3). Eight of the bridges will be single-span, two-lane bridges that range in length from approximately 40 to 90 feet (12.2 m to 27.4 m). There will be one long (550 feet [167.6 m]) multi-span, two-lane bridge across the Newhalen River and eight other multi-span, two-lane bridges that range in length from approximately 125 to 245 feet (38.1 m to 74.7 m).

The typical conventional span bridge construction includes a structural steel box girder or steel I-beam design with steel and concrete supported abutments. Riprap may be placed at the base of abutments below the OHWM for scour protection. Placement of riprap may require removal of material at the base of abutments. For bridge approaches that cross floodplains, riprap will be placed to armor embankment fill. Piers for multi-span bridges will be steel pile sets, typically four piles per set. Steel piles may be filled with concrete and range from 30 to 60 inches (0.8 m to 1.5 m) in diameter depending on pier height, bridge span, and foundation conditions. Pile driving and setting girders will require the construction temporary bridges typically placed immediately adjacent and parallel to the permanent bridge. Pile driving techniques that may be used include impact driving, vibrodriving, pressing, or driving assistance (i.e., jetting, pre-augering, or drilling) or a combination of these methods. Pile driving activities are expected to range from days at single span bridge locations, to a week or two at multi-span bridge locations. Temporary bridges would be removed once no longer needed, and any approach access roads reclaimed. Typical cross section plan views for proposed bridges to be constructed on EFH (See Section 5.1.2.1) are included in Figure A-4 through Figure A-15. The Newhalen River crossing would include the construction of two temporary barge landings approximately 2.1 mi (3.4 km) upstream of the proposed bridge location for operation of a short-term ferry to access the mine site while the Newhalen River bridge is under construction. Both the Newhalen and Iliamna River are navigable rivers and will require authorization from the USCG.

A total of 115 major culverts including round (101), arch (8), and elliptical-design (1) culverts, and equalization culverts (5) have been planned. The culverts diameters would range from 3ft (0.9 m) to 25 ft (7.6 m). Additional small diameter culverts may be installed as needed for drainage management. Road culverts at stream crossings are divided into categories based on whether the streams are fish bearing. Culverts at streams without fish will be designed and sized for drainage only, in accordance with Alaska Department of Transportation and Public Facilities standards. Culverts at streams with fish will be designed and sized for fish passage in accordance with U.S. Fish and Wildlife Service (USFWS) standards (USFWS 2020). Typical culvert designs are included in Figure A-16 through Figure A-20. The natural gas pipeline, fiber optic cable, concentrate pipeline, and water return pipeline will be buried in the toe of the road or in a corridor adjacent to the access road. For bridged river crossings, the pipelines will be attached to the bridge structures (Figure A-4 through Figure A-15).

3.3.1.1 Mine Access Road in Iliamna Bay

A double-lane road would connect the mine site to the Diamond Point port in Iliamna Bay (Figure 1-1). Since Iliamna Bay is bordered by mountains that rise very steeply from tidewater, the road route would be constructed at the toe of the mountain slope within the intertidal zone (Figure 3-2). This design approach is dictated by the steepness of the mountain slopes and the requirement to avoid avalanches and rockslides. Mass rock excavation is required, as is placement of rock select fill and armor rock protection in the intertidal zone (Figure A-21 and Figure A-22). Select rock fill would consist of durable, coarse, free draining material to minimize sedimentation. Roughly 1.7 miles (mi) (2.7 kilometers [km]) of the road in Iliamna Bay would include construction in the intertidal zone. Placement of fill activities would affect 26.3 ac (10.6 ha) of intertidal zone, with 19.1 ac (7.7 ha) of permanent impacts from the placement of fill, and 7.2 ac (2.9 ha) of temporary impacts. Temporary impacts include areas abutting fill placement sites that may be affected by construction activities (e.g., ground scarring from equipment operation, dust/sediment deposition) but are expected to recover once the construction activity ceases.

Average high tide in Iliamna Bay is approximately +12 ft (3.7 m). For this reason, road embankments in the intertidal zone would be constructed to a minimum elevation of 25 ft (7.6 m) above mean sea level (AMSL). The west side of the embankment generally would be at or above the MHW mark and the east side would be in the tidal zone. Drainage and equalization culverts would be installed throughout this road segment.

The concentrate pipeline, return water pipeline, natural gas pipeline, and fiber optic cable installed between the port site and the mine site would be incorporated in a single trench at the road shoulder on the inland side of the road. The concentrate pipeline (6.25-inch-diameter) would transport a mixture of 55 percent concentrate and 45 percent water by mass from the mine site to the port. At the Diamond Point port, the concentrate slurry would be dewatered, and the water returned to the mine site via an 8-inch diameter return water pipeline.

Construction would start with the placement of select, free draining, coarse rock fill directly on the sandy material in the intertidal zone to an elevation above the high tide line. This fill work can mostly be completed when water levels are below the minimum elevation of the surface on which rock is being placed. Armor rock would be placed as the final embankment elevation of 25 ft (7.6 m) AMSL is achieved. Installation of the pipelines would be completed after the road embankment height attains pipeline ditch elevation. Five equalization culverts (Figure 3-2, Figure A-23, Figure A-24) would be installed during embankment construction to maintain cross drainage in the few locations where the full embankment footprint is within the intertidal zone. Blasting at the bedrock cuts along the road alignment would all be above the high tide line and would be done to coincide with the low tide cycle when the bay is partially dry.

The access road would be constructed using typical construction equipment (e.g., dump trucks, dozers, graders, and excavators). This section of the access road would be constructed in June Y1 through September Y1.

3.3.2 Concentrate Slurry Pipeline and Return Water Pipeline

The concentrate pipeline will consist of a single approximately 6.25-inch (15.9 cm) diameter API 5L X60 grade (or similar) steel pipeline with an internal HDPE liner to prevent corrosion. A cathodic protection (zinc ribbon or similar) system will be included for prevention of external corrosion. A pressure-based leak detection system, with pressure transmitters located along the pipeline route, will monitor the pipeline for leaks. Two electric pump stations will be required, one at the mine site and one at an intermediate point. Both pump stations will utilize positive displacement pumps in the 1000 horsepower range and the intermediate one will require a power generation facility (1-2-megawatt range). Rupture discs at the intermediate and terminal stations and pressure monitoring will be utilized to protect the pipeline from overpressure events. Manual isolation and drain valves will be located at intervals no greater than 20 mi (32.2 km) apart.

The return water pipeline is sized to accommodate water from flushing operations with a diameter of approximately 8 in (20.3 cm). The HDPE lined steel pipeline will have similar corrosion protection and safety controls to the concentrate pipeline. No intermediate pump station is required for the water return pipeline.

3.4 Natural Gas Pipeline and Fiber Optic Cable

Natural gas and data will be supplied to the Diamond Point Port and the mine site by a natural gas pipeline and fiber optic cable (Figure 1-1). The pipeline will connect (offtake point) to the existing gas pipeline infrastructure near Anchor Point on the Kenai Peninsula.

A metering station will be constructed at the offtake point that connects to a compressor station located on a land parcel on the east side of the Sterling Highway. The steel pipeline will be designed to meet all required codes and will be a nominal 12 in (30.5 cm) in diameter. Metering stations and pig launching and receiving facilities would be located at the compressor station and offtake points as appropriate. Mainline sectionalizing valves will be installed as required by code, with a spacing of no more than 20 mi (32.2 km) for onshore sections of the pipeline.

3.4.1 Cook Inlet Crossing

The subsea pipeline across Cook Inlet (Figure A-25) will be constructed using heavy wall nominal 12-inch (30.5 cm) diameter pipe designed to have negative buoyancy and provide erosion protection against tidal currents. Horizontal directional drilling (HDD) will be used to install pipe segments from the compressor station out into waters that are deep enough to avoid navigation hazards (0.3 mi [0.5 km]) (Figure A-26). From this point, the heavy wall pipe will be trenched into the sea floor (74.3 mi [119.7 km]) and would be buried over the entire Cook Inlet traverse, to maintain pipe integrity. The pipeline burial depth and thickness of cover would vary depending on geotechnical conditions and regulatory requirements in 49 CFR 192 (Table 3-1). Trenching techniques may include using an extended reach backhoe or clamshell dredge in shallow waters near the shore transition and either a mechanical or jet trencher in deeper waters (Table 3-1, Figure 3-8). The pipeline will come on shore at Ursus Cove (Figure A-25) utilizing trenching (Figure A-27), and cross Ursus Head overland (5.5 mi [8.9 km]), before descending to the tidal waters of Cottonwood Bay (3.6 mi [5.8 km]) prior to coming ashore north of Diamond Point where the port site is located.

3.4.2 Diamond Point Port to Mine Site

From Diamond Point port, the natural gas pipeline and fiber optic cable will follow the access road for a distance of approximately 82 mi (132 km) to the mine site. An offtake at Diamond Point port will supply natural gas to the port site power station and provide site heating. From here the natural gas pipeline and fiber optic cable will be buried with the concentrate and water return pipelines in a trench adjacent to the road prism and will follow the mine access road to the mine site. At bridged crossings the pipeline will be attached to the bridges (Figure A-4 through Figure A-15); otherwise the pipeline will utilize trenching or HDD to cross streams (Figure A-28).

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Table 3-1. Natural gas pipeline trenching requirements and methodologies.

Range from Origin mi (km)[1]		Avg. Water Depth ft (m)	Min. Cover Depth in. (m)	Total Impact Width ft (m)	General Soil Type (Sand)	Relative Density (%)	Extended Reach Backhoe	Clamshell Dredge	Mechanical Trencher	Jet Trencher
Shore Transition (Anchor Point)	0.6 (1.0)	22.6 (6.9)	39.4 (1.0)	90.6 (27.6)	Medium to Coarse	50		✓[2]	✓	✓
0.6 (1.0)	3.7 (6.0)	63.3 (19.3)	19.7 (0.5)	68.2 (20.8)	Dense	50		✓	✓	✓
3.7 (6.0)	9.0 (14.5)	108.3 (33.0)	19.7 (0.5)	68.2 (20.8)	Dense	55		✓	✓	✓
9.0 (14.5)	13.7 (22.0)	137.1 (41.8)	19.7 (0.5)	68.2 (20.8)	Dense	55		Water depth may limit the use of clamshell dredgers	✓	✓
13.7 (22.0)	17.1 (27.5)	196.9 (60.0)	19.7 (0.5)	68.2 (20.8)	Dense	50			✓	✓
17.1 (27.5)	22.0 (35.5)	247.7 (75.5)	19.7 (0.5)	68.2 (20.8)	Dense	50			✓	✓
22.0 (35.5)	28.9 (46.5)	249.7 (76.1)	7.9 (0.2)	56.7 (17.3)	Medium	45			✓	✓
28.9 (46.5)	33.5 (54.0)	182.1 ft (55.5)	7.9 (0.2)	56.7 (17.3)	Dense	45			✓	✓
33.5 (54.0)	65.6 (105.6)	109.3 (33.3)	7.9 (0.2)	56.7 (17.3)	Medium	~45		✓	✓	✓
65.6 (105.6)	69.9 (112.6)	45.6 (13.9)	19.7 (0.5)	68.1 (20.8)	Loose	~30		✓	✓	✓
69.9 (112.6)	72.1 (116.1)	29.5 (9.0)	39.4 (1.0)	90.6 (27.6)	Loose	~30		✓	✓	✓
72.1 (116.1)	73.6 (118.5)	21.7 (6.6)	39.4 (1.0)	90.6 (27.6)	Clay	N/A[3]		✓	✓	✓
73.6 (118.5)	74.1 (119.3)	18.4 (5.6)	39.4 (1.0)	90.6 (27.6)	Loose	~30		✓	✓	✓
74.1 (119.3)	74.3 (119.7)	9.8 (3.0)	47.2 (1.2)	101.7 (31.0)	Dense	~65		✓	✓	✓
79.9 (128.7)	83.0 (133.5)	Tidal 0-15 (0-4.5)	59.1 (1.5)	175.0 (53.5)	N/A	N/A	✓			

[1] Trench burial mode limits shown in Figure 3-8
[2] ✓= Trenching methodology suitable for use
[3] N/A = Not Available

Trenching and pipeline laying might also involve a pipeline trenching plough if it is determined during detailed design that a plough might be suitable for use in lower Cook Inlet (based on substrate conditions). However, at this time, due to the unknown suitability of ploughs, they are not assumed to be a primary option. If ploughing can be used, the shore approaches would still need to be excavated using other means, such as conventional long-reach backhoe excavators or a clamshell dredge. All equipment would work from barges up to 240 ft long by 60 ft wide (73.2 m x 18.3 m). The plough option would require a marine support vessel capable of supporting a large crane or A-frame necessary to deploy and recover the plough and the power to pull the plough through the lower Cook Inlet seafloor sediments.

Material would be excavated, placed to the side of the trench and, following installation of the pipe, returned to the trench with construction equipment and through the natural tidal process (Figure A-25, Figure A-29 through Figure A-31). To provide for on bottom stability and pipe protection the entire alignment is required to be backfilled after pipe installation. Material not naturally backfilled by tidal processes would be replaced using an extended reach backhoe or clamshell dredge.

The Anchor Point shore transition would use shore-based HDD out to approximately 12 ft (3.7 m) of water depth, estimated to be approximately 200 ft (61.0 m) horizontal distance beyond MLLW. The drill rig and other equipment necessary for the HDD installation would be located onshore, approximately 1,600 ft (487.7 m) inland from and 200 ft (61.0 m) above MLLW (Figure A-26). Due to the onshore location of the HDD equipment and the prevalence of sand, generally a very poor conductor of vibrations, it is unlikely HDD activities would generate underwater noise levels. A jackup rig might be deployed to complete the offshore exit portion of the HDD if required as a result of final design and state permitting. For the Cottonwood Bay crossing, the pipeline would be installed in a trench using a barge-mounted excavator in inundated areas, or low ground pressure equipment and mats in tidal areas. The pipeline would come ashore at Diamond Point port, where natural gas would be supplied to the port site power station and for facility heating.

PLP estimated that approximately 569 ac (230.3 ha) of marine substrate would be temporarily disturbed from trenching activities between Anchor Point and Ursus Cove. Additionally, 69.1 ac (28 ha) of marine substrate would be disturbed within the intertidal zone in the head of Cottonwood Bay. This does not include potential seabed disturbance from anchor placement which is discussed below.

The pipe would be laid using a conventional pipe-lay barge, a non-motorized barge that is moved by retrieving and deploying 8 to 12 anchors used to hold it in place while the pipe is welded together and laid over the back of the barge. Sediment disturbance may occur as a result of anchor placement, cable anchor drag, and cable sweep. Anchor handling tugs (AHTs) would be used to reposition the anchors that keep the barge properly positioned. Anchors would be 5 to 15 tons (4.5 to 13.6 tonnes) depending on vessel size and are typically relocated 2,500 ft to 3,000 ft (762 m to 914.4 m) with each move. Anchor relocations would occur multiple times per day (estimated average of 4 to 8 per day), including the need to account for changes in tides and currents (e.g., short distance relocations at slack tide to allow the vessel to prepare for the change in current direction). Anchor placement may extend approximately 650 ft to 4,101 ft (198.2 m to 1,250 m) on either side of the pipeline centerline depending on depth. Sediment disturbance may occur as a result of anchor placement, anchor chain drag, and chain sweep; thus, PLP has estimated a 48,933 ac (19,802 ha) anchor placement corridor (Figure 3-8). However, not all areas inside this corridor would be disturbed by anchor chain drag or chain sweep. In comparison, the Alaska LNG

Project Draft Environmental Impact Statement estimated 5,039 ac (2,039 ha) of potential anchor chain drag and chain sweep from proposed construction of a 27.3-mi (43.9 km) long pipeline in upper Cook Inlet (FERC 2019). Pipeline construction would occur in the months of June through August of a single year and it would take approximately 30 to 40 days to install the pipe, plus an additional 30 to 60 days of pre- and post-pipe laying activities. Equipment and vessels required may include:

- One anchor pipe-laying barge with an 8- to 12-point mooring system.
- Two anchor and barge handling vessels.
- Two tug and barge combinations for pipe haul from shore to the lay barge.
- One survey vessel for pre- and post-lay survey work and touch down monitoring with a remotely operated vehicle (ROV).
- One rock dump and construction support vessel (diving and ROV) for span crossing mitigation as required.
- One cutterhead suction dredge and/or clamshell dredge for offshore trenching as needed.
- One crew boat and supply vessel for personnel and equipment movement.

The pipeline would include a cathodic protection system with 195.4-pound (lb) (88.6 kilogram [kg]) aluminum-zinc anodes placed approximately every 240 ft (73 m), or every sixth joint, along the pipeline. Anode half shells would be clamped centrally on the pipe with overlapping fixing lugs fillet welded together at each anode location. Neoprene liners, felt pads, or similar may be placed between the anode and pipe external anti-corrosion coating to prevent damage to the coating. The anode electrical connection to the pipe would be completed by removing an area of external anti-corrosion coating from the pipeline (one per anode half shell bonding cable), pin brazing the electrical bonding cables, and then repairing the pipe coating using a liquid epoxy repair kit or equivalent. The exposed line pipe surface would be wire brushed prior to making the cable connection.

A fiber optic cable would be installed in conjunction with the natural gas pipeline. The fiber optic cable would be installed adjacent to or bundled with the natural gas pipeline during the same construction event. Alternatively, it is possible that the fiber optic cable would be laid separately and adjacent to the pipeline (although it would occur within the same work period as the pipeline lay). The proposed method for a separate cable lay would be to use a tug or vessel of similar size to the pipeline construction vessels. A separate HDD would not be conducted to transition the cable to shore, but rather the cable would be bundled with the pipeline to utilize the HDD tunnel for both pipe and cable.

3.5 Construction Schedule

Construction would last for approximately four years during which the facilities would be built according to the following schedule (Table 3-2).

Table 3-2. Proposed construction schedule.

Construction Activity	Estimated Start	Estimated Finish
Access Infrastructure		
Williamsport site capture (land by barge)	May Y1	
Construct road to Diamond Point port	June Y1	August Y1

Construction Activity	Estimated Start	Estimated Finish
Construct initial road towards mine site	June Y1	April Y2
Complete on-shore port site preparation	July Y1	September Y1
Final access road construction	November Y1	September Y2
Construct major bridges	May Y2	September Y2
Dredge entrance channel and turning basin	May Y2	August Y2
Construct the on-shore port facilities	May Y2	October Y2
Install causeway and barge dock	July Y2	October Y2
Access infrastructure complete		*October Y2*
Pipelines and Fiber Optic Cable		
Construct pipeline along road segments	November Y1	September Y2
Cook Inlet sub-sea pipeline placement	June Y2	August Y2
Construct concentrate pipeline terminus	May Y3	September Y3
Install Anchor Point compressor station	June Y3	August Y3
Construct concentrate loadout	May Y4	September Y4
Pipelines complete	-	*September Y3*
Mine Site		
Site capture (establish construction infrastructure)	April Y2	July Y2
Major site earthworks	September Y2	February Y4
Mill and infrastructure construction	May Y3	October Y4
Pit pre-production mining	October Y3	September Y4
Commencement of production	*October Y4*	-

3.6 Project Study Area

Watersheds are organized in a hierarchical hydrologic unit code (HUC) system consisting of six levels. In general, the lower the level, the larger the watershed scale is. The proposed project is located within two major HUC 4 watersheds:

1. HUC 4 Bristol Bay Watershed. This watershed drains waters into Bristol Bay and includes the HUC 6 Nushagak River and Kvichak-Port Heiden watershed (Figure 3-5).
2. HUC 4 Cook Inlet watershed. This watershed drains waters into Cook Inlet and includes the HUC 6 Western Cook Inlet watershed and Kenai Peninsula watershed (Figure 3-5).

The proposed mine site is primarily located within the HUC 10 Headwaters Koktuli River watershed, a sub-watershed of the HUC 6 Nushagak River watershed. A small portion of the mine site, and much of the transportation corridor and natural gas pipeline components, would be in the HUC 10 Upper Talarik River, Newhalen River, Iliamna Lake, Chekok Creek, Pile River, and Iliamna River watersheds, which are sub-watersheds of the HUC 6 Kvichak-Port Heiden watershed. The proposed transportation corridor in Iliamna Bay, Diamond Point port, a portion of natural gas pipeline and fiber optic cable are in the HUC 10 Chinitna River-Frontal Cook Inlet watershed, a sub-watershed of the HUC 6 Western Cook Inlet watershed. The natural gas pipeline and fiber optic cable, which traverse Cook Inlet, originate in the HUC

10 Stariski Creek-Frontal Cook Inlet watershed, a sub-watershed of the HUC 6 Kenai Peninsula watershed. The study area of this EFH assessment includes all EFH that intersects, or is adjacent to, the action. Figure 3-5 through Figure 3-8 provide an overview of the location of proposed project components with respect to EFH in the study area.

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 2018), *Fishery Management Plan for Groundfish of the Gulf of Alaska* (Groundfish FMP) (NPFMC 2019a), 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 2019). 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 2019a). EFH has been described for 38 groundfish species within the Project study 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 Study Area by FMP.

Salmon FMP	Groundfish FMP	Scallop FMP
1. Chinook salmon 2. Coho salmon 3. Sockeye salmon 4. Chum salmon 5. Pink salmon	1. Atka mackerel 2. GOA Skates (Rajidae) – (3 species [sp.]) 3. Octopus 4. Pacific cod 5. Sablefish 6. Sculpins (Cottidae) – (3 sp.) 7. Walleye pollock 8. Rockfish (Sebastes) – (19 sp.) 9. Flatfish – (8 sp.) 10. Sharks[1] 11. Forage fish complex- (> 12 sp.)[1] 12. Squids[1] 13. Grenadiers[1]	1. Weathervane scallop

1 No EFH description determined due to insufficient information (NPFMC 2019a), but species identified in project sampling.

4.1 Pacific Salmon

The Bristol Bay watershed and Cook Inlet watershed produce 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 these 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 2018). 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 2019) which shows where spawning adults, rearing fry/juveniles, and presence/absence observations have been documented, much of which was 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 study area is designated by those waters included in the AWC, and PLP data, 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. Table 4-2 presents a breakdown of Pacific salmon EFH including the length of streams and area of lakes (or marine habitat where applicable) by species, life stage, and watershed. Sockeye salmon is the most widely distributed salmon species in the study area. It should be noted that the AWC data in the study area is limited by the number of waterbodies that have been surveyed. PLP's research efforts have contributed to the mapping of all anadromous streams for waterbodies that intersect or are in proximity to the Project. However, there are many waterbodies in study area drainages that will not be affected by any project components, many of which have not been surveyed and are not represented in the AWC. Therefore, while the extent of EFH potentially affected by the project is well documented, total available EFH in area drainages is not. Furthermore, the streams depicted in the AWC are generally derived from 1:63:360 scale USGS quad maps, which simplify stream length. For these reasons, the data in Table 4-2 is considered an underestimate of the total amount of Pacific salmon EFH that exists in each watershed.

EFH for Pacific salmon is present within all project components areas 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 4-3). 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 study area are depicted in Figure 3-5 through Figure 3-8.

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 most of these data are now included in the AWC (Johnson and Blossom 2019). 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. This EFH assessment considers those areas determined in 2018 as being used by Pacific salmon as EFH.

Essential fish habitat for all Pacific salmon, except pink salmon, was found within the three major drainages of the study 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, analyses depicted throughout this assessment rely on densities of Pacific salmon by species and life stage to identify and discuss the relative quality and importance of EFH to managed species within various portions of the study 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 4-4). 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 are presented in Table 4-5. Furthermore, cumulative observations of spawning salmon and densities by reach are presented in Table 4-6 for a more specific depiction of the spawning distribution throughout each river. The general distribution of adult Pacific salmon during the spawning period as shown in the AWC within drainages near the mine site is shown in Figure 4-1. Adult salmon distribution by species from the AWC supplemented with PLP data as appropriate are depicted in Figure 4-2 through 4-11. The distribution of peak adult salmon counts from PLP surveys near the mine site are shown in Figure 4-2, 4-4, 4-6, 4-8 and 4-10. The majority of adult fish and spawning observations for all adult Pacific salmon occurred downstream of waters directly affected by proposed mine facilities (Table 4-5, Table 4-6). 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.

Table 4-2. Pacific salmon EFH by drainage[1,2]

				Chinook Salmon			Sockeye Salmon			Coho Salmon			Chum Salmon			Pink Salmon	
				Present	Spawning	Rearing	Present	Spawning	Rearing	Present	Spawning	Rearing	Present	Spawning	Rearing	Present	Spawning
Drainage (HUC 10)	**AWC Named Streams and Waterbody Crossings**	**AWC Named Waterbodies**	**Freshwater Habitat**														
Chekok Creek	Chekok Creek	Chekok Lake	Streams mi (km)	-	-	-	1.6 (2.6)	28.7 (46.1)	-	20.8 (33.4)	0.8 (1.3)	3.4 (5.5)	-	-	-	-	-
			Lakes ac (ha)	-	-	-	22.3 (9.0)	255.0 (103.2)	-	277.3 (112.2)	-	-	-	-	-	-	-
Chinitna River-Frontal Cook Inlet	Brown's Peak Creek Cottonwood Creek Y-Valley Creek		Streams mi (km)	0.7 (1.1)	-	0.9 (1.4)	8.1 (13.1)	2.6 (4.2)	-	8.7 (13.9)	17.0 (27.3)	7.6 (12.3)	14.3 (23.0)	45.3 (73.0)	-	4.4 (7.0)	37.6 (60.5)
			Lakes ac (ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Headwaters Koktuli River	South Fork Koktuli River North Fork Koktuli River	Big Wiggly Lake	Streams mi (km)	12.4 (19.9)	63.8 (102.7)	83.3 (134.1)	14.8 (23.8)	58.5 (94.2)	52.7 (84.8)	19.8 (31.9)	79.0 (127.1)	122.3 (196.9)	3.5 (5.7)	49.5 (79.7)	6.7 (10.7)	-	-
			Lakes ac (ha)	164.3 (66.5)	-	-	52.0 (21.0)	164.3 (66.5)	151.5 (61.3)	219.1 (88.7)	-	187.1 (75.7)	-	-	-	-	-
Iliamna Lake	Canyon Creek Dennis Creek Eagle Bay T1 East Fork Eagle Bay Creek East Fork Youngs Creek Kokhanok River Knutson Creek Kvichak River Lonesome No. 1 Creek Long Lake Creek Long Lake T1 Lower Talarik Creek Pete Andrews Creek Roadhouse Creek Tommy Creek West Fork Eagle Bay Creek West Fork Youngs Creek	Dumbbell Lake Iliamna Lake Stonehouse Lake	Streams mi (km)	22.8 (36.7)	0.7 (1.2)	1.7 (2.8)	7.5 (12.1)	173.8 (279.8)	1.7 (2.8)	54.6 (87.8)	11.2 (18.0)	19.2 (31.0)	-	<0.002 (<0.004)	-	-	<0.002 (<0.004)
			Lakes ac (ha)	673,407 (272,518)	-	-	47 (19)	674,545 (272,979)	672,756 (272,255)	673,957 (272,741)	35 (14)	23 (9)	672,756 (272,255)	-	-	672,756 (272,255)	-
Iliamna River	Chinkelyes Creek Iliamna River Ptarmigan Creek		Streams mi (km)	13.2 (21.2)	-	-	4.2 (6.8)	36.5 (58.8)	-	18.0 (29.0)	-	1.0 (1.7)	13.2 (21.2)	-	-	13.2 (21.2)	-
			Lakes ac (ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Newhalen River	Lover's Creek Bear Creek Bible Camp Creek Newhalen River Newhalen River Trib 4.2.1 Stuck Creek/ Newhalen River Trib 4.2	Alexcy Lake Iliamna Lake Pickerel Lakes Sixmile Lake	Streams mi (km)	13.6 (21.9)	9.0 (14.5)	-	5.3 (8.5)	30.1 (48.4)	1.5 (2.4)	33.5 (53.9)	-	12.3 (19.8)	-	-	-	-	-
			Lakes ac (ha)	3,999.9 (1,619)	-	-	3,415.0 (1,382)	2,334.7 (944.8)	3,415.1 (1,382)	4,770.3 (1,930)	-	-	0.1 (<0.04)	-	-	0.1 (<0.04)	-
Pile River	Long Lake Creek Pile River	Iliamna Lake	Streams mi (km)	0.5 (0.8)	-	0.1 (0.1)	0.5 (0.8)	12.2 (19.7)	0.1 (0.1)	-	-	-	-	-	-	-	-
			Lakes ac (ha)	0.2 (0.1)	-	-	-	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	-	-	0.2 (0.1)	-	-	0.2 (0.1)	-
Upper Talarik Creek	Upper Talarik Creek	Iliamna Lake	Streams mi (km)	6.4 (10.3)	30.9 (49.8)	25.6 (41.2)	1.1 (1.8)	48.1 (77.4)	31.1 (50.0)	3.1 (5.0)	60.4 (97.2)	71.1 (114.5)	2.4 (3.9)	52.0 (83.6)	-	4.3 (6.9)	-
			Lakes ac (ha)	<0.005 (<0.002)	-	1.0 (0.4)	-	33.4 (13.5)	<0.005 (<0.002)	<0.005 (<0.002)	33.4 (13.5)	33.4 (13.5)	<0.005 (<0.002)	-	-	<0.005 (<0.002)	-

1 Johnson and Blossom 2019, HDR 2019.
2 Drainages defined by hydrologic unit code (HUC) system described above in the Project Study Area, Section 3.6.

Table 4-3. Pacific salmon species life stages[1] by HUC-10 drainages[2] in the study area.

Salmon Species	Chinitna River-Frontal Cook Inlet	Iliamna River	Pile River	Chekok Creek	Iliamna Lake	Newhalen River	Upper Talarik Creek	Headwaters Koktuli River
Chinook salmon	p	p	p	--	s, r	s	s, r	s, r
Sockeye salmon	p	s	s	s	s, r	s, r	s, r	s, r
Coho salmon	s, r, p	p	--	p	s, r	r	s, r	s, r
Chum salmon	s, p	p	--	--	s	p	s	s, r
Pink salmon	s, p	p	--	--	s	p	p	--

1 Pacific salmon life stages present within the primary drainages within the study area: p = present; s = spawning; r = rearing (Johnson and Blossom 2019).

2 Drainages defined by hydrologic unit code (HUC) system described above in the Project Study Area, Section 3.6.

Table 4-4. Peak daily counts and densities (fish per stream kilometer) of adult salmon by stream and year based on aerial surveys 2004 to 2008 and 2009.[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
Chinook salmon	2005	2,889	60.4	47.8	1,660	30.3	54.8	100	1.6	60.9
Chinook salmon	2006	740	16.5	44.9	327	9.1	35.8	90	1.5	60.9
Chinook salmon	2007	531	9.6	55.6	387	7.1	54.8	152	2.5	60.5
Chinook salmon	2008	434	7.8	55.5	590	13.5	43.8	102	1.6	62.5
Chum salmon	2004	435	13.1	33.2	--	--	--	--	--	--
Chum salmon	2005	350	7.8	44.9	361	10.1	35.8	3	0.1	58.2
Chum salmon	2006	753	16.8	44.9	866	24.2	35.8	9	0.1	60.9
Chum salmon	2007	833	18.6	44.9	189	3.4	54.8	10	0.2	60.5
Chum salmon	2008	1,432	31.9	44.9	917	17.9	51.2	44	0.7	62.5
Chum salmon	2004	378	14.6	25.9	270	4.5	60.3	2,621	43.0	60.9
Chum salmon	2005	361	7.6	47.8	565	10.3	54.8	1,041	30.1	34.6

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)
Chum salmon	2006	1,074	23.9	44.9	1,394	38.9	35.8	6,413	110.0	58.3
Chum salmon	2007	114	2.1	55.6	340	5.6	60.3	4,359	72.2	60.4
Chum salmon	2008	1,704	30.7	55.5	1,955	34.4	56.9	5,248	90.3	58.1
Chum salmon	2009							7,542	127.6	59.1
Sockeye salmon	2004	563	12.5	44.9	1,730	48.3	35.8	33,070	543.0	60.9
Sockeye salmon	2005	1,140	25.4	44.9	2,051	40.8	50.3	13,698	224.9	60.9
Sockeye salmon	2006	1,385	30.8	44.9	2,952	53.9	54.8	11,334	186.1	60.9
Sockeye salmon	2007	2,188	39.4	55.6	4,112	75.0	54.8	10,557	174.5	60.5
Sockeye salmon	2008	1,907	34.4	55.5	6,133	140.0	43.8	50,317	805.1	62.5
Sockeye salmon	2009							14,481	862.0	16.8

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 4-5. 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 NFK 1.40, 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	NFK-05	13	3.9	3.0	1	0.3	0.2	23	6.8	1.3	0	0.0	0.0

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)	%
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
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

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)**	**%**
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**		

1 PLP 2018a –SEBD, Tables B2-5, B-10, and B-15, aerial survey data.
2 Stream reaches or potions of stream reaches within the study area are in bold.

Table 4-6. Aerial observations of spawning salmon by stream reach in the North Fork Koktuli River, South Fork Koktuli River and Upper Talarik Creek, 2008.[1,2]

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**		
South 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]	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]	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**		

1 PLP 2011 –EBD 2004 -2008 Tables 15.1-16,15.1-29,15.1-42, aerial survey data.
2 Observations from surveyed tributaries are included in reach counts.
3 UT-A observations for coho and sockeye salmon include tributary UT 1.160.
4 UT-E observations for coho salmon include tributary UT 1.350.

Studies were conducted using metric 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, 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 4-7 presents mainstem and tributary juvenile Pacific salmon densities from 2004-2008 (PLP 2011). Table 4-8 presents juvenile salmon densities from mainstem index surveys summarized by stream reach (PLP 2018a). Table 4-9 presents juvenile salmon densities for selected tributary and mainstem sampling sites from 2008 and 2018 (PLP 2011, PLP 2018c).

Table 4-7. Mainstem and tributary densities of juvenile Pacific salmon by EBD reach, EBD 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
NFK-C	Tributary	27,319.3	0.19	0.00	1.35	0.00
NFK-D	Mainstem	--	[2]	--	--	--
NFK-E	Mainstem	--	[2]	--	--	--
NFK-F	Mainstem	--	[2]	--	[3]	--
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
SFK-B	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
SFK-C	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
SFK-E (with FPL)	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
UT-C	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

EBD Reach	Tributary/ Mainstem	Total Area Surveyed (m²)	Fish Density (fish/100m²)			
			Chinook Salmon	Chum Salmon	Coho Salmon	Sockeye Salmon
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
UT-F	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
UT-G	Tributary	2,277.9	0.00	0.00	1.93	0.00

1 PLP 2011 – EBD 2004-2008.
2 In 2008, 8 juvenile Chinook salmon were observed in NFK-D, 0 in NFK-E, and 4 in NFK-F.
3 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 study 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 study area. Pink salmon, identified in two streams in the study area, are also not considered further in the evaluation as they smolt within hours to a few days and exhibit almost no residency in the study area. Mainstem habitats within the NFK and SFK rivers, and UT Creek had the highest quality rearing 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. Habitat data, where available, illustrate that in areas with lowest detected juvenile salmon densities that channel slopes tended to be high and pool frequency low, with the exception of some NFK-C tributaries that exhibited relatively high pool frequency for the drainage, but were dominated by cobble/gravel and sometimes boulder substrates and relatively high slopes (Table 4-10).

In accordance with the Salmon FMP, freshwater EFH for Pacific salmon is based on the AWC (Johnson and Blossom 2019) which shows where spawning adults, rearing fry/juveniles, and general presence 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 4-8. Densities of juvenile Pacific salmon by EBD reach from mainstem index snorkel surveys, 2009.[1]

EBD Reach	Total Area (m²)	Juvenile Pacific Salmon Density (fish/100m²)			
		Chinook Salmon	Chum Salmon	Coho Salmon	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	--	--	--	--

EBD Reach	Total Area (m^2)	Juvenile Pacific Salmon Density (fish/100m²)			
		Chinook Salmon	Chum Salmon	Coho Salmon	Sockeye Salmon
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					
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	--

1 PLP 2018a – SEBD Table 15-12.

Table 4-9. Juvenile salmon densities in fish/100m² 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-C	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-C	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-E	SFK 1.310 and Tributaries	2,907.2	--	--	--	--
SFK-E	SFK 1.320	23.7	--	--	--	--
SFK-E	SFK 1.330	561.0	--	--	--	--
SFK-E	SFK 1.340	751.2	--	--	--	--
SFK-E	SFK 1.350	616.7	--	--	--	--
SFK-E	SFK 1.370	183.7	--	--	--	--
SFK-E	SFK 1.380	952.0	--	--	--	--
SFK-E	SFK 1.400	288.2	--	--	--	--

EBD Reach	Stream (river km)	Total Area Surveyed (m^2)	Chinook Salmon	Chum Salmon	Coho Salmon	Sockeye Salmon
			Juvenile	Juvenile	Juvenile	Juvenile
Upper Talarik Creek						
UT-F	UT 1.360 and Tributaries	2,240.6	--	--	0.40	--
UT-F	UT 1.370 and Tributaries	2,718.2	--	--	42.12	--
UT-F	UT 1.380 and Tributaries	4,183.5	0.02	--	39.13	0.31
UT-F	UT 1.390 and Tributaries	2,914.3	--	--	2.81	0.34
UT-F	UT 1.400	14.0	--	--	--	--
UT-F	UT 1.410 and Tributaries	2,375.2	--	--	43.45	--
UT-F	UT 1.420	260.7	--	--	45.26	--
UT-F	UT 1.430	234.4	--	--	16.21	--
UT-F	UT 1.440	59.7	--	--	--	--
UT-F	UT 1.460	652.0	--	--	10.58	--
UT-F	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	--

1 Data 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.

Table 4-10. Physical habitat characteristics in mainstem and select tributary reaches in the mine site study area.[1]

Reach	Tributary	Bankfull Width (ft)	Bankfull Depth (ft)	Slope (%)	Substrate (dominant/ subdominant)	Pool frequency (#/100m)	Dominant Riparian
North Fork Koktuli River							
NFK A	n/a-mainstem[2]	66.6	n/a	0.5-1	Gravel/cobble/ sand	n/a	Open willow tall shrub
NFK B	n/a-mainstem[2]	68.4	n/a	0.5	Gravel/cobble/ sand	n/a	Open willow tall shrub
NFK C	n/a-mainstem[2]	61/0	n/a	n/a	Gravel/cobble	n/a	Open willow tall shrub
NFK C	1.190[2]	6.5-30	3.1	2-3	Cobble/gravel	0.8	Willow shrub
NFK C	1.190.10[2]	5.8-14	1.6	0.5-3.7	Cobble/boulder/ gravel	0.4	Willow shrub, fen, other herbaceous
NFK C	1.190.10.03[2]	6.5	1.3	1.5	Sand/silt	0.8	Willow shrub, tundra
NFK C	1.190.10.20	14.6	1.3	2.8	Sand/silt	0.6	Willow shrub
NFK C	1.190.30[2]	4.6	1.3	1.5	Gravel/cobble	1.8	Other herbaceous

Reach	Tributary	Bankfull Width (ft)	Bankfull Depth (ft)	Slope (%)	Substrate (dominant/ subdominant)	Pool frequency (#/100m)	Dominant Riparian
NFK C	1.190.40[2]	8.5	1.6	2.2	Cobble/gravel	1.45	Willow shrub, other herbaceous
NFK C	1.190.40.10	4.5	1.6	3.0	Cobble/boulder	1.8	Willow shrub, other herbaceous
NFK C	1.190.20	5.5	2.2	1.5	Sand/silt	0.6	Willow shrub, other herbaceous
NFK C	1.190.20.10	6.5	1.6	6.0	Boulder/cobble	0	Other herbaceous
NFK C	1.190.25	4.8	1.3	3.7	Cobble/boulder	1.0	Willow shrub, other herbaceous
NFK C	1.190.30	7.0	1.9	3.0	Cobble/boulder/ gravel	1.4	Willow shrub, other herbaceous
NFK C	1.190.40[2]	6.5-11	1.9	1.8-3.2	Sand/silt/cobble/ gravel	1.0	Willow shrub, other herbaceous
NFK C	1.190.40.10	5.9	1.6	3-6.8	Cobble	1.4	Other herbaceous
NFK C	1.190.40.10.10	3.25	1.6	4.5	Sand/silt	1.7	Willow shrub
NFK C	1.190.50	6.8-13.3	1.95	2.7-11	Gravel/cobble	0.5	Willow shrub, other herbaceous
NFK C	1.190.50.10	7.5	1.6	2.8	Gravel	0	Willow shrub, other herbaceous
NFK C	1.190.70	9.75	1.95	3.7-11.5	Boulder	0.1	Other herbaceous
NFK C	1.190.75	10.4	1.3	6.3	Cobble	0.5	Other herbaceous
NFK D	1.200	47.2	1.5	1.1	Gravel/cobble	0.7	Other herbaceous, Willow shrub
NFK D	1.200.10	7.0	1.7	3.5	Cobble/sand-silt	0.3	Other herbaceous, Willow shrub
NFK D	n/a-mainstem	29.2	n/a	1-1.5	Gravel/sand	n/a	Open willow low shrub

Reach	Tributary	Bankfull Width (ft)	Bankfull Depth (ft)	Slope (%)	Substrate (dominant/ subdominant)	Pool frequency (#/100m)	Dominant Riparian
NFK E	n/a-mainstem	8.5	n/a	0.5	Sand/gravel/organics	n/a	Open willow tall shrub
NFK F	n/a-mainstem	n/a	n/a	n/a	n/a	n/a	Open willow low shrub
South Fork Koktuli River							
SFK A	n/a-mainstem[2]	66.3	n/a	0.5	Gravel/sand	n/a	Open willow low shrub
SFK B	n/a-mainstem[2]	59.9	n/a	0.5	Gravel/cobble	n/a	Open willow low shrub
SFK-B	1.190[2]	7.45-33	1.6-2.9	2.5-12	Gravel/cobble/ boulder	0.42	Willow Shrub/other herbaceous
SFK-B	1.190.20	11.3	2.0	6.8-11	Boulder/gravel/ sand-silt	0.57	Willow/alder shrub/other herbaceous
SFK-B	1.190.20.10	6.5	1.4	4.5	Sand-silt/boulder	1.3	Alder shrub/willow shrub
SFK-B	1.190.20.20	9.1	1.3	11	Boulder/sand-silt	1.25	Alder shrub/willow shrub
SFK-B	1.190.20.30	7.4	1.0	10	Sand-silt/boulder	0.9	Alder shrub/willow shrub
SFK-B	1.190.20.40	5.2	1.3	8.5	Sand-silt/cobble	0.8	Willow Shrub/other herbaceous
SFK-B	1.190.20.50	7.8	1.3	24.0	Boulder/cobble	0.5	Other herbaceous
SFK-B	1.190.20.60	5.5	1.3	2.0	Sand-Silt	1.2	Other herbaceous
SFK-B	1.190.30	6.1	1.7	1.5-5.0	Sand-silt/gravel	0.55	Willow Shrub/other herbaceous
SFK-B	1.190.30.10	4.8	1.95	5.0	Sand-silt	0.4	Willow Shrub
SFK-B	1.190.40	8.1	1.95	3.4	Cobble/gravel	0.85	Other herbaceous
SFK-B	1.190.50	6.7	1.6	2.3-6.3	Cobble/boulder	1.3	Alder shrub
SFK-B	1.190.50.10	3.25	0.97	8.0	Sand-silt	0.6	Other herbaceous

Reach	Tributary	Bankfull Width (ft)	Bankfull Depth (ft)	Slope (%)	Substrate (dominant/ subdominant)	Pool frequency (#/100m)	Dominant Riparian
SFK-B	1.190.60[2]	8.5-19	1.7	3.3-5.0	Cobble/boulder/ sand-silt	0.2	Alder shrub/other shrub
SFK-B	1.190.60.10	9.4	1.95	7.0-13.3	Boulder/cobble	1.05	Alder shrub/willow shrub
SFK-B	1.190.60.20	7.15	1.3	7.5-12	Boulder/cobble	1.7	Alder shrub/willow shrub
SFK-B	1.190.60.40	6.17	1.3	11	Gravel/sand-silt	1.45	Willow shrub/other herbaceous
SFK-B	1.190.70	11.3	2.11	12	Boulder/cobble	1.1	Willow/alder shrub, other herbaceous
SFK-B	1.190.80	9.2	1.95	3.3-13	Cobble/gravel/ boulder	0.05	Other shrub
SFK-B	1.190.80.10	6.8	1.3	7.7	Cobble/gravel	0.3	Other herbaceous
SFK-B	1.190.80.20	4.8	1.6	3.0	Gravel/sand-silt	2	Willow shrub
SFK C	n/a-mainstem	26	3.6	0.9	Gravel/sand-silt	2.1	Willow shrub
SFK-C	1.240[2]	4.8-37	0.5	0.8-10.0	Gravel/cobble/ boulder	0.08	Willow/alder shrub, other herbaceous
SFK-C	1.240.10[2]	9.6	0.8	1.0	Cobble/sand-silt/gravel	0.5	Willow/alder shrub, other herbaceous
SFK-C	1.240.10.20	13	1.3	3.0	Cobble/boulder	0.4	Other herbaceous
SFK-C	1.240.10.25	5.5	1.0	6.0	Boulder/Cobble	2.1	Other herbaceous
SFK-C	1.240.10.30	7.4	1.6	9.3	Cobble/boulder	0.3	Alder/Willow shrub/ other herbaceous
SFK-C	1.240.30	11.3-16.5	1.7	3.8-5.0	Cobble/boulder/ gravel	0.03	Willow/other shrub/ other herbaceous
SFK-C	1.240.40	5.2-10.4	1.3	4.5-5.2	Cobble/boulder/ gravel	0.35	Other herbaceous
SFK-C	1.240.40.10	3.5	0.65	4.8	Gravel/cobble	0.6	Other herbaceous

Reach	Tributary	Bankfull Width (ft)	Bankfull Depth (ft)	Slope (%)	Substrate (dominant/ subdominant)	Pool frequency (#/100m)	Dominant Riparian
SFK-C	1.240.70	5.5	1.0	3.3	Boulder/cobble	0	Other herbaceous
SFK-C	1.260[2]	20-28	2.4	1.25	Gravel/sand-silt	2.7	Alder/Willow shrub/ other herbaceous
SFK-C	1.260.10	2.2	1.3	1.0	Organics	0	Willow shrub/other herbaceous
SFK D	n/a-mainstem	39	1.3	0.5	Gravel	0.9	Alder shrub/Willow shrub
SFK E	n/a-mainstem	15.4	2.3	1.3-2.8	Sand-silt/organics	1.0	Willow shrub
SFK-E	1.340	4.55-14.95	1.86	0.3-2.1	Sand-silt/organics	0.74	Willow shrub, other herbaceous
SFK-E	1.340.40	4.8-18.2	2.27	2.1	Organics/sand-silt/gravel	0	Willow shrub, other herbaceous
SFK-E	1.370[1]	--	--	--	Gravel	0	Tundra/other herbaceous
Upper Talarik Creek							
UT A	n/a-mainstem[2]	99	4.6	1.4	Gravel/sand-silt	0.3	Willow shrub
UT B	n/a-mainstem[2]	89	4.6	1.2	Gravel/sand-silt	0.1	Willow shrub
UT C	n/a-mainstem[2]	72[3]	2.5[3]	n/a	n/a	0.1	n/a
UT C	1.190[1]	n/a	n/a	4.6	Cobble/gravel	0.6	n/a
UT D	n/a-mainstem[2]	60[3]	2.3[3]	n/a	n/a	0.2	n/a
UT E	n/a-mainstem[2]	56[3]	2.3[3]	n/a	n/a	0.5	n/a
UT F	n/a-mainstem[2]	25[3]	2.3[3]	1.0-2.5	Gravel/sand-silt	1.7	Alder shrub/Willow shrub
UT-F	1.360[2]	6.5-14.9	2.1	1.7-12.5	Cobble/gravel	0.53	Willow shrub/Alder shrub
UT-F	1.360.50	5.85	1.6	15	Cobble/gravel	0.9	Alder shrub
UT-F	1.410[2]	3.5-13.65	0.75	1.5-4.5	Gravel/sand-silt	0.82 * higher pool densities in lower reach	Willow shrub/other shrub/other herbaceous

Reach	Tributary	Bankfull Width (ft)	Bankfull Depth (ft)	Slope (%)	Substrate (dominant/ subdominant)	Pool frequency (#/100m)	Dominant Riparian
UT-F	1.410.10[2]	4.2-12.0	0.53	2.5-38.0	Gravel/boulder/ sand-silt	0.1	Alder shrub/ Willow shrub/other shrub/Tundra
UT-F	1.410.10.10	5.5	2.2	1.7	Sand-silt	0.2	Willow shrub
UT-F	1.410.30	8.12	2.43	3.5-11.5	Gravel/boulder	1.15	Alder shrub/ Willow shrub/other shrub
UT-F	1.410.40	6.18	1.95	1.8-2.7	Gravel/sand-silt	1.2	Tundra
UT-F	1.410.40.10	6.8	1.95	1.8	Sand-silt	1.7	Tundra
UT-F	1.440	9.1	4.55	1.0	Sand-silt	2.9	Other herbaceous
UT-F	1.460	9.9	2.43	1.0-2.0	Gravel	1.3	Other herbaceous
UT G	n/a-mainstem	1.7	0.7	1.7	Organics/sand-silt	2.3	Willow shrub

1 Source: Preliminary Pebble Project EIS, Table 3.24-2 (USACE 2020)
2 EFH stream
3 Bankfull widths and depths are from geomorphology study, remaining data from channel typing study (R2 et al. 2011a)

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 occur 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 study 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. Table 4-2 presents a breakdown of Chinook salmon EFH in the study area including freshwater (length of streams, and area of lakes) and marine habitats, grouped by watershed and life stage.

All marine/estuarine life stages of Chinook salmon have designated EFH within Cook Inlet, including the shoreline and nearshore areas of Diamond Point proposed by PLP for a port and pipeline landing, and the western shore of Iliamna Bay where the transportation corridor occurs in the intertidal zone below the MHW mark. However, juvenile Chinook salmon were rare from 2004-2012 and not present in 2018 during sampling in the Iliamna and Iniskin bay estuaries, Cottonwood Bay, and Ursus Cove (PLP 2012, Hart Crowser, Inc. 2015, GeoEngineers 2018a). Chinook salmon EFH exists within the study area and includes the NFK River, SFK River, UT Creek, Newhalen River, Long Lake Creek, Iliamna River, Cook Inlet (Table 4-2; Figure 4-2, Figure 4-3) (PLP 2018a, Johnson and Blossom 2019).

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 4-5, Table 4-6) (PLP 2011) suggesting the presence of higher quality spawning habitats for Chinook salmon 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. Habitat data for upper drainage tributaries indicates a predominance of large substrates and often high gradient channels less conducive to spawning (Table 4-10). The AWC shows spawning Chinook salmon have also been documented up to river km 48 in the NFK River and river km 53 in the SFK River (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. The 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 (Table 4-5). 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. 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. Within the SFK River, all adult Chinook salmon observations from 2004–2008 were downstream of Frying Pan Lake (PLP 2018a), and in 2008 all documented spawning occurred downstream of the confluence of SFK 1.190 at approximately river km 34.3 (Table 4-6) (PLP 2011). 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 4-5) (PLP 2011, PLP 2018a, Johnson and Blossom 2019). In 2008, comprehensive spawner surveys found all spawning adult Chinook salmon were located downstream of river km 59.1 (EBD Reach UT-F) and that 37 percent of spawners were in the 8.8 km (5.5 mi) reach between river km 36.3 and 45.1 (EBD Reach UT-E) (Table 4-6), 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 4-2. Chinook salmon peak daily counts show that adults were most frequently observed in NFK River, followed by SFK River and UT Creek (Table 4-4) (PLP 2018a). In four of five years surveyed, 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 and peak densities ranged from a high of 62.4 fish/km in 2004 to a low of 7.8 fish/km in 2008 (Table 4-3, Table 4-4). Within the SFK River, peak counts ranged from 327 in 2006 to 2,780 in 2004 and peak densities ranged from 7.1 fish/km in 2007 to 82.5 fish/km in 2004. Chinook salmon aerial surveys from 2004 through 2008 show a generally decreasing trend with time for both NFK and SFK rivers with the greatest declines occurring after 2005 when peak counts dropped from the 2,000 to 3,000 range to under 1,000 fish. Chinook salmon peak counts within UT Creek ranged from 90 in 2006 to 272 in 2004 with peak densities ranging from 1.6 fish/km in 2005 and 2008 to 4.5 fish/km in 2004 and were the lowest among the three drainages (Table 4-4) (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 4-7, Table 4-9). In reaches upstream of river km 48, juvenile Chinook salmon observations were limited to two juveniles collected just upstream of river km 52.5 (Figure 4-2) (see Appendix 15B, PLP 2011). Juvenile Chinook salmon were most common in mainstem, fast-water habitats in the NFK River with 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 (upper end of NFK-C) (Table 4-7, Table 4-8, Table 4-9). Sampling in NFK upstream from river km 36.6 and tributaries within NFK-C documented lower densities of Chinook salmon juveniles, with densities consistently less than 1 fish/100m^2 (Table 4-7, Table 4-8). The densities for sample sites within NFK 1.190 and 1.200 were 0.11 and 0.08 fish/100m^2 (Table 4-9) (PLP 2011, EBD Chapter 15 Table B3-8).

For the SFK River mainstem reaches sampled from 2004 through 2009, juvenile Chinook salmon densities were highest in SFK-A. From river km 0 to 24.9 juvenile Chinook salmon densities ranged from 19.1 fish/100m^2 in 2009 to 24.9 fish/100m^2 in 2004 through 2008 (Table 4-7, Table 4-8). Densities from tributary sample sites were lower than mainstem densities and were consistently less than 1 fish/100m^2 (Table 4-7, Table 4-9). 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 densities ranged from 0.12 to 11.31 fish/100m^2 as compared to tributaries where sample densities were consistently less than 0.1 fish/100m^2 (Table 4-7, Table 4-8, Table 4-9). 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 4-8).

Along the transportation and natural gas pipeline corridor, Chinook salmon EFH is present at five stream crossings. Chinook salmon rearing was documented in UT Creek from the confluence with Iliamna Lake upstream of crossing T007, and a UT tributary below the crossing T001 (Table 4-11). Chinook salmon spawning has been identified in UT Creek from the confluence with Iliamna Lake to upstream of crossing T007, and in the Newhalen River downstream of the proposed bridge. Chinook salmon presence has been documented in Long Lake Creek from the confluence with Iliamna Lake up to Long Lake, near the proposed bridge location. Chinook salmon presence is also documented in Iliamna River, extending past the proposed bridge location (Figure 4-3) (Johnson and Blossom 2019).

Table 4-11. EFH stream crossings.

Stream Crossing ID	Anadromous Waters Catalog Code[1]	Pacific Salmon Species[2] and Life Stage[3]
Mine Road		
T001[4]	324-10-10150-2183-3307 (UT 1.460)	COr, Kr
T006	324-10-10150-2183-3057 (UT 1.360)	COr
T007	324-10-10150-2183 (Upper Talarik Creek/ UT 1.0)	COr, COs, CHs, Kr, Ks, Sr, Ss
T008	324-10-10150-2183 (UT 1.340)	COr
E004	324-10-10150-2207-3027-4011 (Stuck Creek/Newhalen River Trib 4.2)	COr
E005	324-10-10150-2207-3027-4011 (Newhalen River Trib 4.2.1)	COr
E007	324-10-10150-2207 (Newhalen River)	COp, Ss, Kp
E013	324-10-10150-2235 (Eagle Bay T1)	Ss
D1004	324-10-10150-2239-3005 (West Fork Eagle Bay Creek)	Ss
D1005	324-10-10150-2239 (East Fork Eagle Bay Creek)	COr, Ss
D1006	324-10-10150-2261 (West Fork Youngs Creek)	COp, Ss
D1008	324-10-10150-2261-3006 (East Fork Youngs Creek)	COp, Ss
D1009	324-10-10150-2267-3001 (Chekok Creek T1)	COp, Ss
D1010	324-10-10150-2267 (Chekok Creek)	COp, Ss
D1012	324-10-10150-2273 (Canyon Creek)	Ss, Sr
D1035	324-10-10150-2301 (Knutson Creek)	Ss
D1068	324-10-10150-2333 (Lonesome No. 1 Creek)	Ss
D1076	324-10-10150-2341 (Pile River)	Ss
D1077	324-10-10150-2343 (Long Lake Creek)	Kr, Sr
D1078	324-10-10150-2343-3006 (Long Lake T1)	Ss
D1084	324-10-10150-2402 (Iliamna River)	COp, CHp, Kp, Ss, Pp
Natural Gas Pipeline – Ursus Head		
No ID	248-20-10030 (Cottonwood Bay Tributary)	CHp
No ID	248-10-10040 (Brown's Peak Creek)	CHs, COr, Ps, Sp

1 Johnson and Blossom 2019.
2 Pacific salmon codes: CO = coho salmon; S = sockeye salmon; CH = chum salmon; K = Chinook salmon; P = pink salmon.
3 Pacific salmon life stages: p = present; s = spawning; r = rearing (Johnson and Blossom 2019).
4 Crossing T001 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. Coho salmon EFH in the study area is documented in the AWC and PLP studies. Table 4-2 presents a breakdown of coho salmon EFH in the study area including freshwater (length of streams, and area of lakes) and marine habitats, grouped by watershed and life stage.

All marine/estuarine life stages of coho salmon have designated EFH within Cook Inlet, including the shoreline and nearshore areas of Diamond Point proposed by PLP for a marine and pipeline landing, and the western shore of Iliamna Bay where the transportation corridor occurs in the intertidal zone below the MHW mark. However, juvenile coho salmon were caught in low numbers during sampling in the Iliamna and Iniskin bay estuaries, Cottonwood Bay, and Ursus Cove (PLP 2012, Hart Crowser, Inc. 2015, GeoEngineers 2018a). Abundances of juvenile coho salmon were greatest in 2010 and 2012 at 0.4 fish per set in the Iliamna and Iniskin bay estuaries (Hart Crowser, Inc. 2015).

Coho salmon EFH exists within NFK River, SFK River (including Frying Pan Lake), UT Creek and tributaries, Iliamna Lake, Stuck Creek, Newhalen River and tributaries, East Fork Eagle Bay Creek, East and West Fork Youngs Creek, Chekok Creek T1, Chekok Creek, Iliamna River, and Brown's Peak Creek (Table 4-2; Figure 4-4, Figure 4-5**)** (PLP 2011, PLP 2018a, Johnson and Blossom 2019). 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 4-6). 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 (Table 4-5, Table 4-6) (PLP 2011). 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 4-5). Detailed habitat data for NFK and SFK headwater tributaries shows that available habitats are dominated by large substrates and high gradients that are less conducive to spawning (Table 4-10). During the survey that had the most widespread distribution, less than 7 percent of adult coho salmon were observed in the three tributaries to the SFK River (Table 4-5). 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, including tributaries UT 1.160 and UT 1.350, coho salmon spawning was documented throughout much of the drainage (Table 4-6) (PLP 2011, PLP 2018a, Johnson and Blossom 2019). 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 4-5). Approximately 58 percent of the adults were located in the lower 44.9 km (27.9 mi) of the creek (Table 4-5; Figure 4-4). UT Creek supported the largest run of coho salmon among the three watersheds in the mine study area, with peak counts ranging from 7,542 in 2009 to a low of 1,041 in 2005 (Table 4-4). Within UT Creek, peak densities of coho ranged from 30.1 fish/km in 2005 to 127.6 fish/km in 2009 (Table 4-4). 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). Coho salmon peak counts within NFK ranged from 1,704 in 2008 to 114 in 2007; densities in NFK ranged from 30.7 fish/km in 2008 to 2.1 fish/km in 2007 and were the lowest among the three drainages in four out of five years surveyed (Table 4-4) (PLP 2018a). In UT Creek, upstream spawning was observed at its lowest numbers in 2008 (between UT-6 and UT-7) (Table 4-11; Figure 4-4).

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 study 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 4-5) (PLP 2011). Juvenile coho salmon were most common in mainstem (NFK 1.0) habitats with 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 4-7, Table 4-8, Table 4-9). 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 sample densities of 1.24 fish/100m^2 in NFK 1.190 and 2.24 fish/100m^2 in NFK 1.200 (Table 4-7, Table 4-9). The distribution of sample densities for coho salmon juveniles suggests that within the study area, EFH nearest the proposed mine is of lower quality and/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 4-7, Table 4-8). Densities from tributary samples downstream of Frying Pan Lake were less variable than mainstem densities, ranging from 0.54 to 10.25 (Table 4-9). 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 4-7, Table 4-8, Table 4-9). No juvenile coho salmon were documented in tributaries upstream of Frying Pan Lake (Table 4-7, Table 4-9).

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 4-7, Table 4-8). Juvenile coho salmon densities were similar in the UT tributaries ranging from 0.88 to 115.49 fish/100m^2 (Table 4-7, Table 4-9).

Coho salmon EFH is present at 14 of the 18 Pacific salmon crossings along the transportation and natural gas pipeline corridor (Table 4-11) (R2 Resource Consultants, Inc. 2018, PLP 2011, Johnson and Blossom 2019). Spawning coho salmon have been documented at the upper section of UT Creek, upstream of the proposed bridge (Table 4-11) (PLP 2011, AWC 2019). Rearing coho salmon EFH is located in Brown's Peak Creek up to the proposed crossing, the upper reaches of East and West Fork Youngs Creek above the proposed stream crossings, East Fork Eagle Bay Creek, several Newhalen River tributaries, including Stuck Creek, UT Creek and tributaries, NFK and tributaries, and SFK and tributaries.

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). Sockeye salmon EFH in the study area is documented in the AWC and in PLP studies. Table 4-2 presents a breakdown of sockeye salmon EFH in the study area including freshwater (length of streams, and area of lakes) and marine habitats, grouped by watershed and life stage.

All marine/estuarine life stages of sockeye salmon have designated EFH within Cook Inlet, including the shoreline and nearshore areas of Diamond Point proposed by PLP for a marine and pipeline landing, and the western shore of Iliamna Bay where the transportation corridor occurs in the intertidal zone below the MHW mark. Juvenile sockeye salmon were caught in low numbers in the Iliamna and Iniskin bay estuaries, Cottonwood Bay, and Ursus Cove from 2004 to 2012, though abundances were somewhat higher in 2010 and 2012 at 0.2 fish per set (Hart Crowser, Inc. 2015). The variation in abundance is likely due to inter-annual variation. During 2018 sampling, juvenile sockeye salmon were only captured during sampling at Ursus Cove and Amakdedori Beach and were not present in the Iliamna and Iniskin bay estuaries (GeoEngineers 2018a).

Sockeye salmon freshwater EFH exists within the entire study area and is present at all but six stream crossings (Table 4-11). Sockeye salmon EFH includes NFK River, SFK River, UT Creek, Newhalen River and tributaries, Eagle Bay T1, East and West Fork Eagle Bay Creek, East and West Fork Youngs Creek, Chekok Creek T1, Chekok Creek, Canyon Creek, Knutson Creek, Lonesome No. 1 Creek, Pile River, Long Lake Creek and tributary, Iliamna River, and Brown's Peak Creek. (Table 4-2; Figure 4-6, Figure 4-7) (PLP 2011, Johnson and Blossom 2019).

Sockeye salmon were the most numerous salmon species observed during adult surveys from 2004 through 2009, 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 4-6). The highest number of spawning observations was observed in UT Creek, followed by the SFK and NFK rivers (Table 4-6). 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 (through EBD Reach UT-D) (22.5 mi) upstream including in tributary UT 1.160 that drains into the lowest reach (Table 4-6). 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, including tributary UT 1.160 (Table

4-6). 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 4-5). Over 41 percent (17,667 individual fish) were observed spawning in the tributary UT 1.160 (Table 4-5) 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 three reaches of 0 to 1 sockeye salmon (Table 4-5). Nearly 50 percent of the sockeye salmon 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 4-5). 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 study area around the mine (Table 4-6). 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 4-5). No sockeye salmon EFH was identified in tributary NFK 1.190 (Table 4-5). Adult sockeye salmon were most frequently observed in UT Creek, followed by SFK River and NFK River (Table 4-4, Table 4-5) (PLP 2018a).

UT Creek supported the largest run of sockeye salmon among the three watersheds, with peak counts ranging from 50,317 in 2008 with just over 60 km surveyed to a low of 10,557 in 2007 with a similar length surveyed. In 2009, the peak daily count was 14,481 fish however, the survey reach was only 16.8 km. Peak densities of sockeye salmon in UT Creek ranged from 862.0 fish/km in 2009 to 174.5 fish/km in 2007 (Table 4-4, Table 4-5). 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 4-4, Table 4-5) (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 4-7). The sample densities of sockeye salmon juveniles in mainstem NFK ranged from less than 0.01 to 1.89 (Table 4-7, Table 4-8, Table 4-9). 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 reaches 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 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 4-7, Table 4-8). This finding is consistent with the existing literature in that juvenile sockeye salmon are known to swim upstream in search of a lake for rearing (Healey 1991). The sample densities for sockeye salmon juveniles in SFK mainstem reaches ranged from 0.02 to 1.96 fish/100m^2 (Table 4-7, Table 4-8, Table 4-9). Sockeye salmon juveniles were found in two SFK tributaries, with sample densities of 0.28 fish/100m^2 (1,076 ft^2) in SFK 1.240 and 3.26 fish/100m^2 (1,076 ft^2) in SFK 1.260 (Table 4-9).

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 mainstem reaches, sample densities ranged from 0.39 to 2.28 fish/100m^2 (1,076 ft^2) (Table 4-7). Juvenile sockeye salmon were sampled in two UT tributaries in 2008 with densities of 0.31 and 0.34 for UT 1.380 and UT 1.390 (Table 4-9).

Along the transportation and natural gas pipeline corridor, sockeye salmon EFH is present at 17 of the 23 stream crossings over Pacific salmon EFH (Table 4-11). Sockeye salmon spawning EFH has been documented within portions of Brown's Peak Creek, Iliamna River and a tributary, Pile River, Lonesome No. 1 Creek, Knutson Creek, Canyon Creek, Chekok Creek, East and West Fork Youngs Creek, East and West Fork Eagle Bay Creek, Eagle Bay T1, Newhalen River, and UT Creek (Johnson and Blossom 2019). Juvenile sockeye salmon rearing EFH is located in Long Lake Creek, Canyon Creek, and the UT Creek (R2 Resource Consultants, Inc. 2018a, Johnson and Blossom 2019). 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 saltwater 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).

Chum salmon EFH in the study area is documented in the AWC and by PLP studies. Table 4-2 presents a breakdown of chum salmon EFH in the study area including freshwater (length of streams, and area of lakes) and marine habitats, grouped by watershed and life stage.

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 and in 2018 (PLP 2013, GeoEngineers 2018a). Juvenile chum salmon catch rates were consistent within the Iliamna and Iniskin bay estuaries, Cottonwood Bay, and Ursus Cove. The juvenile chum salmon were typical young of the year fish that likely outmigrated in early summer and showed steady growth throughout summer sampling (Hart Crowser, Inc. 2015). During 2018 sampling, juvenile chum salmon were the dominant species captured at the Iliamna and Iniskin bay estuaries sites and Ursus Cove, with catch rates of 18.5 and 4.0 fish per set, respectively (GeoEngineers 2018a). This pattern of consistent and widespread collections indicates that chum salmon rear throughout the marine habitats along Ursus Cove and the Iliamna and Iniskin bay estuaries.

Chum salmon EFH in freshwater exists within NFK River, SFK River, UT Creek, Iliamna River, Cottonwood Bay tributary, and Brown's Peak Creek (Table 4-2; Figure 4-8, Figure 4-9) (PLP 2011, Johnson and Blossom 2019). The distribution of this species was considerably more restricted in the study 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 species. 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 and tributaries between the SFK River confluence and 36.6 km (22.7 mi) upstream (Table 4-6). 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 4-6). No adult chum salmon were observed in tributary NFK 1.190 on the survey with the most widespread adult distribution (Table 4-5). 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 (Table 4-6). However, during the survey with the most widespread adult distribution, 3.5 percent of adult chum salmon were observed in tributaries (Table 4-5). 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 4-5, Table 4-6) (PLP 2011, Johnson and Blossom 2019). 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 4-4). 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 4-4). 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 fish/km in 2006 (Table 4-4). 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 with peak densities of 0 fish/km in 2004 and 0.7 fish/km in 2008 (Table 4-4).

Essential fish habitat for early juvenile chum salmon is limited within the study area and observations of individuals were low in all three rivers. They were primarily found at mainstem sites with sample densities less than 0.4 fish/100m^2 (Table 4-7). 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 and natural gas pipeline corridors, chum salmon spawning EFH is present within two stream crossings, Brown's Peak Creek and UT Creek (Table 4-11). Chum salmon spawning EFH is documented for the full extent of Brown's Peak Creek (Johnson and Blossom 2019). Within the main channel of UT Creek, chum salmon spawning EFH extends just upstream of the proposed crossing locations (Table 4-6, Table 4-11; Figure 4-8) (Johnson and Blossom 2019).

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. Table 4-2 presents a breakdown of pink salmon EFH in the study area including freshwater (length of streams, and area of lakes) and marine habitats, grouped by watershed and life stage.

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 and 2018 in Ursus Cove, Cottonwood Bay, and the Iliamna and Iniskin bay estuaries (PLP 2013, GeoEngineers 2018a). Juvenile pink salmon catch rates were consistent within the Iliamna and Iniskin bay estuaries, Cottonwood Bay, and Ursus Cove. The juvenile pink salmon were typical young of the year fish that likely outmigrated in early summer and showed steady growth throughout summer sampling (Hart Crowser, Inc. 2015). During 2018 sampling, juvenile pink salmon were similarly abundant to previous sampling efforts (GeoEngineers 2018a). This pattern of consistent and widespread collections indicates that pink salmon rear throughout the marine habitats along Ursus Cove and Iliamna and Iniskin bay estuaries.

Few pink salmon EFH exists within the study area compared to other salmon species distribution. EFH is present within UT Creek, Iliamna Lake, Iliamna River, and Brown's Peak Creek (Table 4-2; Figure 4-10, Figure 4-11) (R2 Resource Consultants Inc. 2018a, Johnson and Blossom 2019). EFH within UT Creek Iliamna Lake, and Iliamna River is based on presence, while Brown's Peak Creek EFH is based on spawning (PLP 2011, Johnson and Blossom 2019). Pink salmon EFH extends upstream to only two stream crossings, located at Brown's Peak Creek, and Iliamna River. 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 318 pink salmon recorded during two aerial surveys: July 31 (n=297) and September 4 (n=21) (PLP 2018a). In 2007, there were 3 pink salmon recorded during two aerial surveys: July 26 (n=1) and August 10 (n=2) (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 study area (Table 4-12). EFH distribution data does not exist for all managed species and life stages within this FMP, such as sharks, forage fish complex species, squid, and grenadiers (NPFMC 2019b). Thirty-eight groundfish species have designated EFH in the study area (Table 4-12). The area of EFH for each species and life stage within the project impact footprint and the GOA is provided in Table 4-13. All designated EFH in the study area for listed species in the Groundfish FMP is depicted in Figure 4-12 through Figure 4-20.

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 study area due to insufficient information available (NPFMC 2019b). Common forage fish species within Cook Inlet include members of families Osmeridae (eulachon, capelin, and other smelt) and Ammodytidae (Pacific sand lance). Table 4-14 lists caught species of the Forage Fish Complex for GOA Groundfish FMPs.

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 study area was quantified by species and life stage where data were available, and the GOA-wide quantity of EFH is also provided in Table 4-13.

Sampling in marine habitats between Ursus Cove and Iniskin Bay was conducted between 2004 and 2018 (PLP 2013, Hart Crowser, Inc. 2015, GeoEngineers 2018a). 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 4-15, Table 4-16). Results from the earlier sampling are consistent with the more recent sampling with minor variability in species composition and catch rates. Designated EFH does not exist for any forage fish complex species within the study area, or in Cook Inlet. However, PLP sampling in the region has identified several species of the forage fish complex in the project area, particularly surf smelt (Table 4-13).

Table 4-12. Designated EFH for multiple life stages of groundfish within the study area.[1]

Group	EFH Species	Egg			Larvae			Juvenile			Adult		
		Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline
Atka mackerel	Atka mackerel (*Pleurogrammus monopterygius*)											✓[1]	✓
GOA Skates (Rajidae)	Alaska skate (*Bathyraja parmifera*)									✓		✓	✓
	Aleutian skate (*Bathyraja aleutica*)											✓	✓
	Bering skate (*Bathyraja interrupta)*									✓		✓	✓
Octopus	Octopus (*Octopoda*)											✓	✓
Pacific cod	Pacific cod (*Gadus macrocephalus*)				✓	✓	✓		✓	✓		✓	✓
Sablefish	Sablefish (*Anoplopoma fimbria*)						✓		✓	✓		✓	✓
Sculpins (Cottidae)	Bigmouth sculpin (*Hemitripterus bolini*)								✓	✓		✓	✓
Sculpins (Cottidae)	Great sculpin (*Myoxocephalus polyacanthocephalus*)								✓	✓		✓	✓
Sculpins (Cottidae)	Yellow Irish lord (*Hemilepidotus jordani*)								✓	✓		✓	✓
Sculpins (Cottidae)	Other										✓[2]	✓[2]	✓[2]

Group	EFH Species	Egg			Larvae			Juvenile			Adult		
		Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline
Walleye pollock	Walleye pollock (*Gadus chalcogrammus*)	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓
Rockfish (Sebastes)	Black rockfish (*Sebastes melanops*)											✓	✓
Rockfish (Sebastes)	Blackspotted rockfish (*Sebastes melanosticus*)									✓			
Rockfish (Sebastes)	Dusky rockfish (*Sebastes variabilis*)								✓	✓		✓	✓
Rockfish (Sebastes)	Greenstriped rockfish (*Sebastes elongatus*)											✓	✓
Rockfish (Sebastes)	Harlequin rockfish (*Sebastes variegatus*)								✓	✓			✓
Rockfish (Sebastes)	Longspine thornyhead rockfish (*Sebastolobus altivelis*)											✓	✓
Rockfish (Sebastes)	Northern rockfish (*Sebastes polyspinis*)									✓		✓	✓
Rockfish (Sebastes)	Pacific ocean perch (*Sebastes alutus*)						✓					✓	✓
Rockfish (Sebastes)	Pygmy rockfish (*Sebastes wilsoni*)											✓	✓
Rockfish (Sebastes)	Quillback rockfish (*Sebastes maliger*)											✓	✓
Rockfish (Sebastes)	Redbanded rockfish (*Sebastes babcocki*)											✓	✓

Group	EFH Species	Egg			Larvae			Juvenile			Adult		
		Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline
Rockfish (Sebastes)	Redstriped rockfish (*Sebastes proriger*)								✓	✓		✓	✓
Rockfish (Sebastes)	Rosethorn rockfish (*Sebastes helvomaculatus*)								✓	✓		✓	✓
Rockfish (Sebastes)	Rougheye rockfish (*Sebastes aleutianus*)											✓	✓
Rockfish (Sebastes)	Sharpchin rockfish (*Sebastes zacentrus*)											✓	✓
Rockfish (Sebastes)	Shortraker rockfish (*Sebastes borealis*)								✓	✓		✓	✓
Rockfish (Sebastes)	Shortspine thornyhead rockfish (*Sebastolobus alascanus*)											✓	✓
Rockfish (Sebastes)	Silvergrey rockfish (*Sebastes brevispinis*)								✓	✓			
Rockfish (Sebastes)	Yelloweye rockfish (*Sebastes ruberrimus*)									✓		✓	✓
Flatfish	Alaska plaice(*Pleuronectes quadrituberculatus*)	✓	✓	✓	✓	✓	✓					✓	✓
Flatfish	Arrowtooth Flounder (*Atheresthes stomias*)						✓		✓	✓			✓
Flatfish	Dover sole (*Microsomus pacificus*)			✓	✓	✓	✓		✓	✓		✓	✓

Group	EFH Species	Egg			Larvae			Juvenile			Adult		
		Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline
Flatfish	Flathead sole (*Hippoglossoides elassodon*)	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓
Flatfish	Northern rock sole (*Lepidopsetta polyxystra*)				✓	✓	✓		✓	✓		✓	✓
Flatfish	Rex sole (*Glyptocephalus zachirus*)	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓
Flatfish	Sand sole (*Pegusa lascaris*)											✓[2]	
Flatfish	Southern rock sole (*Lepisopsetta bilineata*)				✓	✓	✓			✓		✓	✓
Flatfish	Starry flounder (*Platichthys stellatus*)										✓[2]	✓[2]	
Flatfish	Yellowfin sole (*Limanda aspera*)	✓	✓	✓					✓	✓		✓	✓
Sharks		No EFH description determined. Insufficient information available											
Forage Fish Complex	Eulachon (*Theleichthys pacificus*)	No EFH description determined. Insufficient information available											
Forage Fish Complex	Capelin (*Mallotus villosus*)	No EFH description determined. Insufficient information available											
Forage Fish Complex	Pacific sandlance (*Ammodytes hexapterus*)	No EFH description determined. Insufficient information available											
Forage Fish Complex	Pacific sandfish (*Trichodon trichodon*)	No EFH description determined. Insufficient information available											

Group	EFH Species	Egg			Larvae			Juvenile			Adult		
		Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline	Transportation Corridor	Diamond Point Port/ Lightering Station	Natural Gas Pipeline
Forage Fish Complex	Euphausiids	No EFH description determined. Insufficient information available											
Forage Fish Complex	Gnostamatids	No EFH description determined. Insufficient information available											
Forage Fish Complex	Mycotophids	No EFH description determined. Insufficient information available											
Forage Fish Complex	Osmerids	No EFH description determined. Insufficient information available											
Forage Fish Complex	Pholids	No EFH description determined. Insufficient information available											
Forage Fish Complex	Stichaedae (Pricklebacks)	No EFH description determined. Insufficient information available											
Squids		No EFH description determined. Insufficient information available											
Grenadiers		No EFH description determined. Insufficient information available											

1 "✓" indicates presence.

2 Designates a GOA FMP-listed species that has no habitat description, but was captured during PLP sampling (PLP 2013, Hart Crowser, Inc. 2015).

Table 4-13. Designated EFH for multiple life stages of groundfish within the study area and the GOA.

Group	EFH Species	Gulf of Alaska (square kilometers)			
		Egg	Larvae	Juvenile	Adult
Atka mackerel	Atka mackerel				296,740
GOA Skates (Rajidae)	Alaska skate			285,212	300,907
GOA Skates (Rajidae)	Aleutian skate			68,987	299,121
GOA Skates (Rajidae)	Bering skate			285,291	285,196
Octopus	Octopus				300,354
Pacific cod	Pacific cod		319,569	238,111	300,869
Sablefish	Sablefish		319,915	98,484	299,079
Sculpins (Cottidae)	Bigmouth sculpin			285,158	298,233
Sculpins (Cottidae)	Great sculpin			285,269	285,221
Sculpins (Cottidae)	Yellow Irish lord			285,242	294,534
Walleye pollock	Walleye pollock	319,719	319,641	272,531	297,928
Rockfish (Sebastes)	Black rockfish				285,102
Rockfish (Sebastes)	Blackspotted rockfish			285,310	285,338
Rockfish (Sebastes)	Dusky rockfish			285,166	299,309
Rockfish (Sebastes)	Greenstriped rockfish				285,324
Rockfish (Sebastes)	Harlequin rockfish			285,308	285,360
Rockfish (Sebastes)	Longspine thornyhead rockfish				298,135
Rockfish (Sebastes)	Northern rockfish			285,215	296,628
Rockfish (Sebastes)	Pacific ocean perch		319,791	98,698	299,257
Rockfish (Sebastes)	Pygmy rockfish				285,252
Rockfish (Sebastes)	Quillback rockfish				285,196
Rockfish (Sebastes)	Redbanded rockfish			46,330	293,765
Rockfish (Sebastes)	Redstriped rockfish			285,218	285,237
Rockfish (Sebastes)	Rosethorn rockfish			285,254	285,268
Rockfish (Sebastes)	Rougheye rockfish			81,305	301,110
Rockfish (Sebastes)	Sharpchin rockfish			52,662	296,256
Rockfish (Sebastes)	Shortraker rockfish			285,440	291,402
Rockfish (Sebastes)	Shortspine thornyhead rockfish			61,686	298,111
Rockfish (Sebastes)	Silvergrey rockfish			285,244	57,490
Rockfish (Sebastes)	Yelloweye rockfish			285,309	297,413
Flatfish	Alaska plaice	319,541	319,617		285,201
Flatfish	Arrowtooth Flounder		319,817	270,738	299,112
Flatfish	Dover sole	319,924	319,628	256,758	299,945
Flatfish	Flathead sole	319,621	319,576	250,240	298,969
Flatfish	Northern rock sole		319,606	76,558	297,298

Group	EFH Species	Gulf of Alaska (square kilometers)			
		Egg	Larvae	Juvenile	Adult
Flatfish	Rex sole	319,831	319,712	118,611	297,466
Flatfish	Sand sole				
Flatfish	Southern rock sole		319,623	90,964	224,895
Flatfish	Starry flounder				
Flatfish	Yellowfin sole	319,783		285,169	285,194
Sharks		NA[1]	NA	NA	NA
Forage Fish Complex	Eulachon	NA	NA	NA	NA
Forage Fish Complex	Capelin	NA	NA	NA	NA
Forage Fish Complex	Pacific sandlance	NA	NA	NA	NA
Forage Fish Complex	Pacific sandfish	NA	NA	NA	NA
Forage Fish Complex	Euphausiids	NA	NA	NA	NA
Forage Fish Complex	Gnostamatids	NA	NA	NA	NA
Forage Fish Complex	Mycotophids	NA	NA	NA	NA
Forage Fish Complex	Osmerids	NA	NA	NA	NA
Forage Fish Complex	Pholids	NA	NA	NA	NA
Forage Fish Complex	Stichaedae (Pricklebacks)	NA	NA	NA	NA
Squids		NA	NA	NA	NA
Grenadiers		NA	NA	NA	NA

1 NA = No EFH description determined. Insufficient information available.

Table 4-14. Forage fishes of the GOA groundfish FMP identified in Project sampling.

Gulf of Alaska Forage Fish Complex
Eulachon (Osmeridae)
Capelin (Osmeridae)
Other smelts (Osmeridae)
Gunnels (Pholidae)
Pricklebacks (Stichaeidae)
Sand fishes (Trichodontidae)
Sand lances (Ammodytidae)

Table 4-15. Catch per set by bay during nearshore marine sampling between Ursus Cove and Cottonwood, Iliamna, and Iniskin bays (2004-2008, 2010-2012).[1]

Species	Beach Seine 120 ft (36.6 m)						Beach Seine 30 ft (9.1 m)			Gill Net			Trammel Net		
	2004-2008	2010-2012					2008	2010-2012		2008	2010-2012		2008	2010-2012	
	Iliamna and Iniskin Bay	Ursus Cove	Ursus Lagoon	Cottonwood Bay	Iliamna Bay	Iniskin Bay	Iliamna Bay	Ursus Lagoon	Iliamna Bay	Iliamna and Iniskin Bays	Ursus Cove	Cottonwood Bay	Iliamna and Iniskin Bays	Ursus Cove	Cottonwood Bay
EFH Category: Pacific Salmon[2]															
Chinook salmon, juvenile	0.03	1.30		0.10	0.10						0.70	0.30			
Chum salmon, adult	0.22		11.00												
Chum salmon, juvenile	14.42	2.80		23.40	24.10	13.50	29.53		26.20						
Coho salmon, juvenile	0.19			0.30	0.20	0.90	0.07		1.00						
Sockeye salmon, juvenile	2.16	0.30		0.10	0.30	0.20	3.07		1.00						
Pink salmon, adult	0.09														
Pink salmon, juvenile	15.88	17.30		7.80	11.20	10.40	17.67		0.70						
EFH Category: Groundfish Target Species[2]															
Walleye pollock				0.10	0.20	0.40									
Pacific cod	0.19			0.10	0.10	0.90							0.06	0.30	
Arrowtooth flounder	0.02														
Flathead sole	0.00														
Rock sole (*Lepidopsetta bilineata*)	0.01				0.10								0.06		
Sand sole (*Psettichthys melanostictus*)							0.07						0.06	0.30	
Starry flounder	2.93	0.80	5.00	0.60	2.50	0.10	1.93	64.00	0.20	0.06	0.70	0.30	1.17	3.00	1.00
Yellowfin sole	0.01									0.06			0.22		0.50
Flatfish, unid. (Pleuronectidae)	0.01														
Buffalo sculpin (*Enophrys bison*)	0.00														
Calico sculpin (*Clinocottus embryum*)	0.00									0.11			0.06		
Great sculpin	0.19	0.30	1.00	1.60	0.20	0.20					0.30				
Pacific staghorn sculpin (*Leptocottus armatus*)	3.27	0.50	0.50	0.10	0.40		2.00	14.00	2.10	0.06			0.28	1.30	0.50
Sculpin, unid. (Cottidae)	0.01								0.10						
Shorthorn sculpin (*Myoxocephalus scorpius*)		0.50													
Silverspotted sculpin (*Blepsias cirrhosis*)	0.05	0.30			0.10										
Yellow Irish lord	0.01														
Spiny dogfish (*Squalus acanthias*)											0.30	1.00	2.00	4.30	1.50
EFH Category: Prohibited Species															
Pacific halibut (*Hippoglossus stenolepis*)	<0.01												0.22	2.00	0.30
Pacific herring (*Clupea pallasii*)	233.05	405.50		56.20	555.60	0.30	0.47		35.40	8.11	2.00	21.70	0.33	0.30	0.30

Species	Beach Seine 120 ft (36.6 m)						Beach Seine 30 ft (9.1 m)			Gill Net			Trammel Net		
	2004-2008	2010-2012					2008	2010-2012		2008	2010-2012		2008	2010-2012	
	Iliamna and Iniskin Bay	Ursus Cove	Ursus Lagoon	Cottonwood Bay	Iliamna Bay	Iniskin Bay	Iliamna Bay	Ursus Lagoon	Iliamna Bay	Iliamna and Iniskin Bays	Ursus Cove	Cottonwood Bay	Iliamna and Iniskin Bays	Ursus Cove	Cottonwood Bay
EFH Category: Forage Fish[2]															
Capelin	0.00														
Crescent gunnel (*Pholis laeta*)	0.03														
Eulachon (*Thaleichthys pacificus*)						0.10									
Longfin smelt (*Spirinchus thaleichthys*)	1.73			0.30	2.40										
Pacific sandfish	0.02														
Surf smelt (*Hypomesus pretiosus*)	13.84	4.50		1.50	3.60	0.20	0.27		0.20						
Surf smelt larvae															
Pacific sandlance	6.79			2.30	0.20	28.30									
Snake prickleback (*Lumpenus sagitta*)	0.17			0.40	0.20										
EFH Category: Unclassified															
Dolly Varden (*Salvelinus malma*)	4.61	1.80	3.50	7.30	3.90	9.70		1.00	1.10	0.39	1.30		0.11		
Tomcod (*Microgadus proximus*)	0.02														
Lingcod (*Ophiodon elongatus*)	0.00														
Saffron cod (*Eleginus gracilis*)	0.00														
Kelp greenling (*Hexagrammos decagrammus*)	0.00										0.30		0.11		
Whitespotted greenling (*Hexagrammos stelleri*)	0.39			0.20	0.20	0.10			0.10		0.30		2.61	1.00	1.80
Greenling (unid.) (*Hexagrammos* sp.)	0.00			0.30	0.20										
Variegated snailfish (*Liparis gibbus*)	0.17														
Ninespine Stickleback (*Pungitius pungitius*)	0.06														
Threespine stickleback (*Gasterosteus aculeatus*)	0.13				0.40	0.10	893.93		206.70						
Tubesnout (*Aulorhynchus flavidus*)	0.02				0.50										
Sturgeon poacher (*Podothecus acipenserinus*)	0.02									0.11					
Tubenose poacher (*Pallasina barbata*)	0.11	4.30		0.10	0.10										
Larval fish, unid.					0.00										
Number of Species	**40**	**13**	**5**	**19**	**24**	**15**	**7**	**3**	**12**	**7**	**8**	**4**	**13**	**8**	**7**
Number of Sets	**237**	**4**	**2**	**16**	**38**	**15**	**18**	**10**	**10**	**18**	**3**	**3**	**18**	**3**	**4**

1 PLP 2013, Hart Crowser, Inc. 2015.
2 EFH-listed species.

Table 4-16. Catch per set for fish captured by otter trawl between Ursus Cove and Iniskin Bay, 2004-2008 and 2010-2012.[1]

EFH Category	Species	2004-2008	2010-2012	2010-2012	2010-2012	2010-2012
		Iniskin and Iliamna Bays	Ursus Cove	Cottonwood Bay	Iliamna Bay	Iniskin Bay
Groundfish Target Species[2]	Walleye pollock	0.75		0.80	3.00	3.40
Groundfish Target Species	Pacific cod	0.36	14.00		0.40	2.00
Groundfish Target Species	Alaska plaice	0.02			0.10	
Groundfish Target Species	Arrowtooth flounder	0.19		0.30	0.10	0.10
Groundfish Target Species	Dover sole	0.02				
Groundfish Target Species	English Sole (*Pleuronectes vetulus*)			0.30		
Groundfish Target Species	Flathead sole	0.01				
Groundfish Target Species	Rock sole	0.41		0.50	0.50	
Groundfish Target Species	Sand sole	0.29	0.30	0.30	0.50	0.20
Groundfish Target Species	Starry flounder	1.06	0.70	1.80	8.30	0.20
Groundfish Target Species	Yellowfin sole	2.83	2.70	5.30	4.80	1.00
Groundfish Target Species	Flatfish, unid	0.14			0.10	
Groundfish Target Species	Armorhead Sculpin (*Gymnocanthus galeatus*)					
Groundfish Target Species	Buffalo sculpin	0.06				
Groundfish Target Species	Calico sculpin	0.06				
Groundfish Target Species	Great sculpin	0.72			0.50	0.70
Groundfish Target Species	Pacific staghorn sculpin	0.62			1.30	
Groundfish Target Species	Padded sculpin (*Artedius fenestralis*)	0.01			0.20	0.20
Groundfish Target Species	Threaded sculpin (*Gymnocanthus pistilliger*)	0.01				0.20
Groundfish Target Species	Spinyhead sculpin (*Dasycottus setiger*)	0.01				
Groundfish Target Species	Yellow Irish Lord	0.46				0.20
Groundfish Target Species	Sculpin, unid.	0.06				0.20
Groundfish Target Species	Spiny dogfish	0.01		0.30		
Prohibited Species	Pacific halibut	0.56	2.70	2.80	0.80	0.20
Prohibited Species	Pacific herring	2.94		2.30	0.70	0.50

EFH Category	Species	2004-2008	2010-2012	2010-2012	2010-2012	2010-2012
		Iniskin and Iliamna Bays	Ursus Cove	Cottonwood Bay	Iliamna Bay	Iniskin Bay
Forage Fish[2]	Capelin	0.01				
Forage Fish	Crescent gunnel	0.04				
Forage Fish	Longfin smelt (*Spirinchus thaleichthys*)	0.10		1.00	0.70	0.10
Forage Fish	Pacific sandfish	0.02				
Forage Fish	Pacific sandlance	0.01				
Forage Fish	Snake prickleback	5.64	7.70	10.80	2.70	0.90
Forage Fish	Surf smelt	0.02				
Unclassified	Kelp greenling	0.01			0.10	
Unclassified	Rock greenling (*Hexagrammos lagocephalus*)	0.01				
Unclassified	Whitespotted greenling	0.70	3.30	1.00	0.70	0.20
Unclassified	Tomcod	0.01				
Unclassified	Lingcod	0.01	0.70			
Unclassified	Saffron cod	0.01				
Unclassified	Tubesnout		0.70		0.40	
Unclassified	Bering poacher (*Occela dodecaedron*)	0.01			0.10	
Unclassified	Sturgeon poacher	0.33		1.00	0.70	0.10
Unclassified	Tubenose poacher	0.33	0.70		0.50	
Unclassified	Variegated snailfish	0.59			0.10	0.50
Unclassified	Ninespine stickleback	0.01				
Unclassified	Lumpsucker (*Liparis* sp.)			0.30		
Unclassified	Larval fish, unid.			0.50		
Number of Species		**41**	**10**	**16**	**23**	**18**
Number of Sets		**138**	**3**	**4**	**11**	**13**

1 PLP 2013, Hart Crowser, Inc. 2015.
2 EFH-listed species.

In 2004-2008 and 2010-2012, 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. 41 species were captured in trawls from 2004-2008, and 29 species were captured in trawls from 2010-2012, for a total of 46 species. Mean catch rates were very similar between 2004-2008 and 2010-2012, at 19.5 fish/set and 18.4 fish/set, respectively. Trawls in all years were dominated by snake prickleback, flatfishes, and cod/pollock, with the highest catch rates in Cottonwood Bay, Iliamna Bay and Ursus Cove, and lower catch rates in Iniskin Bay (PLP 2013, Hart Crowser, Inc. 2015).

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 4-12, Table 4-13; 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 2019b). 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 2019b). 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 2019b). Maturity is reached at a young age (approximately 50 percent are mature at age 3.6) and juveniles experience fast growth rates and high natural mortality (mortality equals 0.3). Atka mackerel juvenile and maximum average ages are about 5 and 14 years. Females have relatively low fecundity (only about 30,000 eggs/female/year) with large egg diameters and male nest-guarding behavior (NPFMC 2019b).

Eggs: Adhesive eggs are deposited in nests built and guarded by males on rocky substrates or on kelp in moderately shallow water (NPFMC 2019b).

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 2019b).

Juveniles: Little is known of juvenile Atka mackerel distribution until age 2, when they have appeared in the fishery and surveys (NPFMC 2019b).

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 2019b).

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 4-12, Table 4-13). 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 2019b). 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 2019b). 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 2019b).

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 2019b).

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 2019b).

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 4-12, Table 4-13). 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 2019b). 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 2019b). 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 (Waldron and Vinter 1978, Kendall and Dunn 1985). 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 2019b). 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 study 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 2019b).

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 2019b).

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 2019b).

4.2.2.3 Dover Sole

Dover sole are widely distributed throughout the GOA. EFH for dover sole has been defined in Cook Inlet and GOA (Table 4-12, Table 4-13). 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 (Hunter et al. 1990, Jacobson and Hunter 1993, Vetter et al. 1994). 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 2019b), 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 2019b). 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 2019b). Dover sole are batch spawners, and Hunter et al. (1990) concluded that the average 2.2-lb (1 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. 2007a, NPFMC 2019b).

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

Larvae: Dover sole are planktonic larvae for up to 2 years until metamorphosis occurs (NPFMC 2019b).

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 (Buckley et al. 1999, Aydin et al. 2007, NPFMC 2019b).

4.2.2.4 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 4-12, Table 4-13). 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 2019b). 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 2019b). 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 2019b). 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 2019b). 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 2019b). The natural mortality rate used in recent stock assessments is 0.2 (Stockhausen et al. 2007c).

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

Larvae: Flathead sole larvae are planktonic larvae for 3 - 5 months until metamorphosis occurs (NPFMC 2019b).

Juveniles: Juveniles usually inhabit shallow areas less than 330 ft (100 m), preferring muddy substrates (NPFMC 2019b).

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 2019b).

4.2.2.5 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 4-12, Table 4-13). Centers of abundance occur in the central GOA (Alton and Sample 1976, NPFMC 2019b). Northern rock sole exhibit a benthic lifestyle and spawn during the winter through early spring period of December through March (NPFMC 2019b). 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 (Shubnikov and Lisovenko 1964, NPFMC 2019b). 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). Incubation time is temperature dependent and may range from 6.4 days at 52ºF (11ºC) to about 25 days at 52ºF (2.9ºC) (Forrester 1964). Newly hatched larvae are pelagic and have occurred sporadically in eastern Bering Sea plankton surveys (Waldron and Vinter 1978, NPFMC 2019b). 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 2019b). 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 2019b). 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 13 in [33 cm]) (NPFMC 2019b). 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 2019b).

Juveniles: Juveniles inhabit shallow areas at least until age 1 (NPFMC 2019b).

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 2019b).

4.2.2.6 Rex Sole

Rex sole are distributed from Baja California to the GOA (Miller and Lea 1972, Hart 1973). EFH for rex sole has been defined in Cook Inlet and GOA (Table 4-12, Table 4-13). 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 2019b). 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 2019b). 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 2019b). Eggs are fertilized near the seabed, 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. 2007b).

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

Larvae: Larvae are planktonic for at least 2 - 3 months until metamorphosis occurs (NPFMC 2019b).

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 2019b).

4.2.2.7 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 4-12, Table 4-13). 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 2019b). 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 2019b). Spawning females deposit a mass of eggs that are demersal and adhesive (Alton and Sample 1976). Fertilization is believed to be external (NPFMC 2019b). Incubation time is temperature dependent and may range from 6.4 days at 52ºF (11ºC) to about 25 days at 37ºF (2.9ºC) (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 2019b). 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 2019b). Larvae are pelagic and settlement occurs in September and October (NPFMC 2019b). 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 2019b).

Larvae: Larvae are planktonic for at least 2 - 3 months until metamorphosis occurs (NPFMC 2019b).

Juveniles: Juveniles inhabit shallow areas at least until age 1 (NPFMC 2019b).

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 2019b).

4.2.2.8 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 4-12, Table 4-13). 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 2019b). 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 2019b). 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 2019b). 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 2019b). 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 2019b).

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

Larvae: Larvae are planktonic for at least 2 - 3 months until metamorphosis occurs (NPFMC 2019b).

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 2019b).

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 2019b). Most of the biomass for these two species is in the Central GOA (NPFMC 2019b). 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 2019b). The Bering Straits Aleutian Islands (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 2019b). EFH for three species of skates described below has been defined in Cook Inlet and GOA (Table 4-12, Table 4-13; Figure 4-14).

The three skate species with defined EFH in the study 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 2019b).

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 2019b).

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 2019b).

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 2019b). EFH for octopus has been defined in Cook Inlet and GOA (Table 4-12, Table 4-13, Figure 4-15). Known species include *Enteroctopus dofleini, Octopus californicus, Octopus sp. A, Benthoctopus leioderma, Opisthoteuthis californiana, Japetella diaphana* and *Vampyroteuthis infernalis* (NPFMC 2019b). *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 2019b). 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 2019b). Extensive data has been collected on *Enteroctopus dofleini* in British Columbia and Japan and is used as the primary indicator for assemblage (NPFMC 2019b). Preliminary evidence indicates that this species is taken as incidental catch in groundfish fisheries (NPFMC 2019b). 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 2019b). 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 2019b). Little is known about *Octopus californicus.* It is believed to spawn 100 to 500 eggs and the hatchlings are likely benthic (NPFMC 2019b). 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 2019b). 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 2019b). 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 2019b). 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 2019b). *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 2019b). *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 different fin arrangement. Little more is known about their life history (NPFMC 2019b).

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 2019b).

Larvae: Larvae for Alaskan octopus species are likely both pelagic and possibly demersal, however information is limited (NPFMC 2019b).

Juveniles: Juveniles are likely semi-demersal and are widely dispersed on the shelf and upper slope (NPFMC 2019b).

Adults: Adults are demersal and prefer rocks, cobble, and sand/mud habitats (NPFMC 2019b).

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 2019b). EFH for Pacific cod has been defined in Cook Inlet and GOA (Table 4-12, Table 4-13; 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 2019b). 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 2019b). Males become sexually mature at age 2 and females at age 3 (NPFMC 2019b). 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 2019b). 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 2019b). 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 2019b).

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 2019b).

Juveniles: Juveniles occur mostly over the inner continental shelf at depths of 197 ft – 492 ft (60 m - 150 m) (NPFMC 2019b).

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 2019b).

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 2019b). In 2008 the two species were differentiated, and their distribution and morphological characteristics were described for each (Orr and Hawkins 2008, NPFMC 2019b). Rougheye rockfish is typically pale with spots absent from the dorsal fin and possible mottling on the body (NPFMC 2019b). Blackspotted rockfish is darker with spotting almost always present on the dorsal fin and body (NPFMC

2019b). Both species inhabit the outer continental shelf and upper continental slope of the northeastern Pacific (NPFMC 2019b). 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 2019b). 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 2019b). Until such information is available, it will be difficult to undertake distinct population assessments (NPFMC 2019b). 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 4-12, Table 4-13; 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 2019b). Age and size at 50 percent maturity for female rougheye rockfish is estimated at 19 years and 17 in (44 cm) (McDermott 1994). There is no information on male size at maturity or on maximum size of juvenile males (NPFMC 2019b). 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, Nelson and Quinn 1987, McDermott 1994, 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 2019b). There have been no studies on fecundity of rougheye in Alaska (NPFMC 2019b). 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 2019b).

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 2019b).

Juveniles: There is no information on when juvenile fish become demersal (NPFMC 2019b). 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 2019b). 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

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 2019b). 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). The dark rockfish was removed from the FMP in 2009 to allow for more responsive management by the State of Alaska (NPFMC 2019b). EFH for dusky rockfish has been defined in Cook Inlet and GOA (Table 4-12, Table 4-13).

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 2019b). Dusky rockfish are presumed to be demersal and possibly pelagic, however there is no specific evidence of pelagic behavior (NPFMC 2019b). 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 2019b). Consequently, there is little information on seasonal movements or changes in distribution (NPFMC 2019b). 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 2019b). Length of the larval stage, and whether a pelagic juvenile stage occurs, are unknown (NPFMC 2019b). 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 2019b).

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 2019b). 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 approximately 18 in (47 cm) for females (size at 50 percent maturity is 17 in (43 cm) (NPFMC 2019b).

Eggs: No information is known, except that parturition probably occurs in the spring, and may extend into summer (NPFMC 2019b).

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 2019b).

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, ADF&G, 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 2019b).

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 2019b). EFH for both shortspine thornyhead rockfish and longspine thornyhead rockfish has been defined in Cook Inlet and GOA (Table 4-12, Table 4-13). 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 2019b). Shortspine thornyhead spawning, and likely longspine thornyhead, occurs in the late spring and early summer, between April and July in the GOA (NPFMC 2019b). 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 2019b).

Shortspine thornyhead rockfish prey mainly on epibenthic shrimp and fish in the GOA (Yang 1993, 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 2019b).

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 2019b). 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 2019b).

Larvae: Three-day-old larvae are about 0.1 in (3 mm) long and float to the surface (NPFMC 2019b).

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 2019b).

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 2019b). 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 2019b).

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 2019b). EFH for northern rockfish has been defined in Cook Inlet and GOA (Table 4-12, Table 4-13). 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 2019b). 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 2019b). 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 2019b). 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 2019b). Observations during research surveys in the GOA suggest that parturition (larval release) occurs in the spring and is mostly completed by summer (NPFMC 2019b). 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 2019b). 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 2019b).

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 2019b).

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 2019b).

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 4-12, Table 4-13). 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 2019b). 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 2019b). 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 2019b). 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 2019b).

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 2019b). Insemination occurs in the fall, and sperm are retained within the female until fertilization takes place approximately 2 months later (NPFMC 2019b). 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 2019b).

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. 2007). Age at 50 percent recruitment to the commercial fishery has been estimated to be between 7 and 8 years in the GOA (NPFMC 2019b). 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 2019b).

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 2019b). 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 2019b).

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 2019b).

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 2019b).

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 (Mecklenburg et al. 2002, Maloney 2004). EFH for shortraker rockfish has been defined in Cook Inlet and GOA (Table 4-12, Table 4-13). Except for the adult stage, information on the life history of shortraker rockfish is extremely limited (NPFMC 2019b). 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 2019b). 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 2019b). 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 2019b).

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 2019b). 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 2019b). 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 2019b). 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 2019b).

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 2019b).

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 2019b). 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 2019b). 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 2019b).

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 (Eschmeyer et al. 1983, Allen and Smith 1988). EFH for these species of rockfish has been defined in Cook Inlet and GOA (Table 4-12, Table 4-13). 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 2019b). 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 2019b). Parturition occurs in southeast Alaska between April and July with a peak in May (O'Connell and Funk 1987). Fecundity ranges from 1,200,000 to 2,700,000 eggs per season (Hart 1942; O'Connell, ADF&G, 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 2019b). 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 Funk 1987, O'Connell and Fujioka 1991). However, a 121-year-old specimen was harvested in the commercial fishery off Southeast Alaska in 2000 (NPFMC 2019b).

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 2019b).

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 2019b).

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 2019b). EFH for all of these species has been defined in Cook Inlet and GOA and is shown for individual species in Table 4-12 and Table 4-13.

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 2019b).

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 (NPFMC 2019b).

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) (NPFMC 2019b).

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 2019b). EFH for sablefish has been defined in Cook Inlet and GOA (Table 4-12, Table 4-13; 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 2019b). 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 into shallower waters to over winter (NPFMC 2019b). Juvenile distribution is unknown to be highly specific or if it appears that way because sampling is highly inefficient and sparse (NPFMC 2019b). 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 2019b). It is not clear if the juvenile distribution is highly specific or appears so because sampling is highly inefficient and sparse (NPFMC 2019b). 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 2019b).

Pelagic ocean conditions appear to determine when strong young-of-the-year survival occurs (NPFMC 2019b). 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 2019b). Recruitment success also appeared related to water temperature (NPFMC 2019b). 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 2019b).

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 2019b). 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 2019b).

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 2019b).

Larvae: After hatching and yolk adsorption, the larvae rise to the surface and are oceanic through the spring to late summer (NPFMC 2019b).

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 2019b). One or two years later, they begin appearing on the continental shelf and move to their adult distribution as they mature (NPFMC 2019b).

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 2019b).

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 2019b). 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 2019b). 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 2019b). 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 2019b). 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 2019b).

EFH for three species of sculpin has been defined in Cook Inlet and GOA (Table 4-12, Table 4-13; Figure 4-19) and are described below. Several other species of sculpins were caught during sampling in Ursus

Cove and the Iliamna and Iniskin bay estuaries from 2004-2012, including: buffalo sculpin, calico sculpin, Pacific staghorn sculpin, padded sculpin, shorthorn sculpin, silverspotted sculpin, spinyhead sculpin, and threaded sculpin (PLP 2013, Hart Crowser, Inc. 2015).

- 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 2019b).

Larvae: Sculpin are distributed pelagically and in neuston across broad areas of shelf and slope, but predominantly on inner and middle shelf (NPFMC 2019b).

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 2019b).

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 2019b). EFH for walleye pollock has been defined in Cook Inlet and GOA (Table 4-12, Table 4-13; Figure 4-20). Pollock reach 36 in (91 cm) in length and are an important species in commercial fisheries (NPFMC 2019b). 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 2019b). 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 Ursus Cove and in the Iliamna and Iniskin bay estuaries (PLP 2013, Hart Crowser, Inc. 2015, GeoEngineers 2018a).

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 2019b).

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 2019b).

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 2019b).

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 2019b).

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 (NPFMC 2018a). Twelve species from the forage fish complex, were captured during sampling between Ursus Cove and Iniskin Bay inferring EFH within the study area (Table 4-14, Table 4-15).

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 the Iliamna and Iniskin bay estuaries during 2018 (Table 4-16), which indicates that spawning areas were likely close. Eggs were not detected in sampling conducted at 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 Longfin Smelt

Longfin smelt are an anadromous forage fish in the family Osmeridae, the smelts. Longfin smelt are moderately widespread in nearshore areas in southcentral and southeast Alaska, though can be locally abundant (Mecklenburg et al. 2002). They are a small elongate, slender fish, up to 15 cm (5.9 in) in length. Little is known about the marine habitats of longfin smelt; their freshwater spawning habitats are more well-documented.

Longfin smelt are included as a forage fish in the GOA FMP, however, EFH has not been defined for this species complex. Longfin smelt were moderately abundant in Cottonwood, Iliamna, and Iniskin bays during PLP sampling (PLP 2013, Hart Crowser 2015).

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 Eulachon

Eulachon are a forage fish in the family Osmeridae, the smelts. Eulachon are an anadromous fish, with an elongate, slender body up to 25 cm (9.8 in) in length. Juveniles and adults feeding in nearshore marine environments on euphausiids in up to 300 m (984 ft) of water, and adults returning to freshwater to spawn in spring (Mecklenburg et al. 2002). Their distribution ranges from northern California through the GOA.

Eulachon are included as a forage fish in the GOA FMP, however, EFH has not been defined for this species complex. Two eulachon were caught in Iniskin Bay from 2010-2012 during PLP sampling (Hart Crowser 2015).

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 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 Ursus Cove and Iniskin Bay. 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.

4.2.10.5 Pacific Sandfish

Pacific sandfish are a species in the family Trichodontidae, the sandfishes. They are an intertidal fish found up to depths of 400 m (1,312 ft), typically shallower than 200 m (656 ft) (Mecklenburg et al. 2002). They are distributed throughout coastal areas in the GOA west through the Aleutian Islands. Larval and juvenile Pacific sandfish are thought to develop in shallow nearshore areas. Adult Pacific sandfish are typically buried in sand with its upturned mouth above the surface, waiting for prey, in deeper waters (Mecklenburg et al. 2002).

Pacific sandfish are included as a forage fish in the GOA FMP, however, EFH has not been defined for this species complex. They were encountered in nearshore areas in low numbers during PLP marine fish surveys in the Iliamna and Iniskin bay estuaries from 2004-2008 (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.

4.2.10.6 Pacific Sandlance

Pacific sandlance are a species in the Ammodytidae family. They are a small coastal forage fish with an elongate, compressed body, up to 20 cm (7.9 in) in length (Mecklenburg et al. 2002). They are distributed in coastal areas in Alaska as far north as the Beaufort Sea. Pacific sandlance frequently burrow into sand or gravel substrates. They spawn intertidally once a year near burrowing habitats and have been known to spawn in the same locations for decades (Robards et al. 1999). They are a key prey species for many marine predators in the GOA.

Pacific sandlance are included as a forage fish in the GOA FMP, however, EFH has not been defined for this species complex. They were encountered in nearshore areas during PLP marine fish surveys in the Iliamna and Iniskin bay estuaries from 2004-2008, and 2010-2012 (PLP 2013, Hart Crowser, Inc. 2015).

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.

4.2.10.7 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.

4.2.10.8 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 Ursus Cove and the Iliamna and Iniskin bay estuaries (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.

The fished component of the population is aggregated in two limited areas, or scallop beds, located east and southeast of Augustine Island (Figure 4-21). Scallop surveys of these areas were conducted in 1996, 1997, 2001, 2003, 2005, 2007, 2009. Scallop density ranged from 0.01 scallops/m^2 to 0.21 scallops/m^2 (Gustafson and Goldman 2012).

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 study area.

4.5 Diamond Point Port Habitat Mapping

Diamond Point port is in Iliamna Bay on the western shore of Cook Inlet, approximately 165 mi (266 km) southwest of Anchorage and approximately 75 mi (121 km) west of Homer. PLP mapped approximately 29,971 ac (12,129 ha) of nearshore habitat and 19,127 ac (7,740 ha) of offshore habitat in Iliamna, Iniskin, and Cottonwood bays and Ursus Cove combined (PLP 2012, GeoEngineers 2018b).

Iniskin Bay comprised the greatest area, at 14,691 ac (5,945 ha), followed by Cottonwood and Iliamna bays at 6,541 ac (2,647 ha), and Ursus Cove at 3,806 ac (1,510 ha). Iniskin Bay was comprised of 6 percent beach complex, 66 percent intertidal complex, and 28 percent subtidal complex. The intertidal complex was dominated by mixed fines (33 percent), sand/fines (13 percent) and marsh (13 percent). The subtidal complex was mainly composed of sand/fines (25 percent). Cottonwood and Iliamna bays were surveyed together, and were comprised of 4 percent beach complex, 60 percent intertidal complex, and 36 percent subtidal complex. The majority of the intertidal zone was comprised of mixed fines (34 percent) and sand/fines (18 percent). The subtidal complex was dominated by sand/fines (26 percent). Ursus Cove was comprised of only two habitat types in the beach, intertidal, and subtidal complexes, beach complex (45 percent) and reef habitats (55 percent). The complete acreage and percentage of habitat mapped is provided in Table 4-17.

Diamond Point has an extensive rock buttress that projects into the intertidal zone. The edge of the rock habitat transitions to sand/mud flats that extend west into Cottonwood Bay and north into Iliamna Bay. The intertidal rock areas support rockweed and red algae and had abundant barnacles and motile invertebrates. Ursus Cove had minimal rock habitat near the potential gas pipeline landfall, with limited biota present.

Table 4-17. Nearshore habitat mapped by PLP at Ursus Cove and Iliamna, Iniskin, and Cottonwood bays.[1]

Area	Sub-Type	Substrate	Acres	Percent
Cottonwood Bay and Iliamna Bay	Beach Complex	Beach Complex	248	4%
	Beach Complex Total		248	4%
	Intertidal	Beach Complex	171	3%
		Mixed Fine	2,252	34%
		Reef	302	5%
		Sand/Fine	1,156	18%
		Unknown	59	1%
	Intertidal Total		3,940	60%
	Subtidal	Mixed Gravel	491	8%
		Sand/Fine	1,697	26%
		Unknown	164	3%
	Subtidal Total		2,353	36%
	Cottonwood Bay and Iliamna Bay Total		6,541	100%
Iniskin Bay	Beach Complex	Beach Complex	952	6%
	Beach Complex Total		952	6%
	Intertidal	Beach Complex	351	2%
		Marsh	1,871	13%

Area	Sub-Type	Substrate	Acres	Percent
		Mixed Fine	4,885	33%
		Reef	647	4%
		Sand/Fine	1,902	13%
	Intertidal Total		9,656	66%
	Subtidal	Mixed Fine	15	0%
		Mixed Gravel	297	2%
		Rocky	45	0%
		Sand/Fine	3,705	25%
		Unknown	20	0%
	Subtidal Total		4,082	28%
	Iniskin Bay Total		14,691	100%
Ursus Cove	Beach Complex	Beach Complex	855	22%
	Beach Complex Total		855	22%
	Intertidal	Beach Complex	875	23%
		Reef	515	14%
	Intertidal Total		1,390	37%
	Subtidal	Reef	1,561	41%
	Subtidal Total		1,561	41%
	Ursus Cove Total		3,806	100%

1 GeoEngineers 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 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 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 study area (Figure 3-5, Figure 3-6, Figure 3-5, Figure 3-8), generally extending from the mine site to Diamond Point, in Iliamna Bay, and on the Ursus Cove peninsula.

5.1.1 Mine Site

Potential effects to freshwater EFH caused by mine site construction (Figure 3-1) are discussed below. Mine site impacts are summarized in Section 5.1.1.7.

Mine site construction activities would occur year-round:

- Site capture April Y2 – July Y2
- Major site earthworks September Y2 – February Y4
- Construct mill and infrastructure May Y3 – October Y4
- Pit pre-production mining September Y3 – October Y4

5.1.1.1 Loss of Habitat

The proposed action (April Y2 – October Y4) includes the discharge of dredge or fill material into tributaries of the upper Koktuli River identified as NFK 1.190, NFK 1.200 and their tributaries for construction of mine facilities (Figure 3-1). A proposed mine site access road south of the open pit would traverse the SFK 1.0 at the beginning at the uppermost extent of EFH, upstream of Frying Pan Lake. PLP has proposed placement of a culvert designed for fish passage at this location (Figure 3-2).

The proposed action would dredge, fill, drain or block passage that would result in the direct removal of designated EFH in NFK River from NFK 1.190 and NFK 1.200 tributaries to the Koktuli River; no EFH would be permanently removed from within the SFK 1.0 (Table 5-1). Primary EFH losses would result from construction of the bulk and pyritic TSF within the headwater drainage NFK 1.190, with some additional loss from construction of the main WMP within headwater tributary NFK 1.200. Construction of facilities within NFK 1.190, NFK 1.200 and their tributaries would permanently remove 8.5 mi (13.7 km) of the documented 67.4 mi (108.4 km) of EFH in the NFK River. This loss equates to approximately 17 ac (6.9 ha) of low Pacific salmon use NFK River EFH as described below (R2 Resource Consultants, Inc. 2019).

Approximately 7.4 mi (11.9 km) of EFH in NFK-C, all within NFK 1.190 and its tributaries, would be removed, 4.2 mi (2.8 km) of which are documented as low-use spawning habitat for coho salmon (Table 4-5, Table 5-1; Figure 4-4). Aerial survey counts in 2008 on the day of peak distribution within the drainage observed 27 spawning coho salmon in NFK 1.190 out of 1,746 observed in the NFK River, representing 1.5 percent of adult coho salmon in NFK River. Spawning has not been detected in the tributary for any other EFH species. Substrates in NFK 1.190 were dominated by cobble followed by gravel (Table 4-10) indicating spawning habitat is present but not abundant, which was substantiated by the low numbers of spawning salmon observed as described above. NFK 1.190 and its tributaries that would be removed are also used by rearing coho salmon and Chinook salmon (Table 4-7, Table 4-8, Table 4-9). Compared to NFK-wide juvenile densities, overall densities and distribution of juvenile Chinook salmon are low within NFK 1.190 and its tributaries with sample densities of 0.11 fish/100m^2 in 2008 and 2018 sampling as compared to 4.88 fish/100m^2 at NFK 1.0 in the same years (Table 4-9). 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 as well, with densities of 1.24 fish/100m^2 in NFK 1.190 and 25.33 fish/100m^2 at NFK 1.0. Stream reaches within NFK 1.190 that will be removed are small with bankfull widths ranging from 3.25 (1 m) ft to 30 ft (9 m) with most less than

10 ft (3 m) wide, and bankfull depths ranging from 1.3 ft (0.4) to 2.2 ft (0.7 m) deep. Channel slopes in stream reaches to be removed range from 0.5 percent to over 11 percent with EFH documented only in the reaches with channel slopes less than 4 percent (Table 4-10). Pool frequency generally is less than 1 pool per 100 m (328 ft); however, NFK 1.190.30 and 1.190.40 did exceed 1 pool per 100 m (328 ft) of stream. Overall, low numbers of adult and juvenile salmon were detected in NFK 1.190 and its tributaries, suggesting lower EFH quality in the habitats to be removed by the proposed action, or at a minimum, adequate habitat quantity and quality is available in other areas of the drainage, and are being selected by Pacific salmon. Habitat data available for NFK mainstem reaches support this conclusion.

An additional 1.1 mi (1.8 km) of NFK River EFH in NFK-D would be removed from headwater tributary NFK 1.200 during construction of the main WMP. Aerial surveys for Pacific salmon have not documented adults in NFK 1.200. Sampling for juvenile fish in NFK 1.200 in 2018 found Chinook salmon densities of 0.08 fish/100m^2 and 2.24 fish/100m^2 for coho salmon while densities in adjacent mainstem NFK-C were 4.88 fish/100 m^2 for Chinook salmon and 25.33 fish/100m^2 for coho salmon (Table 4-9; Figure 4-1, Figure 4-2, Figure 4-4). EFH reaches of NFK 1.200 that would be removed by the proposed action are dominated by gravel substrates followed by cobbles, a 1.1 percent channel slope, and a pool frequency of less than 1 per 100 m. The stream channel is wider than the lower reaches of headwater tributary NFK 1.190 with a bankfull width of 47 ft (14.3 m) and a bankfull depth of 1.5 ft (0.5 m) because of beaver dam prevalence; however, upstream from ponded areas, bankfull widths are narrow and average 5.9 ft (1.8 m) in Reach 3 (Table 4-10).

Construction of the culvert in the SFK 1.0 could temporarily affect 0.04 mi (0.1 km) of low density coho salmon rearing EFH in the headwaters of SFK River in reach SFK-E, upstream from Frying Pan Lake (Figure 4-1, Figure 4-4, Figure 4-6). While low density juvenile coho and sockeye salmon rearing is documented upstream from Frying Pan Lake, only juvenile coho salmon are listed in the vicinity of the crossing. No adult Pacific salmon were observed within the headwater reach of SFK River during any of the aerial surveys flown from 2004 through 2008 to document the distribution of adult salmon. Habitats that could be temporarily affected exhibited some of the lowest density use by both coho and sockeye salmon juveniles within the SFK drainage, suggesting low overall quality EFH or an abundance of quality habitat in other portions of the drainage. Habitat surveys in SFK-E mainstem reaches with EFH have a bankfull channel width of 15.4 ft (4.7 m) with bankfull depths ranging from 1.3 ft (0.4 m) to 2.8 ft (0.8 m). Channel slopes in SFK-E ranged from 1.3 percent to 2.8 percent with sand-silt to organic dominated substrates. Pools were infrequent with 1 pool per 100 m of stream.

Surveys conducted from 2004 through 2008 in mainstem SFK River found that juvenile salmon densities generally decreased with distance from the confluence with NFK River with 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. Sockeye salmon juvenile densities were much lower in mainstem habitats with sample 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 4-7). Baseline studies found rearing Pacific salmon were rare upstream from Frying Pan Lake in SFK (Figure 4-1, Figure 4-4, Figure 4-6) (PLP 2011, PLP2018a).

Mortality of managed species is possible and would most likely occur in streams removed during Project construction (Table 5-1). 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 small NFK River tributaries that would be removed have low Pacific salmon presence as described above illustrating that the overall potential for mortality is also low. Construction timing will be determined during detailed project design and in consultation with the Alaska Department of Fish and Game (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.

Direct impacts of EFH removal within NFK-C and NFK-D would be permanent. However, considering the low densities of juvenile Chinook salmon and coho salmon detected and habitat characteristics of EFH to be removed within NFK 1.190 and 1.200, along with the low numbers of coho salmon of spawning in NFK 1.190, it is unlikely that drainage-wide impacts to Pacific salmon populations could occur.

In total, 8.5 mi (13.7 km) of freshwater EFH within the Koktuli River drainage would be lost, all within headwater streams of the NFK River around the mine footprint. The removal of these narrow, steep, and higher gradient headwater streams is permanent, but the impacts in the context of EFH species use by life stage and density is low and localized when compared to the higher quantity and higher use EFH immediately downstream in the NFK River. The larger, downstream reaches documented to be more heavily used by Pacific salmon for spawning and rearing would not be directly impacted. 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 salmon (Figure 4-1, Figure 4-2), coho salmon (Figure 4-1, Figure 4-4), sockeye salmon (Figure 4-1, Figure 4-6), and chum salmon (Figure 4-1, Figure 4-8), and are discussed in Section 5.1.1.3. Overall, because the loss of these low density use habitats is permanent, as defined in Section 5, the degree of habitat loss impact is moderate: EFH for low numbers of rearing Chinook salmon and coho salmon and spawning and developing embryonic coho salmon would be permanently removed in areas with low densities of managed species with lower habitat value characteristics. Impacts could be detectable in the short-term, but population level effects within the HUC-10 watershed of the NFK River, SFK River, and UT Creek are not anticipated, and effects outside of the HUC-10 watershed of the Koktuli River are less likely.

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

Stream Reach	Stream Code	Anadromous Waters Catalog Code	EFH Removed mi (km)
NFK-C	NFK 1.190	325-30-10100-2202-3080-4083-5215	4.2 (6.7)
NFK-C	NFK 1.190.10	325-30-10100-2202-3080-4083-5215-6001	1.7 (2.8)
NFK-C	NFK 1.190.10.03	325-30-10100-2202-3080-4083-5215-6001-7012	0.05 (0.1)
NFK-C	NFK 1.190.30	325-30-10100-2202-3080-4083-5215-6006	0.5 (0.8)
NFK-C	NFK 1.190.40	325-30-10100-2202-3080-4083-5215-6007	0.9 (1.5)
		Subtotal NFK-C	***7.4 (11.9)***
NFK-D	NFK 1.200	325-30-10100-2202-3080-4083-5217	1.1 (1.8)
		Subtotal NFK-D	***1.1 (1.8)***
		TOTAL EFH REMOVED	**8.5 (13.7)**

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 study 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 on fish.

Occasionally, blasting could occur near fish-bearing waters along EFH tributaries of NFK River and the headwaters of SFK River north of Frying Pan Lake (Figure 3-1). 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. Additionally, blasting may release ammonia and nitrate contaminants that could affect water quality.

In a review of research on the effects of various overpressures and particle velocities on fish and fish eggs, Kolden and Aimone-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 pounds per square inch (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

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

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 study area, fish are expected to return to the site of blasting and habitat conditions are expected to return to a usable state once blasting is complete, with the exception of those areas permanently removed during construction. The degree of impact 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 during construction (September Y2 through October Y4) would result in temporary streamflow changes to the NFK River and the SFK River. Water diverted around construction areas would be returned to the respective stream of removal shortly (within days) after construction of embankments and would therefore not alter downstream stream flows beyond the initial period of damming (Knight Piésold 2019). Effects to EFH from changes in stream flow during construction of embankments and water diversion operations would therefore be primarily limited to the direct effects to EFH removed by the proposed action. The effects of direct losses to EFH are addressed in loss of habitat (Section 5.1.1.1). Overall, any reduction in water flow into the NFK River and the SFK River drainages during embankment construction and diversion operations could impact Pacific salmon habitat, Pacific salmon spawning, egg survival, and Pacific salmon rearing. However, because changes in flow would be temporary, only during the period of filling of diversion dams, the overall potential impact to EFH would be negligible.

5.1.1.4 Water Temperature

Water temperatures within the NFK River and SFK River drainages are seasonally variable and are known to exceed Alaska Department of Environmental Conservation (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 construction. Because water could be held in settling ponds and behind embankments for a short duration prior to release back to the stream of origin, some warming or cooling, pending the season of retention, would be expected. Overall, because retention periods are anticipated to be short, substantial changes in water temperature to downstream EFH in NFK and SFK rivers are not anticipated. The primary effects to EFH would be those associated with the direct loss of habitat (Section 5.1.1.1). The overall degree of impact is negligible: once initially established, there would be low retention time of diverted water and water temperatures would not be anticipated to change measurably however, any changes would be long-term.

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, which may be disrupted by construction mining activities through changes in water quality (Lewis-Russ 1997). Naturally occurring minerals and metals, but primarily sediment can be liberated from rock and soil substrates from construction earthwork activities (September Y2 through October Y4). The introduction of sediment and increased turbidity into the aquatic ecosystem can have adverse impacts on the ecology of entire watersheds. Construction of embankments and settling ponds will initially increase sediment transport and turbidity in EFH stream reaches, however, water management for construction and diversions will move water to settling ponds or hold water long enough prior to discharge back into the source stream such that sediments released during construction will settle out prior to water discharge. Some increases in sediments and turbidity would be anticipated at the initiation of embankment and diversion construction activities but those inputs would be localized to the construction site and would be short term lasting only days in duration. Initiation of pumping from settling ponds or impoundments could also cause increases in sediment and turbidity, however by keeping pumping at receiving stream pre-diversion flow rates, increases in sediment and erosion would be short term lasting only days to hours in duration.

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 freshwater diversion channels, the open pit WMP, the main WMP, the TSFs, seepage collection and recycle ponds, sediment ponds, and two water treatment plants. Surplus water collected during construction would be discharged into nearby NFK River, SFK River and UT Creek, pursuant to stormwater management regulations. Wastewater will be treated prior to discharge to water quality levels that are protective of aquatic life consistent with Alaska water quality standards. Diversions and storm water runoff would be handled in accordance with the SWPPP and ADF&G fish habitat permits including required monitoring of discharges and are expected to be effective at maintaining suitable water quality for managed species during construction.

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 that 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. It is unlikely, given the required spill prevention control measures, that an incidental spill would release petroleum lubricants and fuels that would result in a 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 5-2 summarizes potential impacts to freshwater EFH and their assessed degree of impact.

Table 5-2. 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. 8.6 mi (13.8 km) 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. 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 (Diversion of flow around construction areas)	- No predicted stream flow changes to NKF River, SFK River and UT Creek.	**Temporary**	The degree of impact is **negligible**: - Changes would be short term and limited to the period of diversion filling prior to discharge back to the stream of origin, effect limited to days.
Water temperature (Diversion of flow around construction areas)	- Potential changes in water temperature from retention during diversion.	**Temporary**	The degree of impact is **negligible**: - Water temperature changes would occur following initial filling of impoundments and settling ponds. - Water temperature changes are expected to be within the range of seasonal variability.

Potential Impact			
Type (Source)	**Description**	**Duration**	**Degree**
Water quality (Sediment increases during embankment and diversion construction)	- Potential increases in sediment and turbidity.	**Temporary**	The degree of impact is **negligible**: - SWPP would mitigate most increases in construction sediment and diversions would retain water briefly prior to discharge allowing sediment to settle out prior to discharge back to the stream of origin.
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 access road are discussed below. The discussion on potential effects to EFH from the road is grouped by fish passage and habitat loss, pile driving, material source development, water use, water quality, contaminant release, blasting, and invasive species. Impacts are summarized in Section 5.1.2.9.

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 initial road towards mine site — June Y1 – April Y2
  - Final access road construction — November Y1 – September Y2
  - Construct major bridges — May Y2 – September Y2

5.1.2.1 Fish Passage and Habitat Loss

Project roads (Figure 3-3) will cross 132 drainages and streams, using 17 bridges and 115 culverts. Twelve of these bridges and nine culverts would be in designated EFH for Pacific salmon (Table 5-3). These structures 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 Figure A-4 through Figure A-20. Bridges would be constructed between May Y2 and September Y2, while culvert installation would take place between June Y1 and September Y2.

- Five single span, two-lane bridges, ranging in length from approximately 50 – 90 ft (15.2 – 27.4 m) are proposed for UT Creek (UT 1.0), West Fork Eagle Bay Creek, West Fork Youngs Creek, East Fork Youngs Creek, and Lonesome No. 1 Creek.
- Seven multi-span, two-lane bridges ranging from 140 – 510 ft (42.7 – 155.5 m) are proposed for the Newhalen River, Chekok Creek, Canyon Creek, Knutson Creek, Pile River, Long Lake Creek, and Iliamna River.

- The 15 ft (4.6 m) steel arch culverts, will be installed for the Eagle Bay T1, Chekok Creek Trib 1, and Long Lake T1 crossings.
- Culverts ranging from 5 – 15ft (1.5 – 4.6 m) in diameter will be installed in designated freshwater EFH in 4 streams. Culverts will be designed and sized in accordance with USFWS standards for fish passage (USFWS 2020). Fish passage design standards accommodate anticipated levels of flow, maintain sufficient channel width, and minimize slope changes (Figure A-16 through Figure A-20). 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 5-3. Stream crossings on Pacific salmon EFH streams.[1]

Stream Crossing ID	AWC Code[2]	Pacific Salmon Species[3] and Life Stage[4]	Mine Access Road Crossing	Road Crossing Details	Road Crossing Details	Road Crossing Details	Pipelines[6] and Fiber Optic Cable Crossing	Pipelines[6] and Fiber Optic Cable Crossing Type
				Type	Bridge Length ft (m)	Culvert Diameter /Length ft (m)		
Transportation Corridor								
T001[5]	324-10-10150-2183-3307 (UT 1.460)	COr, Kr	Yes	Culvert-Elliptical	--	8/180 (2.4/54.9)	Yes	Trench or HDD

Stream Crossing ID	AWC Code[2]	Pacific Salmon Species[3] and Life Stage[4]	Mine Access Road Crossing	Road Crossing Details	Road Crossing Details	Road Crossing Details	Pipelines[6] and Fiber Optic Cable Crossing	Pipelines[6] and Fiber Optic Cable Crossing Type
				Type	Bridge Length ft (m)	Culvert Diameter /Length ft (m)		
T006	324-10-10150-2183-3057 (UT 1.360)	COr	Yes	Culvert	--	8/110 (2.4/33.5)	Yes	Trench or HDD
T007	324-10-10150-2183 (Upper Talarik Creek/ UT 1.0)	COrs, CHs, Krs, Srs	Yes	Bridge-Single span	90 (27.4)	--	Yes	Suspend pipeline beneath bridge
T008	324-10-10150-2183 (UT 1.340)	COr	Yes	Culvert	--	5/190 (1.5/57.9)	Yes	Trench or HDD
E004	324-10-10150-2207-3027-4011 (Stuck Creek/ Newhalen River Trib 4.2)	COr	Yes	Culvert	--	15/80 (4.6/24.4)	Yes	Trench or HDD
E005	324-10-10150-2207-3027-4011 (Newhalen River Trib 4.2.1)	COr	Yes	Culvert	--	5/125 (1.5/38.1)	Yes	Trench or HDD
E007	324-10-10150-2207 (Newhalen River)	COp, Ss, Kp	Yes	Bridge-Multi-span	510 (155.4)	--	Yes	Suspend pipeline beneath bridge
E013	324-10-10150-2235 (Eagle Bay T1)	Ss	Yes	Culvert-Arch	--	15/170 (4.6/51.8)	Yes	Trench or HDD
D1004	324-10-10150-2239-3005 (West	Ss	Yes	Bridge-Single span	50 (15.2)	--	Yes	Suspend pipeline

Stream Crossing ID	AWC Code[2]	Pacific Salmon Species[3] and Life Stage[4]	Mine Access Road Crossing	Road Crossing Details	Road Crossing Details	Road Crossing Details	Pipelines[6] and Fiber Optic Cable Crossing	Pipelines[6] and Fiber Optic Cable Crossing Type
				Type	Bridge Length ft (m)	Culvert Diameter /Length ft (m)		
	Fork Eagle Bay Creek)							beneath bridge
D1005	324-10-10150-2239 (East Fork Eagle Bay Creek)	COr, Ss	Yes	Culvert	15/125 (4.6/38.1)	--	Yes	Trench or HDD
D1006	324-10-10150-2261 (West Fork Youngs Creek)	COp, Ss	Yes	Bridge-Single span	50 (15.2)	--	Yes	Suspend pipeline beneath bridge
D1008	324-10-10150-2261-3006 (East Fork Youngs Creek)	COp, Ss	Yes	Bridge-Single span	50 (15.2)	--	Yes	Suspend pipeline beneath bridge
D1009	324-10-10150-2267-3001 (Chekok Creek Trib 1)	COp, Ss	Yes	Culvert-Arch	--	15/100 (15.2/30.5)	Yes	Trench or HDD
D1010	324-10-10150-2267 (Chekok Creek)	COp, Ss	Yes	Bridge-Multi-span	240 (73.2)	--	Yes	Suspend pipeline beneath bridge
D1012	324-10-10150-2273 (Canyon Creek)	Ssr	Yes	Bridge-Multi-span	200 (61)	--	Yes	Suspend pipeline beneath bridge
D1035	324-10-10150-2301 (Knutson Creek)	Ss	Yes	Bridge-Multi-span	240 (73.2)	--	Yes	Suspend pipeline beneath bridge

Stream Crossing ID	AWC Code[2]	Pacific Salmon Species[3] and Life Stage[4]	Mine Access Road Crossing	Road Crossing Details	Road Crossing Details	Road Crossing Details	Pipelines[6] and Fiber Optic Cable Crossing	Pipelines[6] and Fiber Optic Cable Crossing Type
				Type	Bridge Length ft (m)	Culvert Diameter /Length ft (m)		
D1068	324-10-10150-2333 (Lonesome No. 1 Creek)	Ss	Yes	Bridge-Single span	90 (27.4)	--	Yes	Suspend pipeline beneath bridge
D1076	324-10-10150-2341 (Pile River)	Ss	Yes	Bridge-Multi-span	240 (73.2)	--	Yes	Suspend pipeline beneath bridge
D1077	324-10-10150-2343 (Long Lake Creek)	Kr, Sr	Yes	Bridge-Multi-span	140 (42.7)	--	Yes	Suspend pipeline beneath bridge
D1078	324-10-10150-2343-3006 (Long Lake T1)	Ss	Yes	Culvert-Arch		15/160 (4.6/48.8)	Yes	Trench or HDD
D1084	324-10-10150-2402 (Iliamna River)	COp, CHp, Kp, Ss, Pp	Yes	Bridge-Multi-span	200 (61)	--	Yes	Suspend pipeline beneath bridge
Natural Gas Pipeline and Fiber Optic Cable Corridor[7]								
No ID	248-20-10030 (Cottonwood Bay Tributary)	CHp	No	--	--	--	Yes[7]	Trench or HDD
No ID	248-10-10040 (Brown's Peak Creek)	CHs, COr, Ps, Sp	No	--	--	--	Yes[7]	Trench or HDD

1 Source: PLP GIS data: Recon 2020.
2 Johnson and Blossom 2019.
3 Pacific salmon codes: CO = coho salmon; S = sockeye salmon; CH = chum salmon; K = Chinook salmon; P = pink salmon.
4 Pacific salmon life stages: p = present; s = spawning; r = rearing (Johnson and Blossom 2019).
5 Crossing T001 is located more than 984 ft (300 m) up stream of AWC upper extent in tributary 324-10-10150-2183-3307.
6 Pipelines include: natural gas pipeline, concentrate pipeline and return water pipeline
7 Ursus Cove Peninsula.

5.1.2.2 Pile Driving

The multi-span bridges (7) over EFH streams (Table 5-3) will require the installation of piles for bridge support (Figure A-4, Figure A-5, Figure A-6, Figure A-8, Figure A-9, Figure A-10, and Figure A-14). Most piles would be installed instream. The pile driving techniques that would be used for construction of bridge supports may include impact driving, vibrodriving, pressing, or driving assistance (i.e., jetting, pre-augering, or drilling) or a combination of these methods. Pile driving activities are expected to range from days at single span bridge locations to a week or two at multi-span bridge locations.

Pile driving can generate intense underwater sound pressure waves that may adversely affect EFH. Adverse effects on EFH may range from changes in fish behavior to immediate mortality (Limpinsel et al. 2017). Short-term exposure to peak SPLs above 190 dB (re:1 μPa) is thought to impose physical harm on fish (Hastings 2005). However, 155 dB (re:1 μPa) may be sufficient to stun small fish temporarily (Limpinsel et al. 2017). The type and intensity of the sounds produced during pile driving depend on a variety of factors, including installation method (i.e., impact driving or vibrodriving), equipment, and the size of hammer, the type and size of the pile, the firmness of the substrate into which the pile is being driven, and the depth of water (Limpinsel et al. 2017). Driving large, hollow steel piles with impact hammers produces intense, sharp spikes of sound that can easily reach levels injurious to fish. Pile driving using vibratory hammers produces sounds of lower intensity, but with a rapid repetition rate. Fish normally respond to vibratory sound by avoiding the area and do not become habituated. However, fishes may respond to the first few strikes of an impact hammer with a startle response, but after initial strikes, the startle diminishes, and the fishes may remain within the field of a potentially harmful sound. Therefore, impact hammers may be more harmful than vibratory hammers because they produce more intense pressure waves and because the sounds produced do not elicit an avoidance response in fishes, which exposes them to those harmful pressures for longer periods (Limpinsel et al. 2017).

Methods to minimize the adverse effects of pile driving to EFH include the selection of construction timing to avoid sensitive life stages (i.e., larval and juvenile stages), and use of construction methods that reduce the transmission of underwater sound. PLP has proposed mitigative measures to attenuate underwater sounds from pile driving 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]) (See Section 6.8). Mitigative measures should be effective at minimizing potential adverse effect to EFH. The degree of impact is low: pile driving may cause temporary degradation of EFH (coho salmon spawning and rearing; Chinook salmon presence; sockeye salmon spawning; and chum salmon spawning). Pile driving activities are temporary; EFH characteristics would return to normal after the activity ceases.

5.1.2.3 Material Source Development

Fill material for road and pad construction associated with the transportation facilities will be sourced at 30 newly developed material sites located adjacent to the road. Material sites would be constructed concurrent to road and pad construction operations from June Y1 – September Y2.

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 were located outside of EFH. 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 potential effects to EFH of sediment and erosion discharges associated with material sites will be minimized through compliance with required stormwater pollution prevention plans (SWPPPs) (Section 5.1.2.5) and implementation of sediment control BMPs. The effects to EFH from material site development and operation are anticipated to be negligible.

5.1.2.4 Water Use

Construction activities for the proposed road, natural gas, concentrate, and return water pipelines and fiber optic cable, would require water for construction (dust control, compaction, etc.) and hydrostatic testing between June Y1 and September Y3. Water would be withdrawn from waterbodies adjacent to the construction zone on an as needed basis. A total of 35 temporary water withdrawal sites have been identified along the transportation corridor for road and pipeline construction. Twenty-one of the planned water extraction sites for construction of the access road will be at Pacific salmon EFH streams or lakes (Table 5-4). 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 Alaska Department of Natural Resources (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 5-4. Planned temporary water extraction sites from EFH waterbodies.

Name	Designation	Waterbody	Pacific Salmon Species[1] and Life Stage[2]	Use	Facilities	Estimated Volume (Mgal)[3]
Natural Gas Pipeline and Fiber Optic Cable Corridor[4]						
WES-P01	Brown's Peak Creek	Stream	CHs, COr, Ps, Sp	Pipeline construction and testing	Pipeline	3
WES-P02	Brown's Peak Creek	Stream	CHs, COr, Ps, Sp	Pipeline construction and testing	Pipeline	1
WES-P03	Cottonwood Bay Creek	Stream	CHp	Pipeline construction and testing	Pipeline	3
Transportation Corridor						
WES-N10	Iliamna River	River	CHp, COp, Kp, Pp, Ss	Road and pipeline construction	Pipeline and road	8
WES-N11	Xing-103 Creek	Stream	Sp	Road and pipeline construction	Pipeline and road	3
WES-N12	Long Lake Creek	Stream	Kp, Sp	Road and pipeline construction	Pipeline and road	3
WES-N13	Pile River	River	Ss	Road and pipeline construction	Pipeline and road	8
WES-N15	Lonesome Creek No. 1	Stream	Ss	Road and pipeline construction	Pipeline and road	3
WES-18	Dumbbell Lake Creek	Lake	Ss	Road and pipeline construction	Pipeline and road	3
WES-N20	Knutson Creek	Stream	Ss	Road and pipeline construction	Pipeline and road	8
WES-N22	Canyon Creek	Stream	Ssr	Road and pipeline construction	Pipeline and road	3
WES-N23	Chekok Creek	Stream	COpr, Ss	Road and pipeline construction	Pipeline and road	5
WES-N24	East Fork Youngs Creek	Stream	COpr, Ss	Road and pipeline construction	Pipeline and road	3
WES-25	West Fork Youngs Creek	Stream	COpr, Ss	Road and pipeline construction	Pipeline and road	3

Name	Designation	Waterbody	Pacific Salmon Species[1] and Life Stage[2]	Use	Facilities	Estimated Volume (Mgal)[3]
WES-N26	East Fork Eagle Bay Creek	Stream	COr, Ss	Road and pipeline construction	Pipeline and road	3
WES-N27	Roadhouse Creek/Eagle Bay T1	Stream	COs, Ss	Road and pipeline construction	Pipeline and road	3
WES-N29	Newhalen River	River	COsr, Kp, Ssr	Road and pipeline construction	Pipeline and road	8
WES-N30	Newhalen River	River	COsr, Kp, Ssr	Road and pipeline construction	Pipeline and road	5
WES-N31	Stuck Creek	Stream	COr	Road and pipeline construction	Pipeline and road	3
WES-16	UT Creek	Stream	COsr, Kps, Ssr, CHs	Road and pipeline construction	Pipeline and road	1
WES-17	SFK 1.370	Lake	COr	Road and pipeline construction	Pipeline and road	1

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 2019).
3 M=million gallons. The volumes reported here are the total expected withdrawals over the construction period June Y1 – September Y3.
4 Ursus Cove Peninsula

5.1.2.5 Water Quality

Road construction (June Y1 – September Y2), bridge and culvert installation, and pile installation or removal, 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 (Bash et al. 2001). 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 study area (Gregory 1992).

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.

5.1.2.6 Contaminant Release

Incidental spills of petroleum lubricants and fuels during road construction (June Y1 – September Y2), water released from consolidation of dredge sediment, 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. It is unlikely, given the required spill prevention control measures, that an incidental spill would release petroleum lubricants and fuels that would result in a 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.

5.1.2.7 Blasting

Blasting would be required for road and pipeline construction (June Y1 – September Y2). Blasting would occur along approximately 24.3 mi (39.1 km) of the mine access road. Depending on the blasting location and estimated pressure and vibration forces, blasting could result in disruption to the pre-existing balance of suspended sediment transport and turbidity; direct impacts to fish spawning and nesting habitats (redds), adults, juveniles, and prey items.

Based on the ADF&G blasting standards (Timothy 2013) for the proper protection of fish (i.e., instantaneous pressure change limit of 7.3 psi) and assuming a conservatively high upper limit for typical ground response, approximate setbacks in a solid rock substrate (based on scaled distance relationship equations) would be 76 feet for a 10 lb/millisecond delay charge and 240 feet for 100 lb/millisecond delay charge (ADF&G 1991). Reducing the charge per millisecond delay can reduce the needed setback to avoid potential injury to fish. Using the same assumptions above but considering the ADF&G standards for the proper protection of embryos (i.e., peak particle velocity of 2.0 inches pers second), approximate setbacks from spawning gravels would be somewhat less restrictive per charge weight per delay. Therefore, using the charge weight examples above, blasting within 76 and 240 feet of EFH could potentially affect EFH species. Charge weights per millisecond delay of as low as 1 lb would require a setback of 24 ft to avoid potential impact to EFH species.

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. PLP has identified areas where blasting may be required for road and pipeline construction. Most blasting would occur at distances greater that 240 ft from Pacific salmon EFH. Current estimates are that approximately 1.6 mi (2.6 km) of the mine access road where blasting would occur within 240 ft of an anadromous stream. 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). Regulatory compliance and collaboration with agency staff will likely result in conditions that require overpressures and particle velocities not to exceed levels that have been shown to cause injury or mortality to salmonids and salmonid embryos and timing activities for 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.

5.1.2.8 Invasive Species

Road construction (June Y1 – September 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). PLP has prepared an invasive species management plan (PLP 2019) that would be implemented prior to construction. 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.

5.1.2.9 Summary of Transportation Corridor Potential Effects to Freshwater Ecosystem EFH

Potential effects to freshwater EFH associated with the transportation corridor are discussed in section 5.1.2.1 and 5.1.2.8. 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 5-5.

Table 5-5. Summary of potential effects 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; 12 bridges and 9 culverts in EFH)	- 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 USFWS 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.
Pile driving (Noise effects from pile driving associated with bridge construction)	- 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. These criteria have identified a peak SPL 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.
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. - Potential effects of turbidity and sedimentation on EFH will be minimized through implementation of required SWPPPs and BMPs.

Potential Impact			
Impact (Source)	**Description**	**Duration**	**Degree**
Water use (Temporary withdrawal of water from 21 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.
Water quality (Stormwater runoff from road construction)	- Potential increases in turbidity and sedimentation.	**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.
Contaminant release (Incidental spill of petroleum lubricants and fuels from road)	- 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; petroleum lubricants and fuel spills would be cleaned up promptly.
Blasting (Blasting near EFH for construction of the road)	- Degradation of EFH through introduction of pressure and vibration forces that can potentially injure 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.
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.

5.1.3 Natural Gas, Concentrate and Return Water Pipelines, and Fiber Optic Cable

Potential effects to freshwater EFH from construction of the natural gas, concentrate, and return water pipelines (Figure 1-1) 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 the natural gas, concentrate, and return water pipelines and fiber optic cable construction impacts.

Onshore natural gas, concentrate, and return water pipelines and fiber optic cable construction from Diamond Point port to the mine site will occur simultaneously with road construction. Construction of the Ursus Head natural gas pipeline segment from Ursus Cove to Diamond Point will occur in the spring or fall months. Trenching 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:

- Construct Anchor Point compressor station June Y3 – August Y3
- Construct concentrate pipeline terminus May Y3 – September Y3
- Construct concentrate loadout May Y4 – September Y4
- Construct pipelines along road segments November Y1 – September Y2
- Pipelines complete September Y3

5.1.3.1 Loss of Habitat

Construction of the natural gas, concentrate, and return water pipelines between Diamond Point port and the mine site would encounter EFH at 18 stream crossings (Table 5-3) and the natural gas pipeline and fiber optic cable across Ursus Head (Ursus Cove to Cottonwood Bay) would encounter EFH at two stream crossings (Table 5-3). For stream crossings, the natural gas pipeline would be suspended from bridges at 12 of the locations where bridges are planned or installed using trenching or HDD techniques (Table 5-3). Construction would take place November Y1 through September Y2. The following discussion addresses potential loss of habitat for the different pipeline water crossing construction techniques:

- <u>Suspended pipeline beneath bridges.</u> This crossing method would place the pipelines and fiber optic cable above the stream, suspended or secured from 12 bridges; no loss of EFH is expected.
- <u>HDD.</u> This technique would place the pipelines under the streambed. HDD typically results in minimal disruption to riparian vegetation adjacent to the stream, and no disturbance to the streambed. Loss of EFH is not expected.
- <u>Stream trenching.</u> 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 temporarily stored above the creek OHWM. When working adjacent to access roads, the material would be temporarily stored within the abutting 30 ft road construction buffer. The trench would be deep enough to provide the design soil/sediment cover depth required 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.

Trenching activities may result in short-term EFH losses, but this will be limited to the excavation trench areas. The area of substrate disturbance for trenching across streams is expected to result in a disturbance width of 12 ft (3.7 m) per crossing as material extracted would not be stored below the OHWM of streams. The EFH area affected will be minimized by completing the crossing perpendicular to the streams. 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 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, concentrate, and return water pipelines and fiber optic cable could result from the withdrawal of water from 21 local lakes and streams for use during pipeline hydrotesting or construction activities and eventual release back into the environment (Table 5-3). Water withdrawals for construction of the road, natural gas, concentrate, and return water pipelines and fiber optic cable are discussed in Section 5.1.2.4.

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 September 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 return to normal after the activity ceases.

5.1.3.4 Contaminant Release

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

- <u>Hydrostatic testing.</u> 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 little effect 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 5.1.2.7.

5.1.3.6 Summary of Potential Effects to Freshwater EFH for Construction of the Natural Gas, Concentrate, and Return Water Pipelines 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 5-6.

Table 5-6. Summary of potential impacts to freshwater ecosystem EFH for the natural gas, concentrate, and return water pipelines 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.	**Temporary to short-term**	The degree of impact is **low:** - The EFH area affected will be minimized by completing the crossings perpendicular to the streams. - 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)
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 SWPPPs 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	- Hydrostatic testing - Potential spills of petroleum lubricants and fuels in EFH which are toxic to fish.	**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.

Potential Impacts			
Type (Source)	**Description**	**Duration**	**Degree**
petroleum lubricants and fuels)	- Potential temporary increase in turbidity or siltation from frac-out that could negatively impact aquatic life.		- 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 potentially injure 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 study area in Iliamna, Cottonwood, Iniskin Bays and Cook Inlet.

5.2.1 Mine Access Road in Iliamna Bay

Approximately 2.5 mi (4.0 km) of the mine access road, would be constructed on the west side of Iliamna Bay from June Y1 through August Y1. Roughly 1.7 miles (mi) (2.7 kilometers [km]) of the road in Iliamna Bay includes construction in the intertidal zone.

5.2.1.1 Loss of Habitat and Fish Passage

Placement of fill material for construction of the mine access road would affect approximately 26.3 ac (10.6 ha) of marine EFH in the intertidal zone along the west shore of Iliamna Bay. This includes 19.1 ac (7.7 ha) of permanent habitat loss from placement of fill for construction of the access road (i.e., road prism, culverts, pipelines); and 7.2 ac (2.9 ha) of temporary habitat loss for areas abutting fill placement sites that may be affected by construction activities (e.g., ground scarring from equipment operation, dust/sediment deposition) but are expected to recover once the construction activity ceases. Construction activities are estimated between June Y1 and August Y1. Adverse impacts to marine EFH from the introduction of fill material include the loss of habitat function and changes in hydrologic patterns. Aquatic habitats sustain high levels of productivity and support various life stages of fish species and their prey. These habitats are often used for multiple purposes, including spawning, feeding, and supporting growth to maturity. The introduction of fill material eliminates those functions and permanently removes the habitat from production (NMFS 2017).

The intertidal habitat in Iliamna Bay is generally characterized as an outwash plain of gravel/sand mix (mud flat) that is subject to substantial wind waves and swell at higher tides (GeoEngineers 2018b). Eelgrass is the prevalent marine microvegetation extending in a patchy but near-continuous band along the mudflat to the central point of the Bay (Hart Crowser, Inc. 2015). Eelgrass is a highly productive species and is a "foundation" or habitat forming species (NMFS 2014). Eelgrass contributes to ecosystem functions at multiple levels as a primary and secondary producer, as a habitat structuring element, as a substrate for epiphytes and epifauna, and as a sediment stabilizer and nutrient cycling facilitator (Murphy et al. 2000).

Infauna of this mudflat has been sampled both in the late 1970s (Lees et al. 1980) and from 2004 to 2008 (PLP 2012). Based on these reports, the infaunal assemblages were comprised of organisms commonly found within southcentral Alaskan waters. Polychaetes generally dominated in terms of abundance; bivalves (especially *Mya* spp. and *Macoma* spp.), because of their typically larger sizes, shared dominance in biomass with a few larger polychaetes (e.g., *Nephtys* spp.). In more compacted areas, the spoon worm, *Echiurus echiurus* often contributed considerable biomass. At high tide, these areas supported large numbers of crustaceans including crangonid shrimp and mysids. Those crustaceans along with exposed siphon tips of Macoma, provided a substantial prey base for fish, especially starry flounder, *Platichthys stellatus*, that move in with each tide (GeoEngineers 2018a).

Generally, fill placement would take place along the shore. Near the head of Iliamna Bay, the mine access road would bisect approximately 10 ac (4 ha) of intertidal zone. Formation of dikes along the shore or drainage of bisected areas will be prevented through the installation of 5 equalization culverts (Table 5-7). Culvert design includes embedding the culverts 25 percent of the culvert diameter to facilitate fish passage (Figure A-23, Figure A-24). Additional culverts would be installed in the Iliamna Bay portion of the access road to maintain drainage and upland connectivity; however, these culverts are not required for fish passage.

Marine EFH removed from construction of the mine access road would be permanent, but minimal relative to the abundance of similar nearshore habitat in Iliamna Bay. The degree of impact is moderate: the discharge of fill would permanently remove EFH areas used by managed species (rearing and adult Pacific salmon; larval Pacific cod; egg and larval walleye pollock; egg, larval, and adult flatfish species; and forage complex species including surf smelt larvae and adults).

Table 5-7. Marine EFH connectivity equalization culverts.

Stream Crossing ID	EFH Species	Access Road Crossing	Road Crossing Details	Road Crossing Details	Road Crossing Details	Pipeline[1] and Fiber Optic Cable Crossing	Pipeline[1] and Fiber Optic Cable Crossing Type
			Type	Quantity	Culvert Diameter/ Length (ft) (m)		
D1099	Marine EFH species	Yes	Culvert	1	8/120 (2.4/36.6)	Yes	Buried on road embankment
D1100	Marine EFH species	Yes	Culvert	1	8/120 (2.4/36.6)	Yes	Buried on road embankment
D1101	Marine EFH species	Yes	Culvert	1	8/120 (2.4/36.6)	Yes	Buried on road embankment
D1105	Marine EFH species	Yes	Culvert	1	6/130 (1.8/39.6)	Yes	Buried on road embankment
D1106	Marine EFH species	Yes	Culvert	1	6/130 (1.8/39.6)	Yes	Buried on road embankment

1 Pipelines include natural gas pipeline, concentrate pipeline and return water pipeline

5.2.1.2 Noise disturbance

Temporary degradation of habitat due to the introduction of noise from construction activities is not likely. Fill work in the intertidal zone would mostly be completed when water levels are below the work area on which rock is being placed reducing or eliminating the potential for in-water noise generation.

The degree of impact is negligible; the noise disturbance would temporarily affect EFH used by managed species (rearing and adult Pacific salmon; larval Pacific cod; egg and larval walleye pollock; egg, larval, and adult flatfish species; and forage complex species including surf smelt larvae and adults).

5.2.1.3 Water quality

Fill placement activities could result in temporary increases of in-water sediment; however, effects would be minimized by using coarse rock fill materials and timing construction activities to minimize in-water work. Construction would start with the placement of select, free draining, coarse rock fill directly on the sandy material in the intertidal zone to an elevation above high tide line. This fill work can mostly be completed when water levels are below the minimum elevation of the surface on which rock is being placed. Armor rock would be placed as the final embankment elevation of 25 ft (7.6 m) AMSL is achieved. Turbidity increases should be minimal and localized to the immediate vicinity of the fill placement area, dissipating quickly with the movement of the tides.

The degree of impact is negligible; the introduction of sediment from construction activities will temporarily impact marine EFH used by managed species (rearing and adult Pacific salmon; larval Pacific cod; egg and larval walleye pollock; egg, larval, and adult flatfish species; and forage complex species including surf smelt larvae and adults).

5.2.1.4 Contaminant Release

The evaluation of potential effects from invasive species is similar to that of the mine access road sections on freshwater habitats (section 5.1.2.6). The degree of impact is negligible; contamination releases during construction will be minimized by implementing control measures, and will temporarily impact marine EFH used by managed species EFH (rearing and adult Pacific salmon; larval Pacific cod; egg and larval walleye pollock; egg, larval, and adult flatfish species; and forage complex species including surf smelt larvae and adults).

5.2.1.5 Blasting

Blasting at the bedrock cuts (1.2 mi [1.9 km]) along the road alignment out to Diamond Point would all be above the high tide line and would be done to coincide with the low tide cycle when the bay is partially dry (June Y1 through August Y1). Therefore, blasting is not likely to directly affect EFH managed species. 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). Regulatory compliance and collaboration with agency staff will likely result in conditions that require overpressures and particle velocities not to exceed levels that have been shown to cause injury or mortality to salmonids and salmonid embryos and timing activities for when marine EFH managed are least likely to be present. The degree of impact is negligible; blasting will have temporary impacts on EFH used by managed species (rearing and adult Pacific salmon; larval Pacific cod; egg and larval walleye pollock; egg, larval, and adult flatfish species; and forage complex species including surf smelt larvae and adults).

5.2.1.6 Invasive species

The evaluation of potential effects from invasive species is similar to that of the mine access road sections on freshwater habitats (section 5.1.2.8). The degree of impact to marine EFH (rearing and adult Pacific salmon; larval Pacific cod; egg and larval walleye pollock; egg, larval, and adult flatfish species; and forage complex species including surf smelt larvae and adults) is negligible.

5.2.1.7 Summary of Mine Access Road in Iliamna Bay Potential Effects to Marine Ecosystem

Potential effects to marine EFH associated with the mine access road are discussed in sections 5.2.1.1through 5.2.1.6. Potential direct effects include the loss of habitat, in-water noise, changes in water quality, potential releases of contaminants from the placement of fill into waters of the U.S, and introduction of invasive species. A summary of potential impacts to EFH and their assessed degree of severity is included in Table 5-8.

Table 5-8. Summary of potential impacts to marine ecosystem EFH for the mine access road.

Potential Impact			
Impact (Source)	**Description**	**Duration**	**Degree**
Loss of habitat (Discharge of fill associated with construction of mine access road)	- Removal of approx. 19.1 ac (7.7 ha) of nearshore EFH habitat.	- Removed habitat would be **permanent**.	The degree of impact is **moderate:** - Habitat loss is minimal relative to areas that would remain undisturbed in Diamond Point.
Noise disturbance (Vibratory pile-driving)	- Degradation of habitat due to the introduction of noise.	**Temporary**	The degree of impact is **negligible**: - Fill work can mostly be completed when water levels are below the minimum elevation of the surface on which rock is being placed.
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 **negligible**: - Turbidity increases should be minimal and localized to the immediate vicinity of the fill placement area, dissipating quickly with the movement of the tides.
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 Diamond Point and open port design.
Blasting (Blasting near EFH for bedrock cuts as required)	- Degradation of EFH through introduction of pressure and vibration forces that can potentially injure or cause mortality of fish or eggs in spawning gravels.	**Temporary**	The degree of impact is **negligible**: - Blasting would be done above the high tide line and would be done to coincide with the low tide cycle when the bay is partially dry - 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.
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.

5.2.2 *Diamond Point Port*

Potential effects to EFH from construction of the Diamond Point port facilities, including construction and maintenance of the navigation channel and basin (Figure 3-2, Figure A-1, and Figure A-2) 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 5.2.2.6.

Construction schedule for Diamond Point Port includes:

- Williamsport site capture (land by barge) May Y1
- Complete on-shore port site preparation July Y1 – September Y1
- Dredging of entrance channel and turning basin May Y2 – August Y2
- Installation of causeway and barge dock July Y2 – October Y2
- Construction of on-shore port facilities May Y2 – October Y2

5.2.2.1 Loss of Habitat

The proposed construction of Diamond Point port includes placement of fill and dredging in marine EFH for the installation of a caisson supported causeway and marine jetty, construction and maintenance of the navigation channel and basin, and installation of permanent anchors for a lightering station (July Y1 through October Y2).

5.2.2.1.1 Diamond Point Port, Navigation Channel, and Basin

Initial dredging for construction of the Diamond Point port, including the navigation channel and basin (May Y2 through August Y2) would result in 78.8 ac (31.9 ha) of habitat loss (Table 5-9). The majority of the marine port components would be constructed with the initial dredging footprint. Marine components installed below the HWM would result in 3.4 ac (1.4 ha), and 2.8 ac (1.1 ha) of overwater structures (Table 5-9). Dredged channels are prone to sedimentation and the navigation channel and basin (71.4 ac [28.9 ha]) would require maintenance dredging approximately every 5 years (Table 5-9).

Table 5-9. Diamond Point port, channel, and basin permanent habitat impacts.

Activity/Structure	Area
Construction dredging area including, navigation channel, turning basin, and jetty footprint	78.8 ac (31.9 ha)
Port marine components (fill bellow the HWM)	3.4 ac (1.4 ha)
Port marine components (over-water structures)	2.8 ac (1.1 ha)
Maintenance dredging of the navigation channel and basin (every 5 years)	71.4 ac (28.9 ha)

Adverse impacts to EFH from the introduction of fill material and dredging include the loss of habitat function and changes in hydrologic patterns. Overwater structures can affect EFH via changes in ambient light conditions, and alterations of the wave and current energy regimes.

Habitat loss from construction of the port, including dredging, would result in the physical removal of sand/fine nearshore subtidal habitat, including sparsely vegetated eelgrass areas. Benthic communities would endure the longest lasting effects from sea floor removal. Recovery rates of macrobenthic communities are known to range from several months for estuarine muds, to up to two or three years for sands and gravels (NMFS 2017). However, recovery rates are highly dependent on site-specific conditions and it cannot be assumed that the dredged navigation channel would undergo a total recovery between dredging events. Furthermore, although macrobenthic communities may recover total abundance and biomass within a few month or years, their taxonomic composition and species diversity may remain different from pre-dredging to post-dredging for more than three to five years (Blanchard and Feder 2003, Michel et al. 2013). Therefore, forage resources for benthic feeders within the dredge areas may range from substantially reduced to none.

Many managed fish species forage on infaunal and bottom-dwelling organisms and would be adversely affected by the loss of foraging habitat from dredging activities. Managed species use of this area was documented by various PLP studies. Marine fish and invertebrates were sampled in the Iliamna and Iniskin bay estuaries (2004 to 2008, and 2010 to 2012) and in Cottonwood Bay and Ursus and Rocky coves (2010 to 2012) by beach seining, otter trawling, and gill or trammel netting in two different time periods to establish baseline conditions and temporal variations in species composition and abundance in the marine habitat (PLP 2012, Hart Crowser, Inc. 2015). The use of multiple sampling gears provided a better coverage of several habitat types, potential spawning area, nursery areas, species distribution, and use in and outside of embayment in marine and estuarine environments.

Forty-one fish species were captured by beach seine in nearshore sandy/cobble habitats in the Iliamna and Iniskin bay estuaries; however, not all species were captured at all stations and months. Overall, Pacific herring, juvenile pink salmon, juvenile chum salmon, and forage fish species such as surf smelt and Pacific sand lance were the most common EFH species captured in beach seines (Table 4-15). The presence of both juvenile and larger salmonids indicated that species use the nearshore locations as migration corridors between marine and freshwater environments. Catch of larval surf smelt suggested drift of these larvae from other locations. The fishes captured in otter trawl represented fauna of open water and deeper waters than represented by seine (PLP 2012). A total of 45 species were captured, dominated by snake prickleback, yellowfin sole, starry flounder, Pacific herring, and walleye pollock. Trawl catch rates were highest from 2004-2012 in the Iliamna and Iniskin bay estuaries, followed by Ursus Cove (PLP 2012, Hart Crowser, Inc. 2015); catch rates in 2018 were much lower across all sampling locations (GeoEngineers 2018a) (Table 4-16). In gill nets, Pacific herring (multiple-year classes) dominated the catch in both sampling periods. Trammel nets mostly captured starry flounder (PLP 2012) (Table 4-15).

The capture of young Pacific herring and salmonids suggests that these species use areas of the Iliamna and Iniskin bay estuaries and Ursus Cove for rearing. The Pacific herring supported a strong commercial fishery for roe until 1998; it was closed for fishing in 1999 due to low abundance, and biomass of Pacific herring has since not improved to historical levels (ADF&G 2016). Herring spawning was observed in the Iliamna and Iniskin bay estuaries during surveys conducted in 2008, 2010-2012, and 2018 (Hart Crowser, Inc. 2015, GeoEngineers 2018a). Spawning consistently occurred from late May through mid-June. Herring spawning was observed along approximately 5.5 miles of shoreline and reef habitat within the Iliamna and Iniskin bay estuaries. Little to no spawning was observed in Iliamna or Cottonwood bays.

Construction of marinas and ports have the potential to cause alterations in hydrologic patterns, including wave and current energy regimes from fill and overwater structures, can impact the nearshore detrital food web by altering the size, distribution, and abundance of substrate and detrital materials (Limpinsel et al. 2017). Combined, these changes can alter natural processes that build spits and beaches and provide substrates required for plant propagation, fish and shellfish settlement and rearing, and forage fish spawning (Limpinsel et al. 2017). The caisson design of the Diamond Point port would allow for nearly unimpeded flow of water between the caissons, resulting in little change of existing hydrologic patterns.

Shading caused by overwater structures can affect plant, macrobenthic, and fish communities below. Distributions can be limited in under-dock environments when compared to adjacent, unshaded habitats (NMFS 2017). The size, shape, and intensity of the shadow cast by a structure depends upon its height, width, construction materials, and orientation (NMFS 2017). However, effects from shading and changes in hydrologic patterns may be offset by the creation of fish habitat and cover from overwater structures and supporting caissons, particularly for nearshore rockfish species.

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

5.2.2.1.2 Lightering Station

PLP has proposed one lightering station in Iniskin Bay which includes a spread anchor mooring system consisting of six floating mooring buoys attached to permanent anchors set on the seabed. The proposed mooring structure includes a 2,300 ft x 1,700 ft (700 m x 520 m) spread anchor mooring system in approximately 50 ft to 70 ft (15.2 m to 21.4 m) of water, consisting of 10 anchors and 6 mooring buoys. Placement of the anchors would result in approximately <0.1 ac (<0.1 ha) of fill.

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 0.2 ac (0.1 ha) habitat similar to a reef type. 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 Iniskin 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, GOA skates, and octopus; juvenile and adult sablefish, sculpin, and rockfish species; all life stages of flatfish species and walleye pollock; and forage complex species including surf smelt larvae and adults) during construction, but EFH characteristics would 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 organisms creating new habitat.

5.2.2.2 Noise Disturbance

Construction (July Y1 – October Y2) activities would introduce in-water noise that could affect EFH. Noise generating activities and sources include installation of caissons and operation of heavy equipment, including vessels. 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.

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

5.2.2.3 Water Quality

Initial dredging for construction of the Diamond Point port (May Y2 – August Y2), including the navigation channel and basin, could result in increased sedimentation to surrounding marine habitats. 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 port surfaces 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.

Dredging would be accomplished using a cutterhead dredge. Cutterhead dredges use suction to entrain sediment for pumping through a pipeline to a designated discharge site. Production rates vary greatly based on pump capacities and the type (size and rotational speed) of cutter used, as well as distance between the cutterhead and the substrate. Sediments are re-suspended during lateral swinging of the cutterhead as the dredge progresses forward. USACE (1983) modeling results of cutterhead dredging indicated that sediment concentrations above background levels would be present throughout the bottom six feet (1.8 m) of the water column for approximately 1,000 feet (305 meters) (NMFS 2017). Burton (1993), and Wilber and Clarke (2001), determined that in-water TSS levels expected for cutterhead dredging, which could be as high as 550.0 mg/L, are below those shown to have adverse effect on fish (typically up to 1,000.0 mg/L; (NMFS 2017). TSS levels are shown to have adverse effects on benthic communities when they exceed 390.0 mg/L (USEPA 1986). Increased TSS could reduce the light intensity that reaches photosynthetic organism (e.g., eelgrass) as well.

The increased short-term turbidity from material excavation is likely to be negligible and quickly disperse, given the location of the Project area, when existing conditions are characterized by significant turbulence and mixing due to tidal swings and resulting currents. Large tidal swings that can exceed 24.5

ft (7.5 m) and current velocities up to 9.5 ft/sec (3.0 m/sec) (PLP 2011) would dilute the concentration, thereby decreasing the potential area of impact.

Consequences of in-water work and modification of land-based areas could release sediments into marine habitats. Drainage from stockpiles of dredged material could be discharged to marine waters after capture and treatment (Section 5.2.2.3). Quarried fill material will be placed directly into the caissons minimizing the release of sediments into the environment. Construction operations at Diamond Point port should result in some suspension of sediments, with the majority resettling close to the site. As mentioned in the paragraph above, tidal action and current would quickly dissipate suspended sediments. 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 Diamond Point 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, GOA skates, and octopus; juvenile and adult sablefish, sculpin, and rockfish species; all life stages of flatfish species and walleye pollock; and forage complex species including surf smelt larvae and adults) but EFH characteristics would return to normal after the activity ceases.

5.2.2.4 Contaminant Release

Port construction (May Y2 – October 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 (Michel et al. 2013, Limpinsel et al. 2017).

The release of water resulting from the consolidation of dredged sediment may temporarily increase suspended sediment concentration, thus elevating turbidity in the receiving waterbody (Iliamna Bay). However, by discharging the water through settling ponds or other controls prior to the water entering Iliamna Bay, remaining sediment in the water will be allowed to settle out of suspension, thereby eliminating listed species exposure to elevated concentrations of suspended sediment.

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 Diamond Point 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, GOA skates, and octopus; juvenile and adult sablefish, sculpin, and rockfish species; all life stages of flatfish species and walleye pollock; and forage complex species including surf smelt larvae and adults) from contaminant releases during construction are expected to be negligible.

5.2.2.5 Invasive Species

The introduction of nonnative organisms from construction operations (May Y2 – October 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.

5.2.2.6 Summary of Diamond Point Port Potential Effects to Marine Ecosystem EFH

Potential effects to marine ecosystem EFH associated with the Diamond Point port are discussed in sections 5.2.2.1 through 5.2.2.5. 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 5-10. Summary of potential impacts to marine ecosystem EFH for the Diamond Point port and mooring sites.

Potential Impact			
Impact (Source)	**Description**	**Duration**	**Degree**
Loss of habitat (Discharge of fill associated with construction of the Diamond Point Port)	- Removal of approx. 2.1 ac (0.1 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 Iliamna Bay. - 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 (Spread anchor mooring systems)	- 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 Iniskin 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.
Noise disturbance (Vibratory pile-driving)	- Degradation of habitat due to the introduction of noise.	**Temporary**	The degree of impact is **low**: - EFH conditions would return to normal shortly after the noise generating activity ceases.
Water quality (Changes in water quality due to increased 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 Diamond Point and port open design.

Potential Impact			
Impact (Source)	**Description**	**Duration**	**Degree**
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 Diamond Point and port open design.
Invasive species (Movement of construction barges from the U.S. West Coast)	- 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.

5.2.3 Natural Gas Pipeline and Fiber Optic Cable

Potential effects to EFH from construction of the natural gas pipeline and fiber optic cable in marine ecosystem EFH (Figure 3-8) are discussed below are organized by: loss of habitat, noise disturbance, water quality, and contaminant release. A summary of impacts is included in Section 5.2.3.5.

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

5.2.3.1 Loss of Habitat

PLP estimated that approximately 569 ac (230.3 ha) of marine substrate would be temporarily disturbed from trenching activities between Anchor Point and Ursus Cove. Additionally, 69.1 ac (28 ha) of marine substrate would be disturbed within the intertidal zone in the head of Cottonwood Bay. This does not include potential seabed disturbance from anchor placement. Anchor placement can scar the substrate 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 proposed pipeline burial and vessel anchoring actions can change EFH by altering substrates used for feeding or shelter of EFH species. Trenching and side cast of materials, 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. 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. Shallow-water environments, rocky reefs, nearshore and offshore rises, are more likely to be adversely impacted than open-water habitats due to their higher sustained biomass (Gowen 1978, in NMFS 2017). The majority of substrate that would be traversed by the pipeline route includes ripples, waves, dunes, complex and compound bedforms, and scour, which are indicative of dynamic and constantly changing substrate across Cook Inlet. Substrate footprint scars within dynamic substrate areas expected to recover quickly as biomass is likely lower and organisms are also likely adapted to the constant rearrangement of the substrate. EFH recovery in these areas should be relatively quick ranging from days to weeks. Submerged boulder areas or isolated rocks and rock outcrop areas could include greater biomass than sandy dynamic areas, making for a longer recovery time ranging from months to years.

Adult Cook Inlet resident EFH species are expected to avoid the altered habitats while construction lasts, but would return once the activity ceases, and recolonize habitats as recovery occurs. Approximately 132 ac (53.2 ha) of weathervane scallop EFH (late juvenile and mature) 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. The construction of the natural gas pipeline would avoid the fished scallop beds (Figure 4-21) in Cook Inlet (Gustafson and Goldman 2012).

Habitat losses resulting from pipeline installation would range from temporary to short-term and would be minimal within the extent of EFH in lower Cook Inlet unaffected by this activity. 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; larval, juvenile, and adult Pacific cod, rockfish species, and sablefish; forage complex species; and weathervane scallop), but EFH characteristics would likely return to normal after the activity ceases, and habitat would be altered with minimal functional changes.

5.2.3.2 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. Scallops may close their shells temporarily or relocate short distances. 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; larval, juvenile, and adult Pacific cod, rockfish species, and sablefish; forage complex species; and weathervane scallop), but EFH characteristics would return to normal after the activity ceases.

5.2.3.3 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 construction areas.

Consequences of the action on suspended sediments would vary based on site-specific conditions (e.g., bathymetry, currents, tides), material (e.g., sand versus silt), and sources (e.g., dredge type). NMFS (2017) reviewed estimates of impacts due to turbidity from mechanical dredging, cutterhead dredging, and jet plow technology. According to this review, total suspended solids (TSS) as a measure of turbidity for mechanical dredging, independent of bucket type or size, can expect elevated suspended sediment concentrations at several hundreds of milligrams per liter (mg/L) above the background in the immediate vicinity of the bucket but would settle rapidly within a 2,000 ft (610 m) radius of the dredge location (NMFS 2017). Cutterhead dredges use suction to entrain sediment that is then pumped through a pipeline to a designated discharge site. Production rates vary greatly based on pump capacities and the type (size and rotational speed) of cutter used, as well as distance between the cutterhead and the substrate. Sediments are re-suspended during lateral swinging of the cutterhead as the dredge progresses forward. Based on NMFS (2017) review, elevated suspended sediment levels are expected to be present only within a 1,000-ft (305-m) radius of the of the cutterhead dredge (NMFS 2017). TSS concentrations associated with cutterhead dredge sediment plumes typically range from 11.5 to 282.0 mg/L with the highest levels detected adjacent to the cutterhead dredge and concentrations decreasing with greater distance from the dredge (Nightingale and Simenstad 2001). Jet plow technology has been shown to minimize impacts to marine habitat caused by excessive dispersion of bottom sediments, but some increased turbidity and resuspension of sediments can be expected. Based on the Applied Science Associates, Inc. model used by the ESS Group, Inc. (2008) (as cited in NMFS 2017), the maximum suspended sediment concentration at 65 ft (20 m) from the jet plow is 235.0 mg/L, with concentrations decreasing to 43.0 mg/L within 656 ft (200 m) from the plow (NMFS 2017). In almost all cases, the majority of re-suspended sediments resettle close to the dredge area within 1 hour, although very fine particles could settle during slack tides only to be re-suspended by ensuing peak ebb or flood currents (Anchor Environmental 2003).

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, closing their shells or relocating short distances. The deposition of sediments can smother fish and scallop 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; larval, juvenile, and adult Pacific cod, rockfish species, and sablefish; forage complex species; and weathervane scallop), but EFH characteristics would return to normal after the activity ceases.

5.2.3.4 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; larval, 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.

5.2.3.5 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 5.2.3.1 through 5.2.3.4. 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 5-11. 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. 569 ac (230.3 ha) in Cook Inlet and 69.1 ac (28 ha) in Cottonwood Bay of habitat alteration from pipeline burial. - Anchor scars and cable sweep area.	**Temporary to short-term**	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.
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 sessile species would avoid construction areas, followed by rapid post-construction return or re-colonization by these species. - Sedentary managed species, such as scallops, may close their shells or relocate short distances. - 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 Mine Site Construction

- 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.
- Effects of sedimentation on fish habitat will be minimized through implementation of required stormwater management plans and BMPs.

6.2 Road Building and Maintenance

- Where reasonable, bridges rather than culverts were proposed for stream crossings.
- Bridge abutments will be designed to minimize disturbances to stream banks and placed outside of the floodplain whenever possible.
- Culverts will be sized, constructed, and maintained to match the gradient and width of the stream, accommodate design flood flows, and provide for migratory passage of adult and juvenile fishes. Culvert design will use the culvert guidelines contained in the USFWS Culvert Design Guidelines for Ecological Function (USFWS 2020).
- 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 where 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 maintained as required by stormwater management plans and design requirements.
- Blasting for road construction in Iliamna Bay will be done during low tides.

6.3 Material Sites

- Material 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 parameters 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.
- Only select fill with minimal fines will be used for construction of the road in Iliamna Bay.

6.6 Dredging Operations

- The navigation channel area and volume of material to be dredged was reduced to the maximum extent practicable.
- Sediments will be tested for contaminants as per EPA and USACE requirements prior to dredging.
- Dredged sediment disposal site will be on land.
- Beneficial uses of dredged material will be considered (e.g., caisson fill).
- The on-land sediment disposal sites will be properly managed to minimize impacts associated with dredged material, including construction of berms, and settling ponds to manage runoff.
- Sediment disposal sites will be acquired for the entire project life and maintained as needed to support maintenance dredging.

6.7 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, and nonpoint source contaminants from upland facilities related to vessel operations and navigation.
- 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 Diamond Point Port 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.

6.8 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 to reduce sound generated by pile driving (CADoT 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, piles are first driven as deep as possible with a vibratory hammer and then with the impact hammer to drive the pile to its final position.

Implement measures to attenuate the sound from impact hammering if expected sound 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:

- Use a smaller hammer to reduce sound pressure (the sound produced has a direct relationship to the force used to drive the pile).
- 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.

6.9 Pipeline Installation

- Use HDD for the shore transition at Anchor Point where there is a steep erodible bluff adjacent to the intertidal zone.
- Backfill excavated wetlands 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.

- Bury the 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.
- Attach pipelines to constructed bridges at stream crossings.

6.10 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.

6.11 Compensatory Mitigation Plan

PLP has prepared a Draft Compensatory Mitigation Plan (CMP) to fulfill the requirements established by the U.S. Army Corps of Engineers (USACE) regulations (33 CFR 320.4(r) and 40 CFR 230).

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, water use, and including pile driving. No impact, or negligible effect, to EFH is anticipated from contaminant release resulting from potential spills of petroleum oil and lubricants, water temperature changes, introduction of contaminants, material source development, noise, 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	Impact Type	Degree of Impact	Duration			
			Temporary	Short-term	Long-Term	Permanent
FRESHWATER ECOSYSTEM						
Mine Site	Loss of habitat	Moderate	--	--	--	✓
	Blasting	Low	✓	--	--	--
	Water flow	Negligible	✓	--	--	--
	Water temperature	Negligible	✓	--	--	--
	Water quality	Negligible	✓	--	--	--
	Contaminant release	Negligible	--	--	--	--
Transportation Corridor	Fish passage and habitat loss	Low	✓	✓	--	--
	Pile driving	Low	✓	--	--	--
	Material source development	Negligible	--	--	--	--
	Water use	Low	✓	--	--	--
	Water quality	Low	✓	--	--	--
	Contaminant release	Negligible	--	--	--	--
	Blasting	Low	✓	--	--	--
	Invasive species	Negligible	--	--	--	--
Concentrate, Return Water, and Natural Gas Pipelines and Fiber Optic Cable	Loss of habitat	Low	✓	✓	--	--
	Water use	Low	✓	--	--	--
	Water quality	Low	✓	--	--	--
	Contaminant release	Negligible	--	--	--	--
	Blasting	Low	✓	--	--	--
MARINE ECOSYSTEM						
Mine Access Road in Iliamna Bay	Loss of habitat and fish passage	Moderate	--	--	--	✓
	Noise disturbance	Negligible	✓	--	--	--
	Water quality	Negligible	✓	--	--	--

Project Component	Impact Type	Degree of Impact	Duration			
			Temporary	Short-term	Long-Term	Permanent
	Contaminant release	Negligible	--	--	--	--
	Blasting	Negligible	✓	--	--	--
	Invasive species	Negligible	--	--	--	--
Diamond Point Port	Loss of habitat (Diamond Point 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 and Diamond Point port and dredging for the Diamond Point port navigation channel and basin would result in permanent removal of EFH. The only effects that rise to the level of moderate are to a small quantity of EFH used by low densities of Pacific salmon in NFK River where alternative higher use habitats are readily available, and the small quantities of marine EFH removed from construction of the mine access road in Iliamna Bay. This loss of EFH is minimal relative to the area that would remain undisturbed. Furthermore, habitat removed is generally of lower habitat value and documented as low use habitat by EFH species. 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**.

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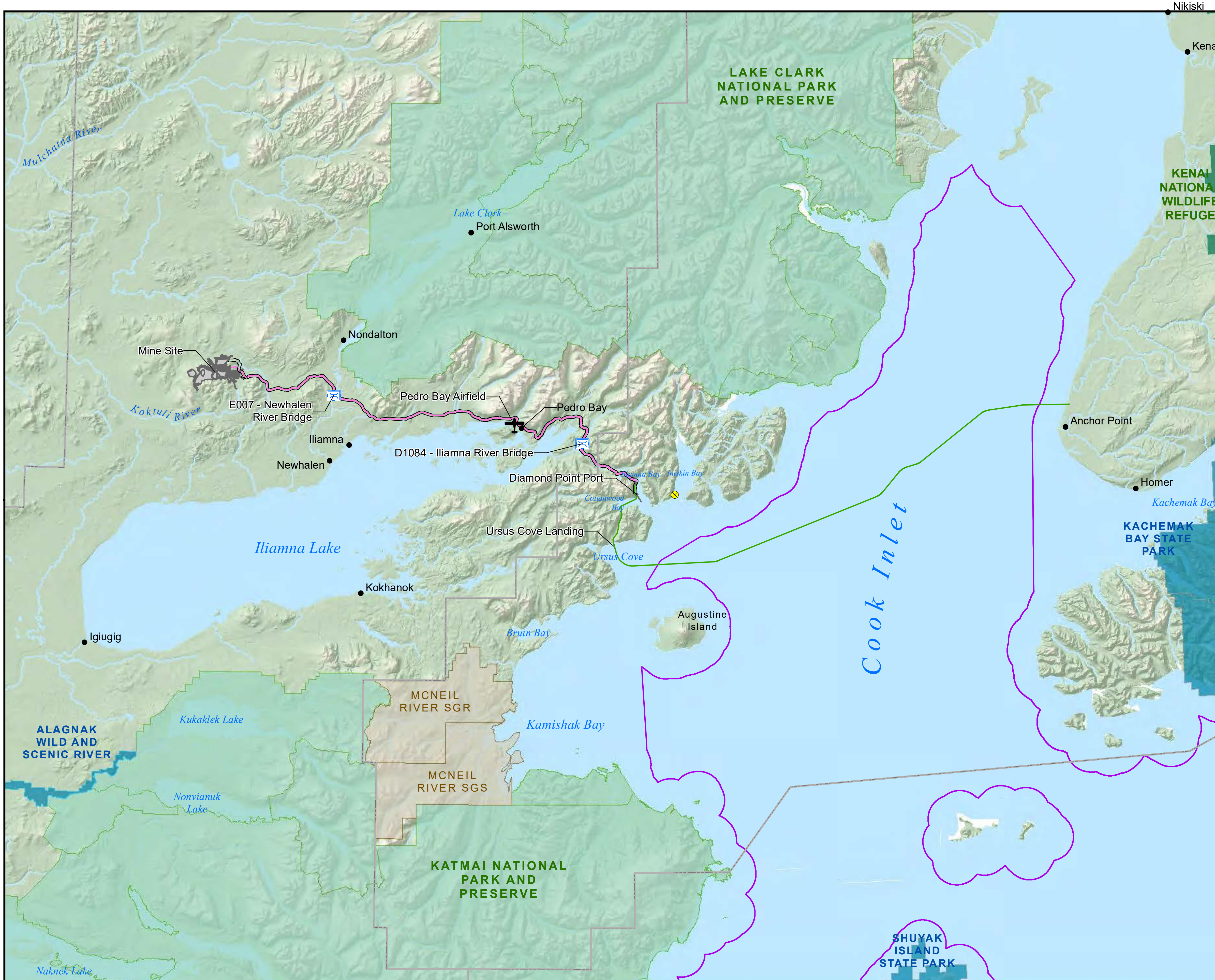
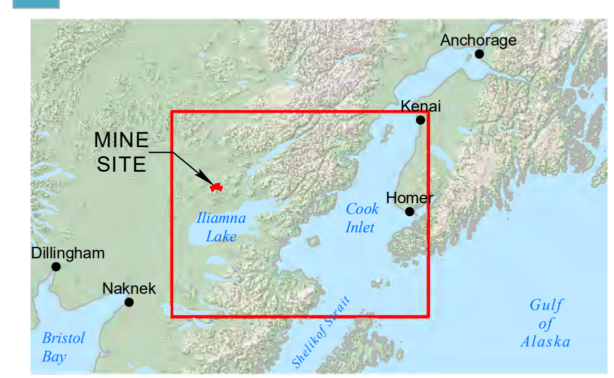
FIGURES



THE pebble PARTNERSHIP

- Lightering Station
- Bridge
- Pedro Bay Airstrip (Existing)
- Access Road
- Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)
- NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
- Mine Site
- Diamond Point Port
- Borough Boundary
- State Seaward Boundary
- National Park
- National Wildlife Refuge
- Alaska State Park
- Wild and Scenic River
- State Game Refuge/Sanctuary



Miles

0 10 20 30 40

Scale 1:900,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
1-1

Project Location

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_011	Date: 5/28/2020
Revision: 01	Author: ORNRC

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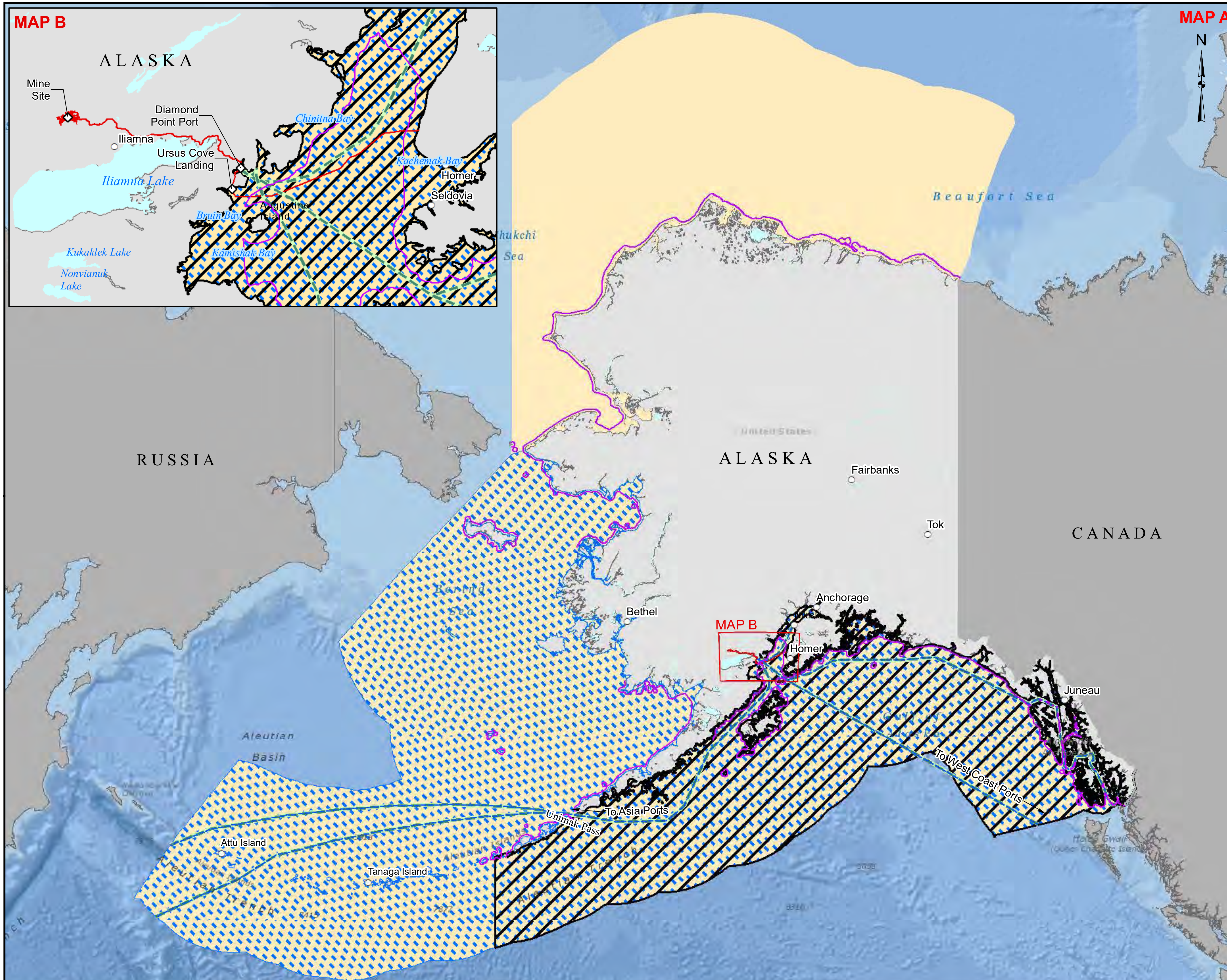


THE pebble PARTNERSHIP

◇ Project Feature
Maritime Traffic
Project Components

Fisheries Management Plan

Groundfish FMP
Scallop FMP
Salmon FMP

Reference

State Seaward Boundary

Miles
0 200 400 600 800
Scale1:27,000,000

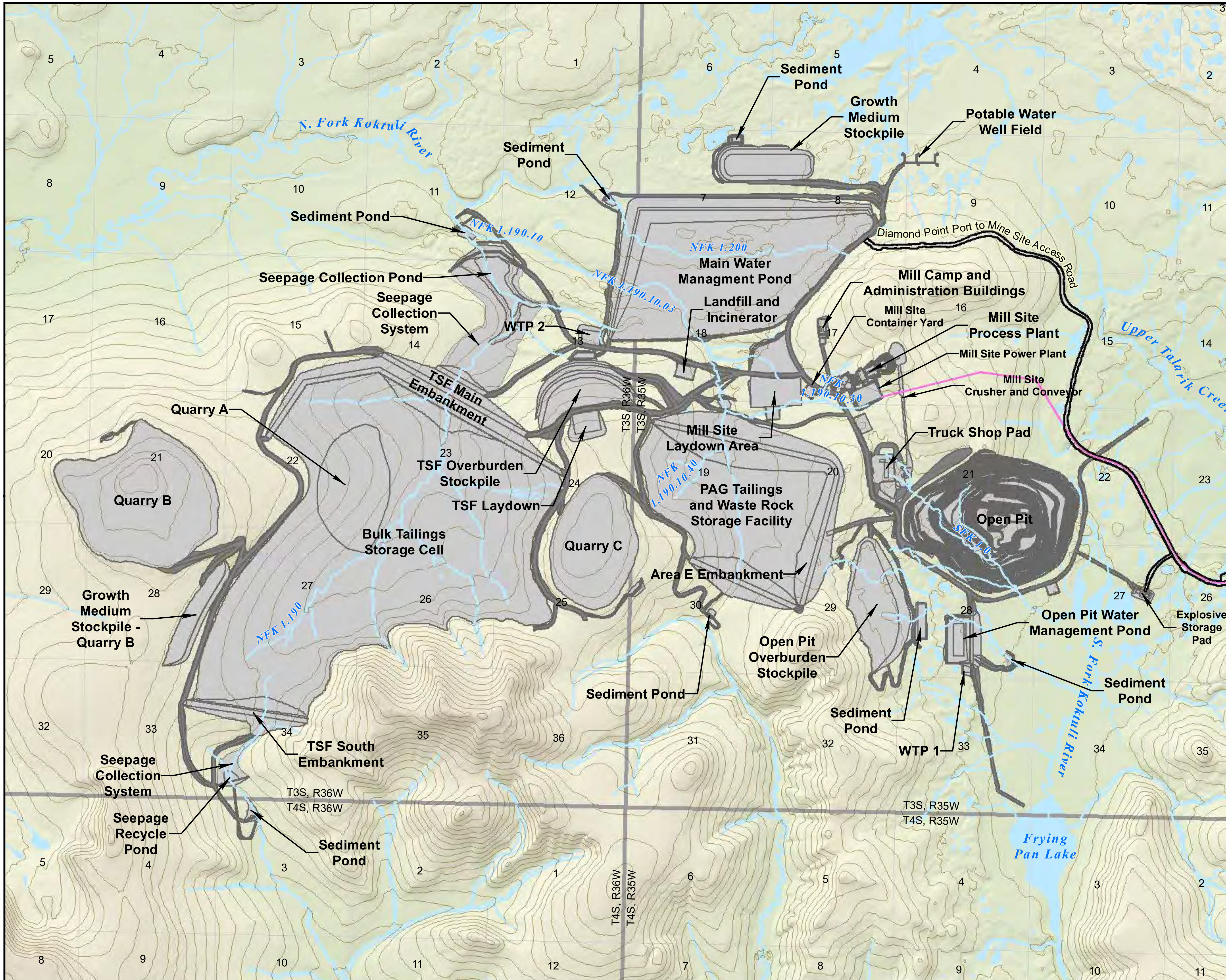
WGS 1984 Web Mercator Auxiliary Seward Meridian

Figure: **1-2**

Fisheries Management Plans

Essential Fish Habitat Assessment

File: PLPEFH_036	Date: 6/4/2020
Revision: 00	Author: ORNRC



THE pebble PARTNERSHIP

Access Road

NGP, FOC, Concentrate Pipeline, and Return Water Pipeline

Mine Site Haul/Service Road

Mine Site

80' Contour (Existing)

Section Boundary

Township Boundary

Miles

0 0.55 1.1 1.65 2.2

Scale 1:46,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
3-1

Mine Site

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_009

Date: 5/27/2020

Revision: 00

Author: ORNRC

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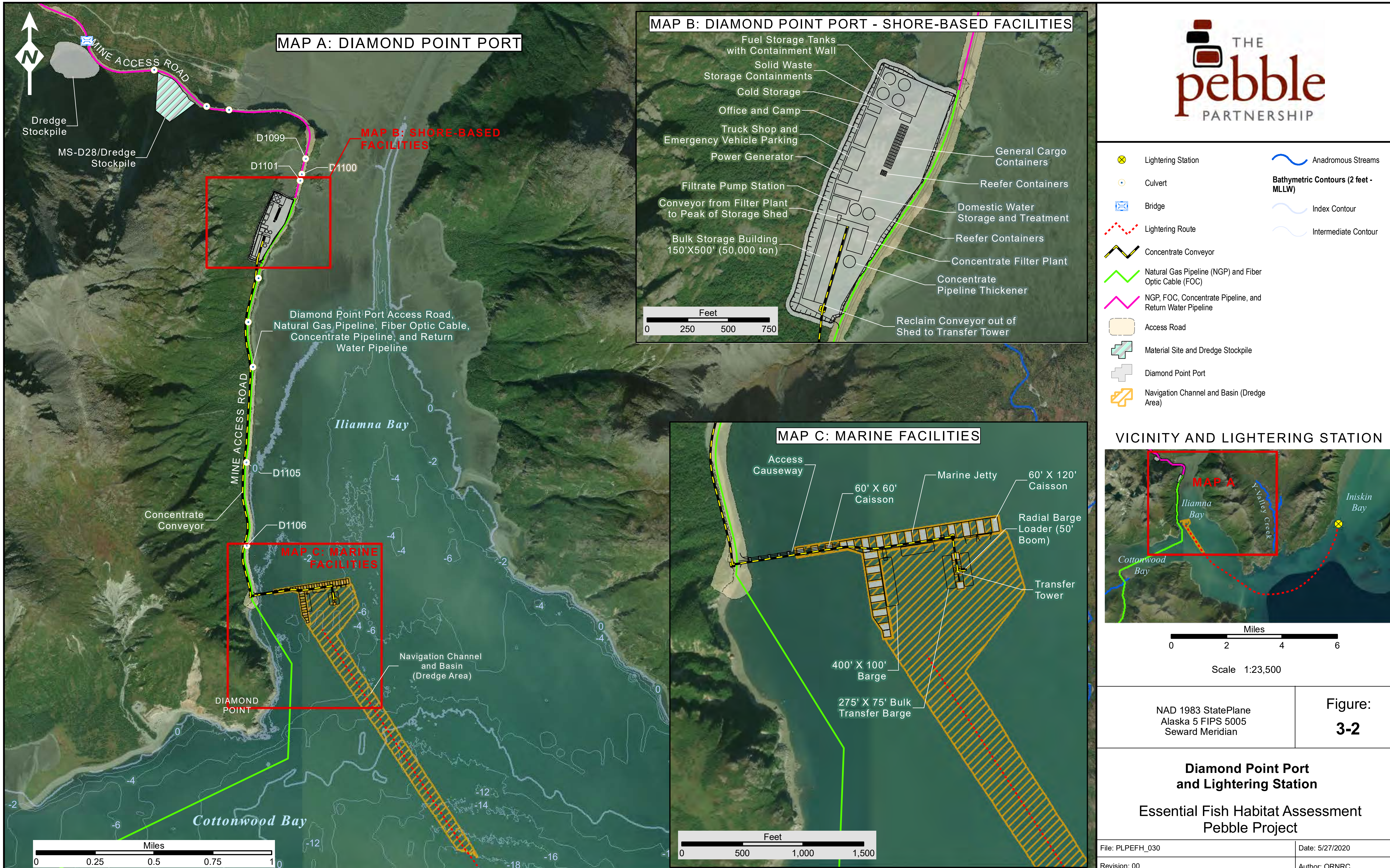

Figure: 3-2

Diamond Point Port and Lightering Station

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_030 | Date: 5/27/2020
Revision: 00 | Author: ORNRC

THE pebble PARTNERSHIP

- Lightering Station
- Culvert
- Bridge
- Stream Crossing
- Access Road
- Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)
- NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
- Mine Site
- Diamond Point Port
- State Seaward Boundary

Miles
0 5 10 15 20

Scale 1:400,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
3-3

Transportation Corridor

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_010	Date: 5/28/2020
Revision: 01	Author: ORNRC

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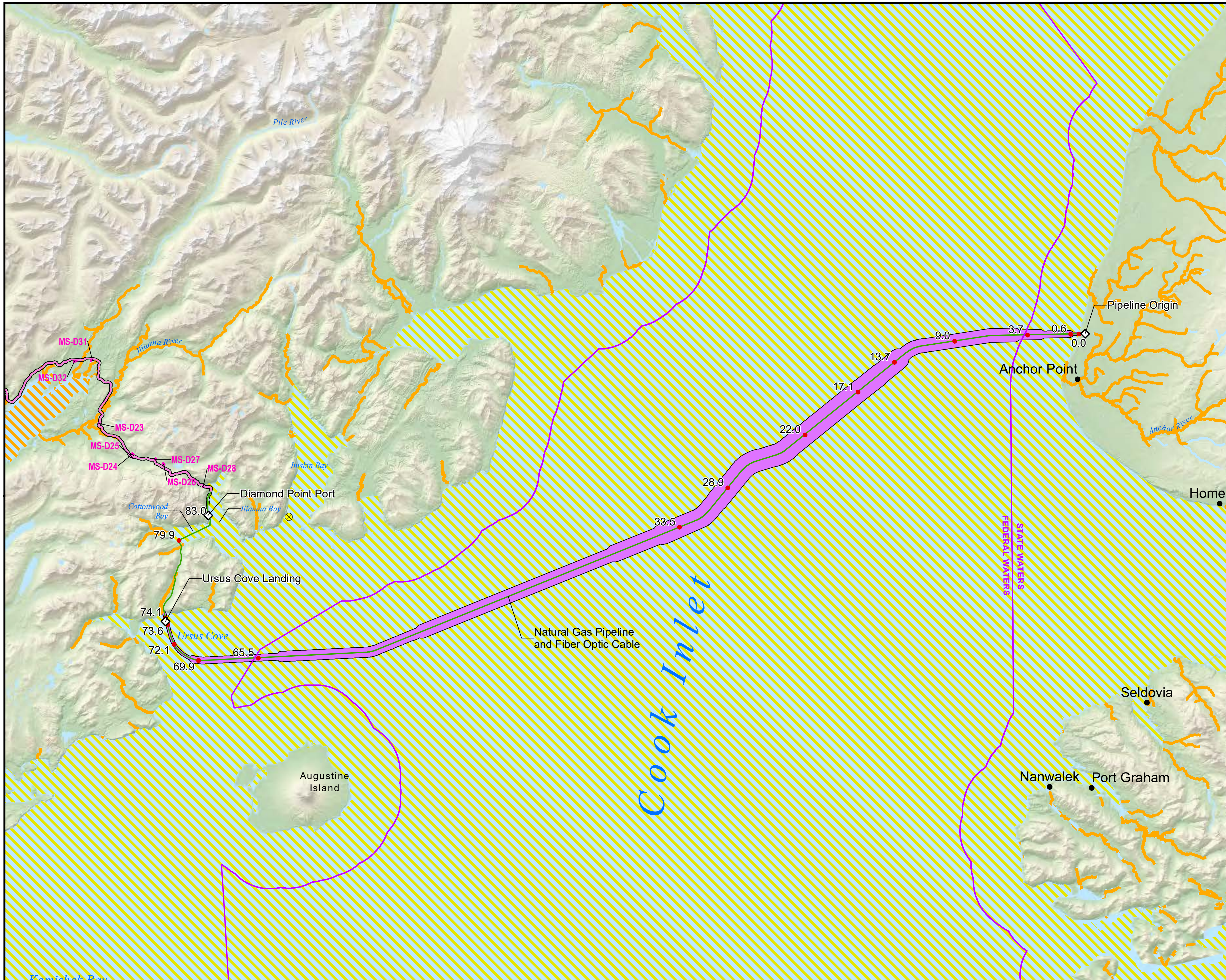

THE pebble PARTNERSHIP

FMP EFH

Salmon FMP EFH Freshwater Streams (AWC and PLP)

Salmon FMP EFH Freshwater Lakes

Groundfish and Salmon FMP EFH

Project Components

Project Feature

Lightering Station

Trench Burial Mode Limits (miles)
(See Table 3-1 and Figure 3-8)

Access Road

Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)

NGP, FOC, Concentrate Pipeline, and Return Water Pipeline

Material Site

Sea Anchor Placement

Miles
0 5 10 15 20

Scale 1:450,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
3-4

EFH - Natural Gas Pipeline and Fiber Optic Cable Trenching Requirements

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_012	Date: 5/27/2020
Revision: 00	Author: ORNRC

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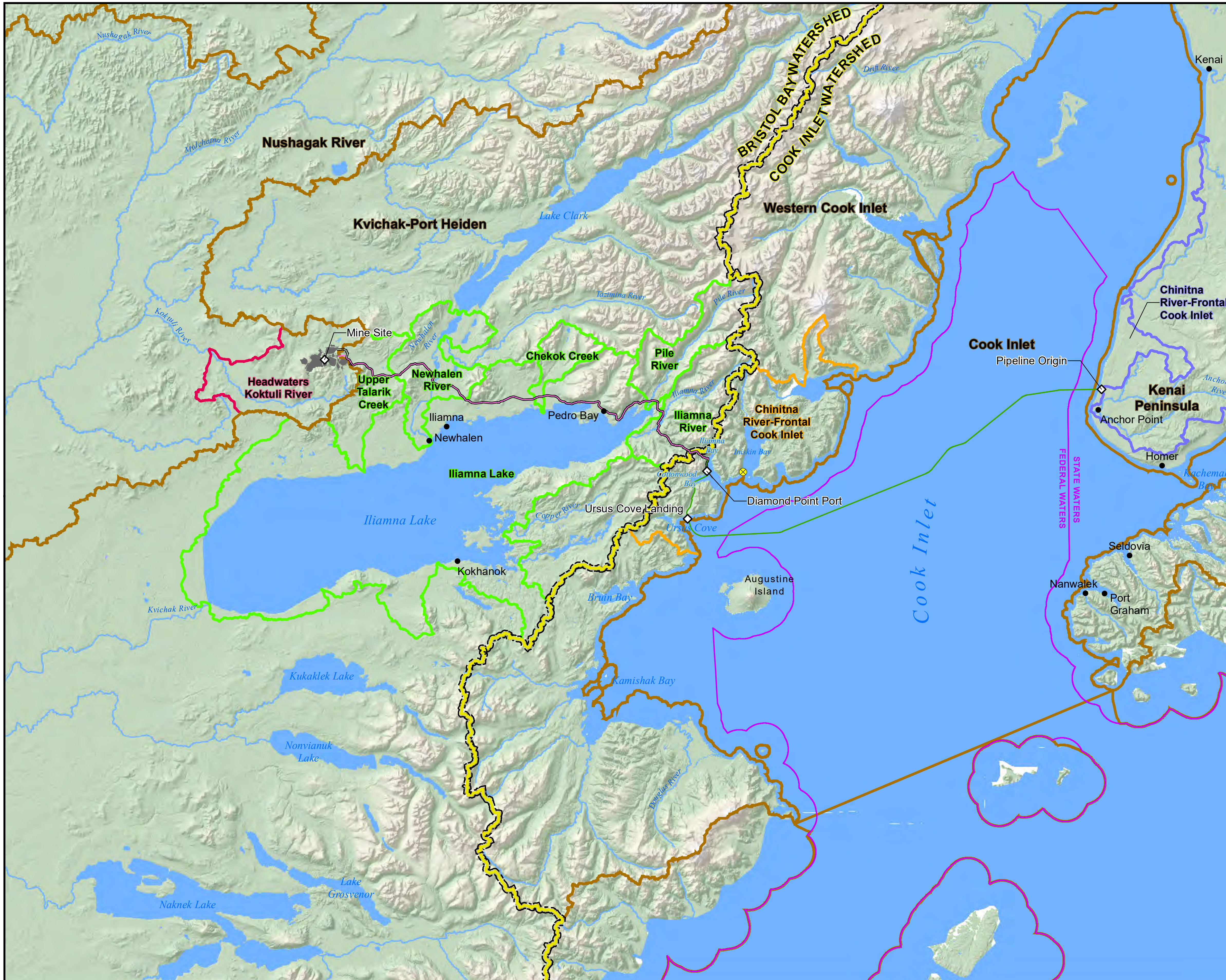


THE pebble PARTNERSHIP

Project Components

- Project Feature
- Lightering Station
- Access Road
- Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)
- NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
- Mine Site

Reference

- State Seaward Boundary

Hydrologic Unit Hierarchy (HUC)

- HUC 4
- HUC 6
- HUC 10 (Drainage to Bristol Bay)
- HUC 10 (Drainage to Bristol Bay)
- HUC 10 (Drainage to Cook Inlet)
- HUC 10 (Drainage to Cook Inlet)

Miles

0 10 20 30 40

Scale 1:1,000,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

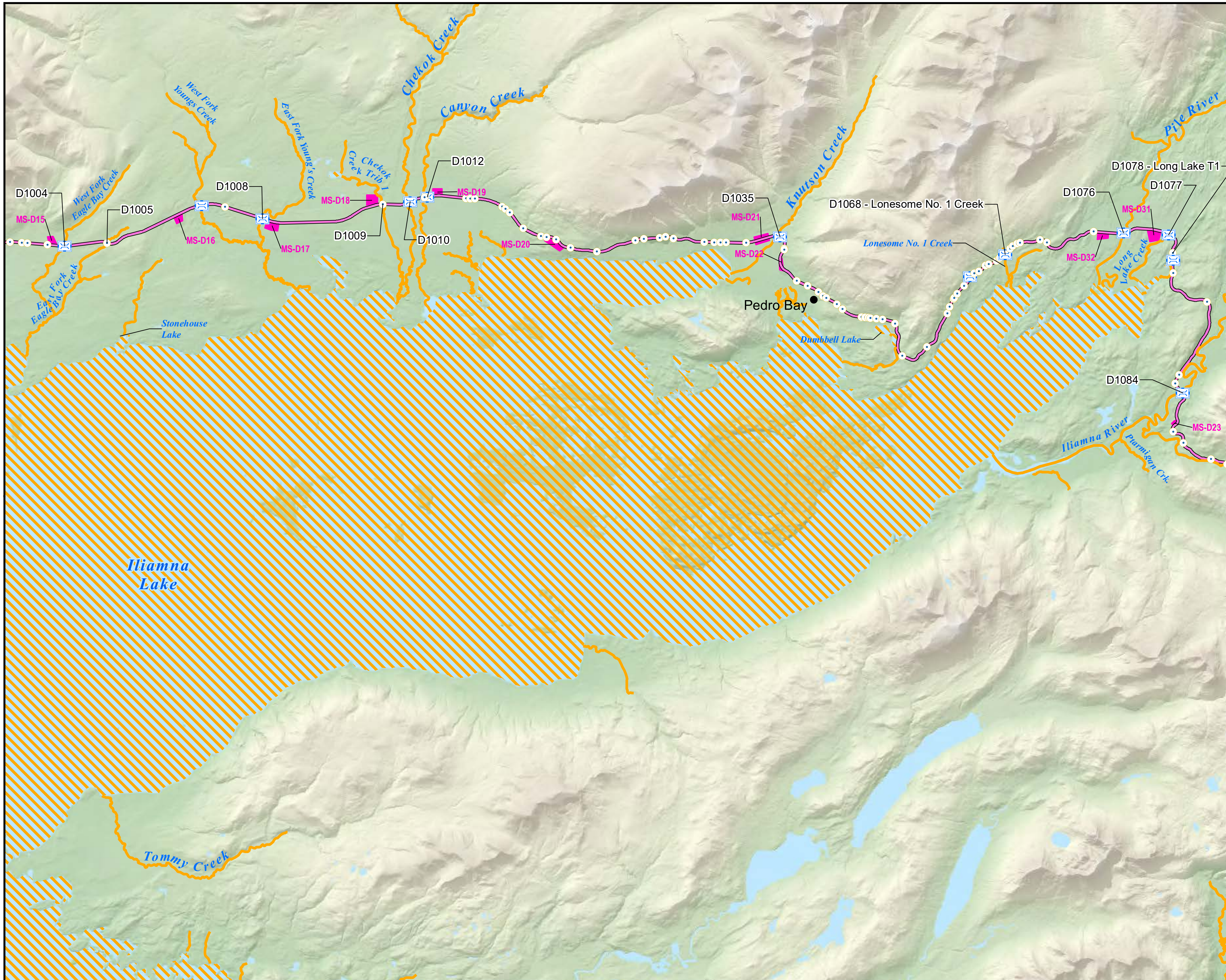
Figure: 3-5

EFH - Proposed Action in Watersheds

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_001	Date: 6/3/2020
Revision: 02	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_001.mxd



THE pebble PARTNERSHIP

Salmon FMP EFH

Freshwater Streams (AWC and PLP)

Freshwater Lakes

Project Components

Access Road

NGP, FOC, Concentrate Pipeline, and Return Water Pipeline

Material Site

Culvert

Bridge

Miles

0 1.5 3 4.5 6

Scale 1:150,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
3-6

EFH - East Transportation Corridor

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_003	Date: 5/28/2020
Revision: 01	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_003.mxd

THE pebble PARTNERSHIP

Salmon FMP EFH

Freshwater Streams (AWC and PLP)

Freshwater Lakes

Project Components

Access Road

NGP, FOC, Concentrate Pipeline, and Return Water Pipeline

Mine Site

Material Site

Culvert

Bridge

Flow Station (Existing)

Miles

0 2 4 6 8

Scale 1:175,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

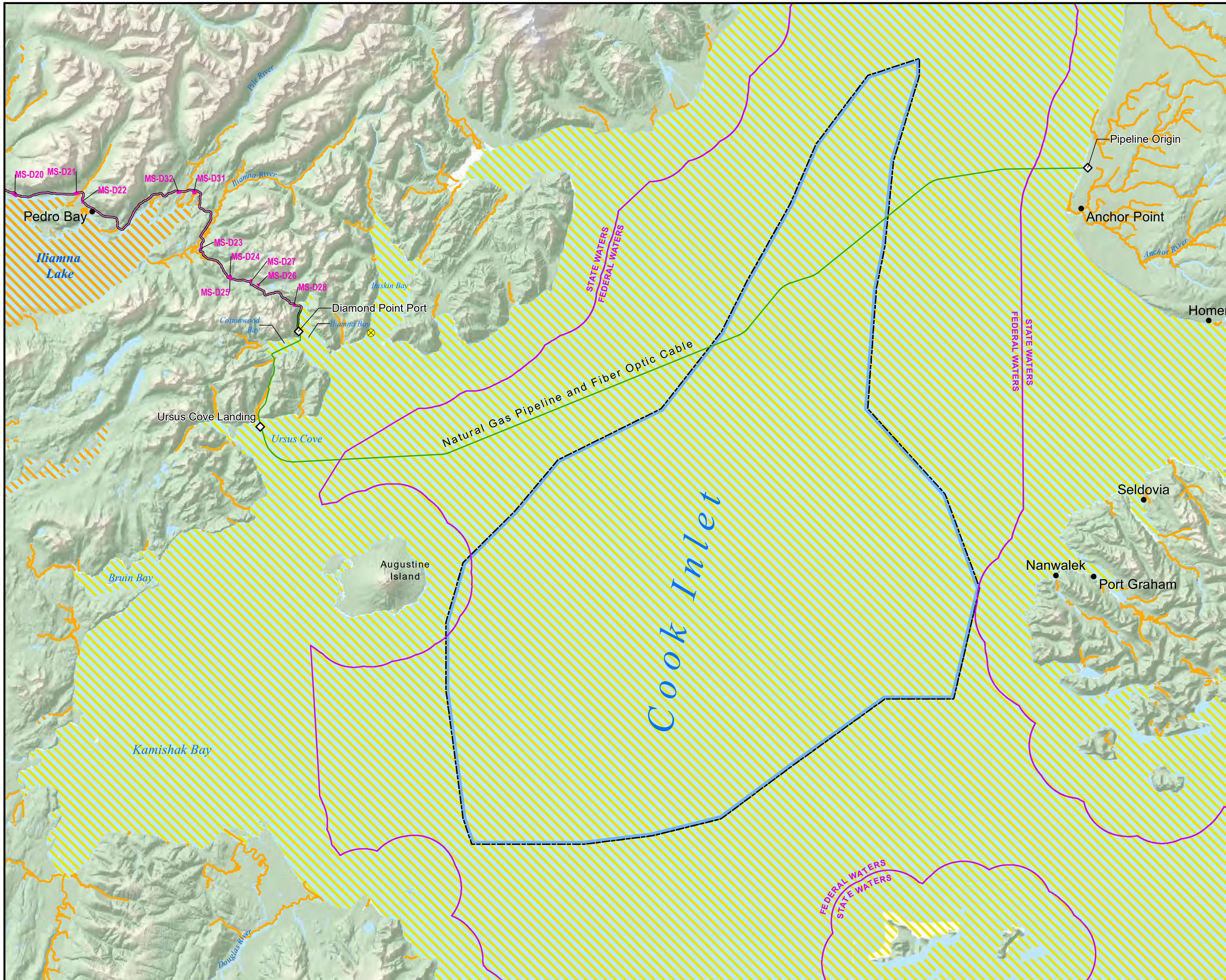
Figure:
3-7

EFH - Mine Site and North Transportation Corridor

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_002	Date: 5/28/2020
Revision: 01	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_002.mxd



![The Pebble Partnership]

- Scallop FMP EFH
- Salmon FMP EFH Freshwater Streams (AWC and PLP)
- Salmon FMP EFH Freshwater Lakes
- Groundfish and Salmon FMP EFH

Project Components

- Project Feature
- Lightering Station
- Access Road
- Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)
- NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
- Material Site

Reference

- State Seaward Boundary

Miles

0 5 10 15 20

Scale 1:500,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

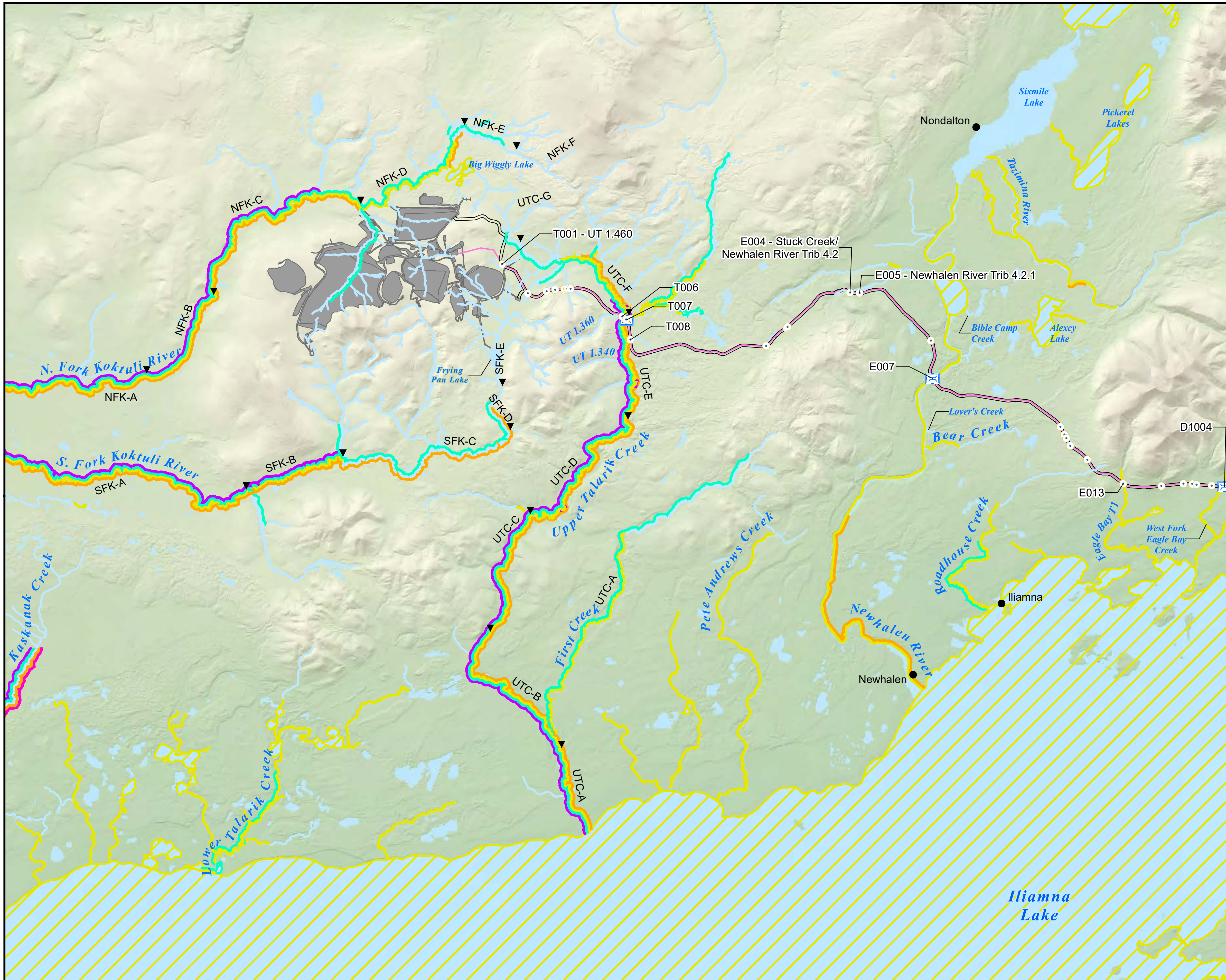
Figure:
3-8

EFH - Cook Inlet

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_004	Date: 5/28/2020
Revision: 01	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_004.mxd



THE pebble PARTNERSHIP

▼ Stream Reach Boundary

Access Road

NGP, FOC, Concentrate Pipeline, and Return Water Pipeline

Mine Site

Spawning Salmon Distribution by Species (AWC and PLP)

Chum

Coho

Sockeye

Pink

Chinook

Coho

Sockeye

N

Miles

0 2.5 5 7.5 10

Scale 1:200,000

NAD 1983 StatePlane Alaska 5 FIPS 5005 Seward Meridian

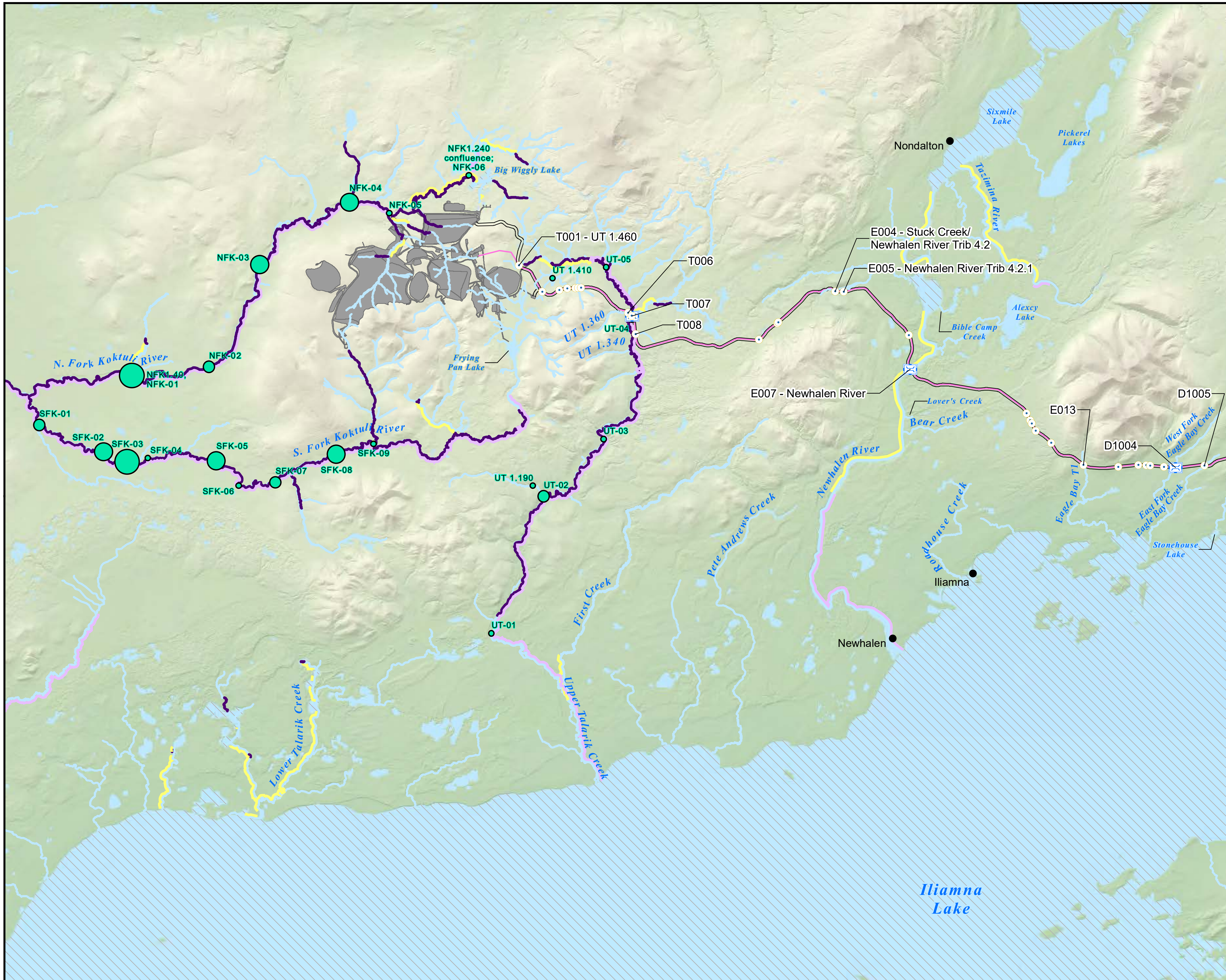
Figure: **4-1**

Documented Pacific Salmon Spawning Habitat North of Iliamna Lake

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_008	Date: 5/27/2020
Revision: 00	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_008.mxd



THE pebble PARTNERSHIP

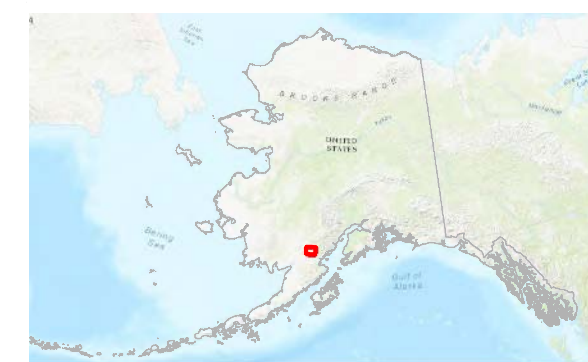
- Access Road
- Culvert
- NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
- Bridge
- Mine Site

Aerial Survey Counts of Adult Chinook Salmon, 2008

- 1 - 25
- 26 - 60
- 61 - 120
- 121 - 190

Chinook Salmon - Life Stage (AWC and PLP)

- Present
- Rearing
- Spawning
- Early Juvenile/Adults



Miles

0 2 4 6 8 10

Scale 1:220,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

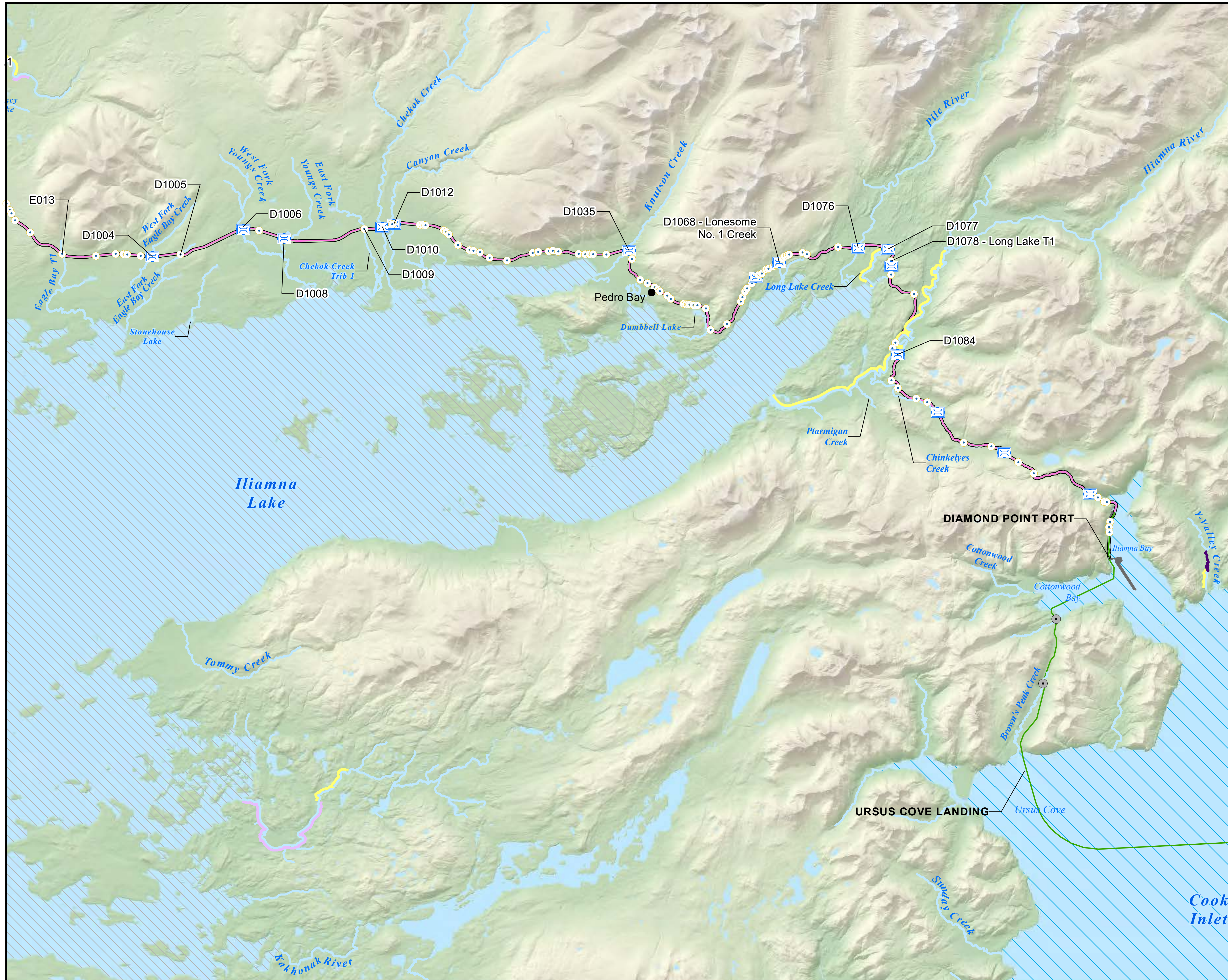
Figure:
4-2

Chinook Salmon Distribution - Mine Site and West Transportation Corridor

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_005	Date: 5/27/2020
Revision: 00	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_005.mxd



THE pebble PARTNERSHIP

Access Road
Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)
NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
Diamond Point Port
Culvert
Bridge
Stream Crossing

Chinook Salmon - Life Stage (AWC and PLP)

Present
Rearing
Spawning
Early Juvenile/Adults

N

Miles
0 2 4 6 8 10

Scale 1:225,000

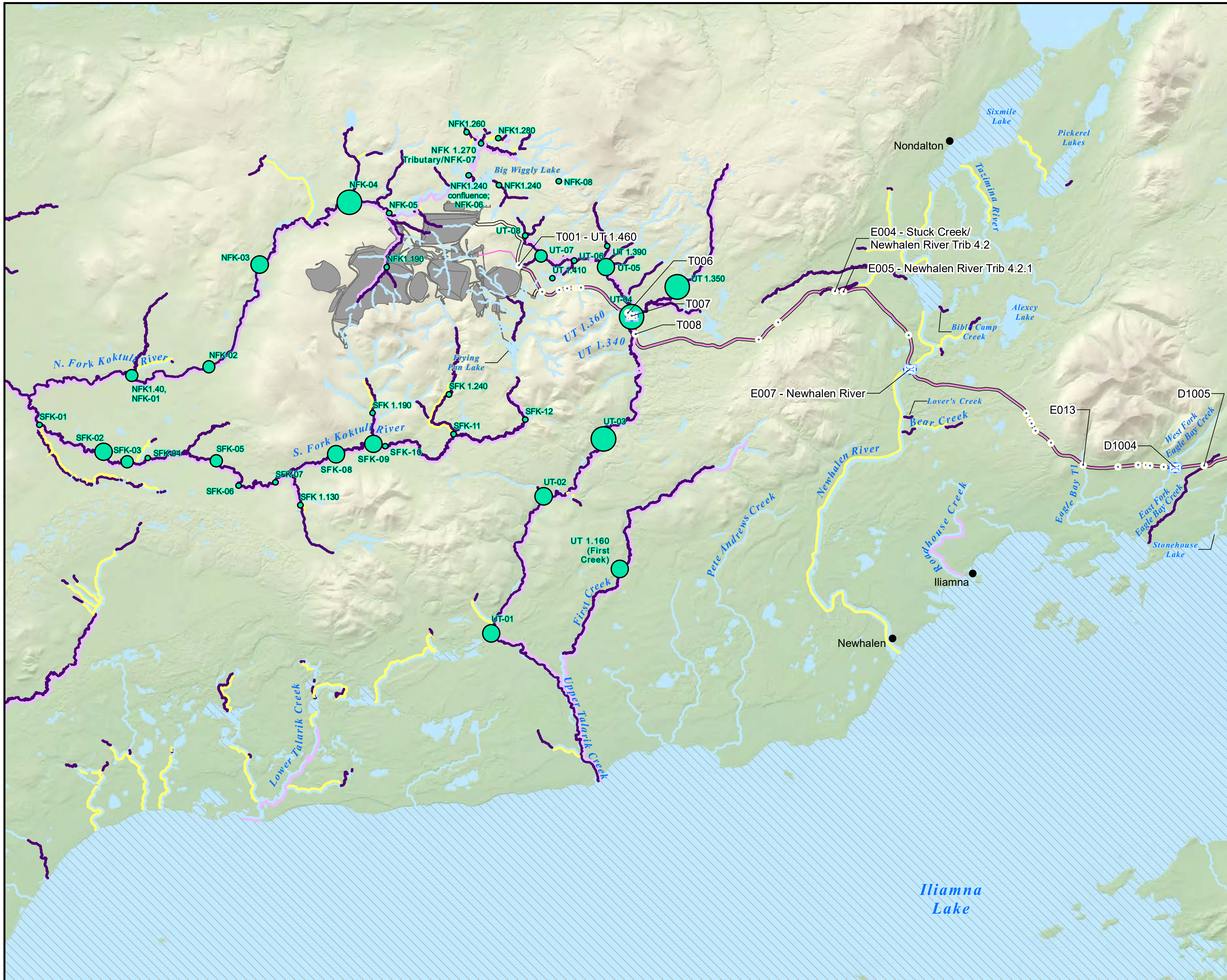
NAD 1983 StatePlane Alaska 5 FIPS 5005 Seward Meridian

Figure: **4-3**

Chinook Salmon Distribution - East Transportation Corridor

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_005	Date: 5/27/2020
Revision: 00	Author: ORNRC



THE pebble PARTNERSHIP

Access Road

NGP, FOC, Concentrate Pipeline, and Return Water Pipeline

Mine Site

Culvert

Bridge

Aerial Survey Counts of Adult Coho Salmon, 2008

- 1 - 85
- 86 - 210
- 211 - 450
- 451 - 880

Coho Salmon - Life Stage (AWC and PLP)

- Present
- Rearing
- Spawning
- Early Juvenile/Adults

Miles

0 2 4 6 8 10

Scale 1:220,000

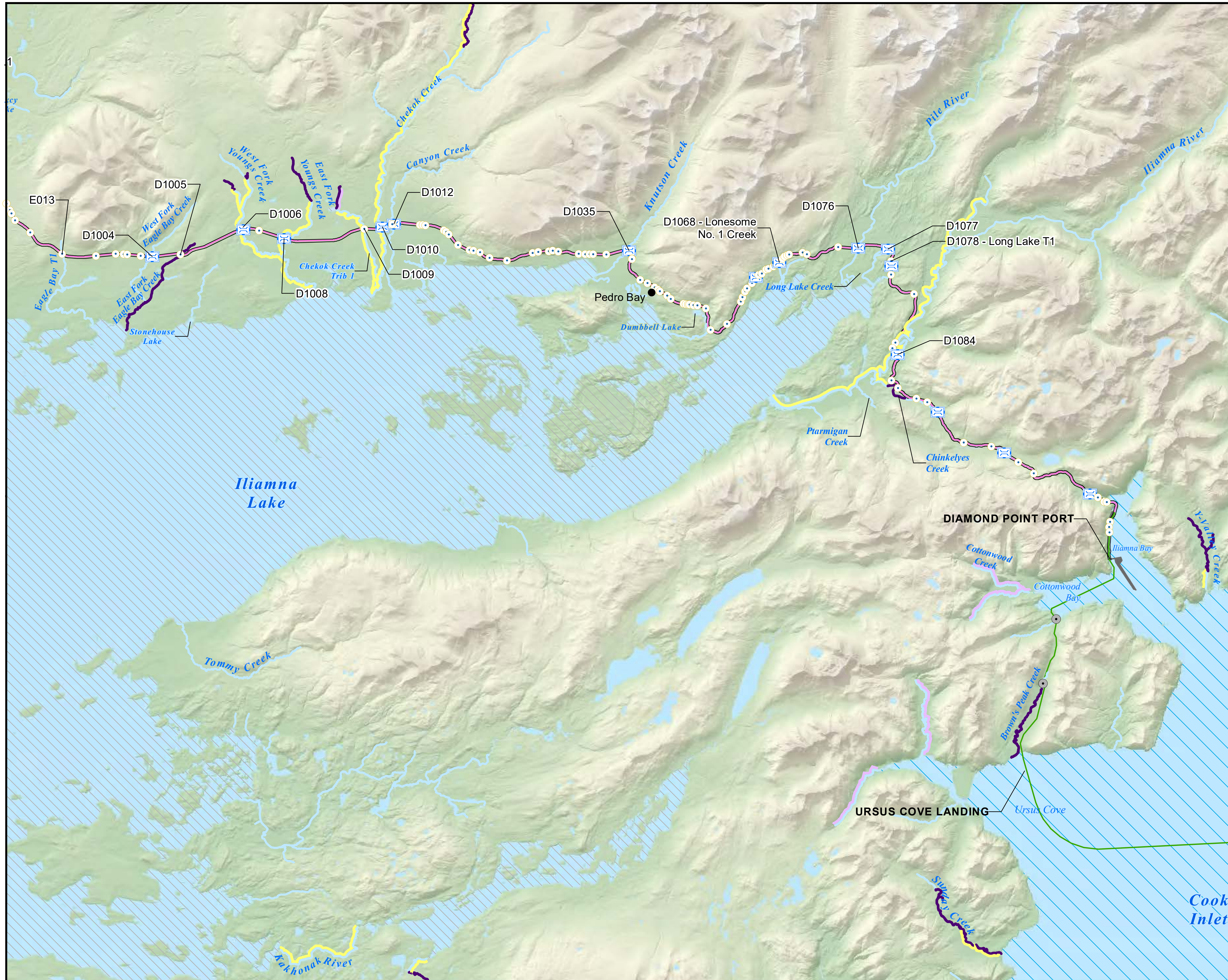
NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
4-4

Coho Salmon Distribution - Mine Site and West Transportation Corridor

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_005	Date: 5/27/2020
Revision: 00	Author: ORNRC

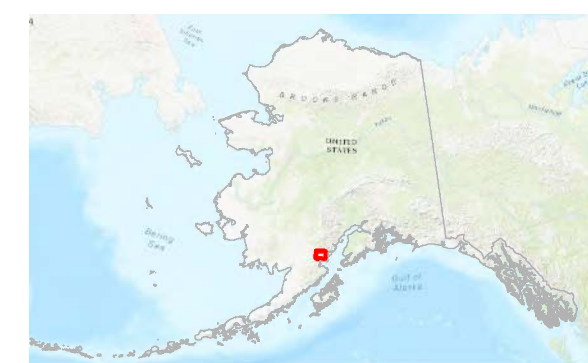


THE pebble PARTNERSHIP

Access Road
Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)
NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
Diamond Point Port
Culvert
Bridge
Stream Crossing

Coho Salmon - Life Stage (AWC and PLP)

Present
Rearing
Spawning
Early Juvenile/Adults



Miles
0 2 4 6 8 10
Scale 1:225,000

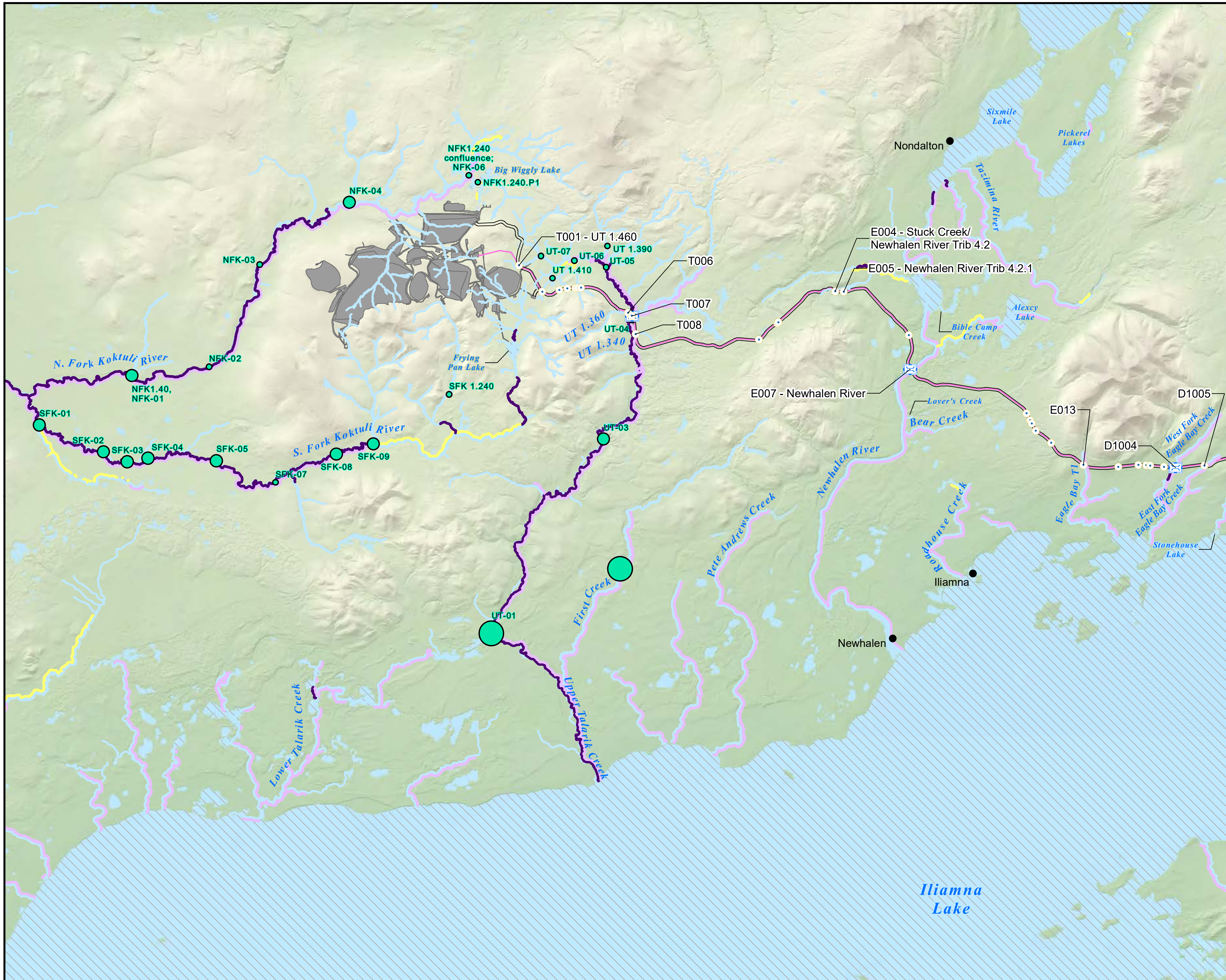
NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
4-5

Coho Salmon Distribution - East Transportation Corridor
Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_005	Date: 5/27/2020
Revision: 00	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_005.mxd



Access Road
NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
Mine Site
Culvert
Bridge

Aerial Survey Counts of Adult Sockeye Salmon, 2008

1 - 100
101 - 3100
17501 - 21554

Sockeye Salmon - Life Stage (AWC and PLP)

Present
Rearing
Spawning
Early Juvenile/Adults

Miles
0 2 4 6 8 10
Scale 1:220,000

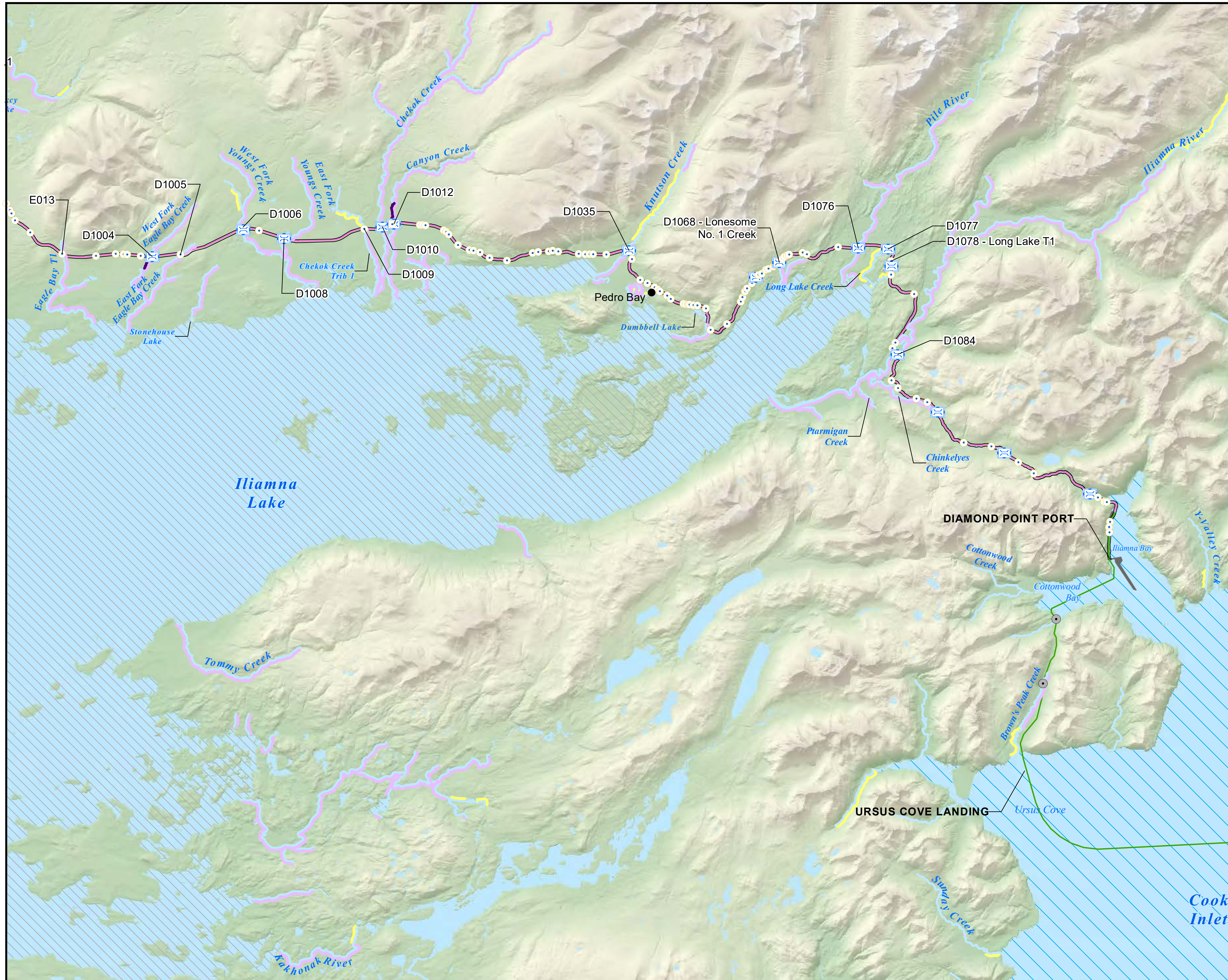
NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
4-6

Sockeye Salmon Distribution - Mine Site and West Transportation Corridor
Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_005	Date: 5/27/2020
Revision: 00	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_005.mxd



THE pebble PARTNERSHIP

Access Road

Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)

NGP, FOC, Concentrate Pipeline, and Return Water Pipeline

Diamond Point Port

Sockeye Salmon - Life Stage (AWC and PLP)

Present

Rearing

Spawning

Early Juvenile/Adults

Culvert

Bridge

Stream Crossing

Miles

0 2 4 6 8 10

Scale 1:225,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

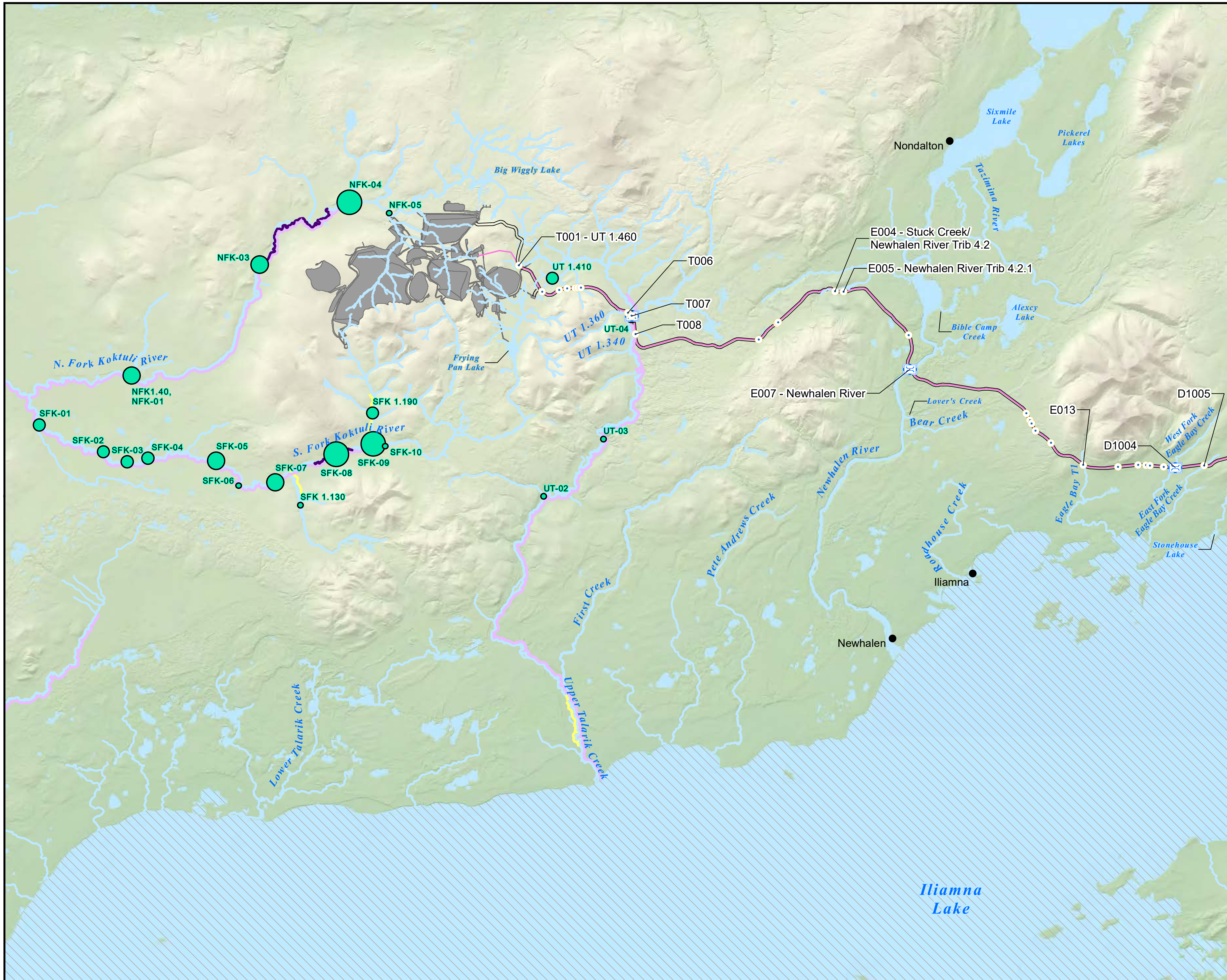
Figure:
4-7

Sockeye Salmon Distribution - East Transportation Corridor

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_005	Date: 5/27/2020
Revision: 00	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_005.mxd



THE pebble PARTNERSHIP

Access Road
NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
Mine Site
Culvert
Bridge

Aerial Survey Counts of Adult Chum Salmon, 2008

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

Chum Salmon - Life Stage (AWC and PLP)

- Present
- Rearing
- Spawning
- Early Juvenile/Adults

Miles
0 2 4 6 8 10
Scale 1:220,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

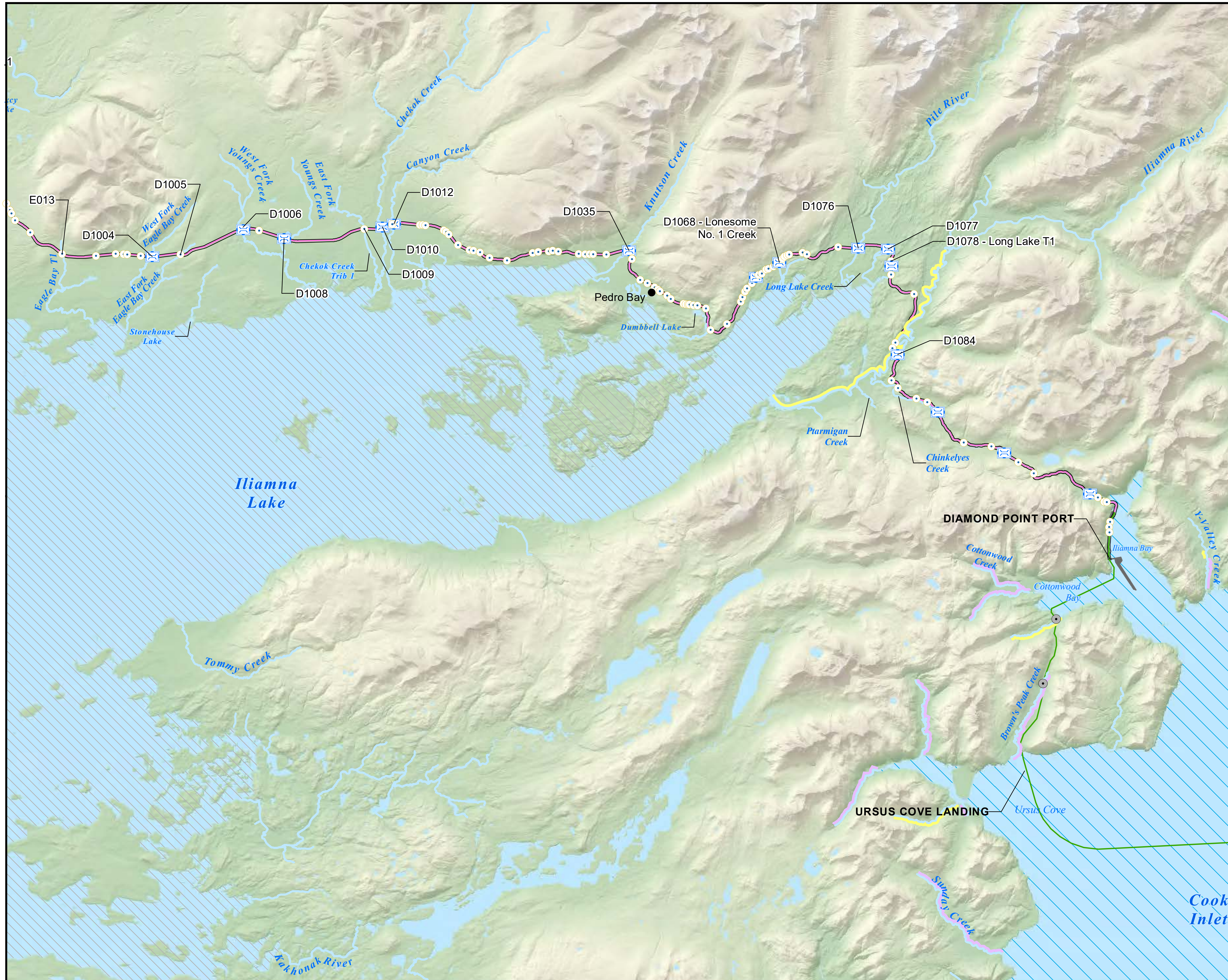
Figure:
4-8

Chum Salmon Distribution - Mine Site and West Transportation Corridor

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_005
Date: 5/27/2020
Revision: 00
Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PL\PEFH\PLPEFH_005.mxd



THE pebble PARTNERSHIP

Access Road

Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)

NGP, FOC, Concentrate Pipeline, and Return Water Pipeline

Diamond Point Port

Chum Salmon - Life Stage (AWC and PLP)

Present

Spawning

Early Juvenile/Adults

Culvert

Bridge

Stream Crossing

Miles

0 2 4 6 8 10

Scale 1:225,000

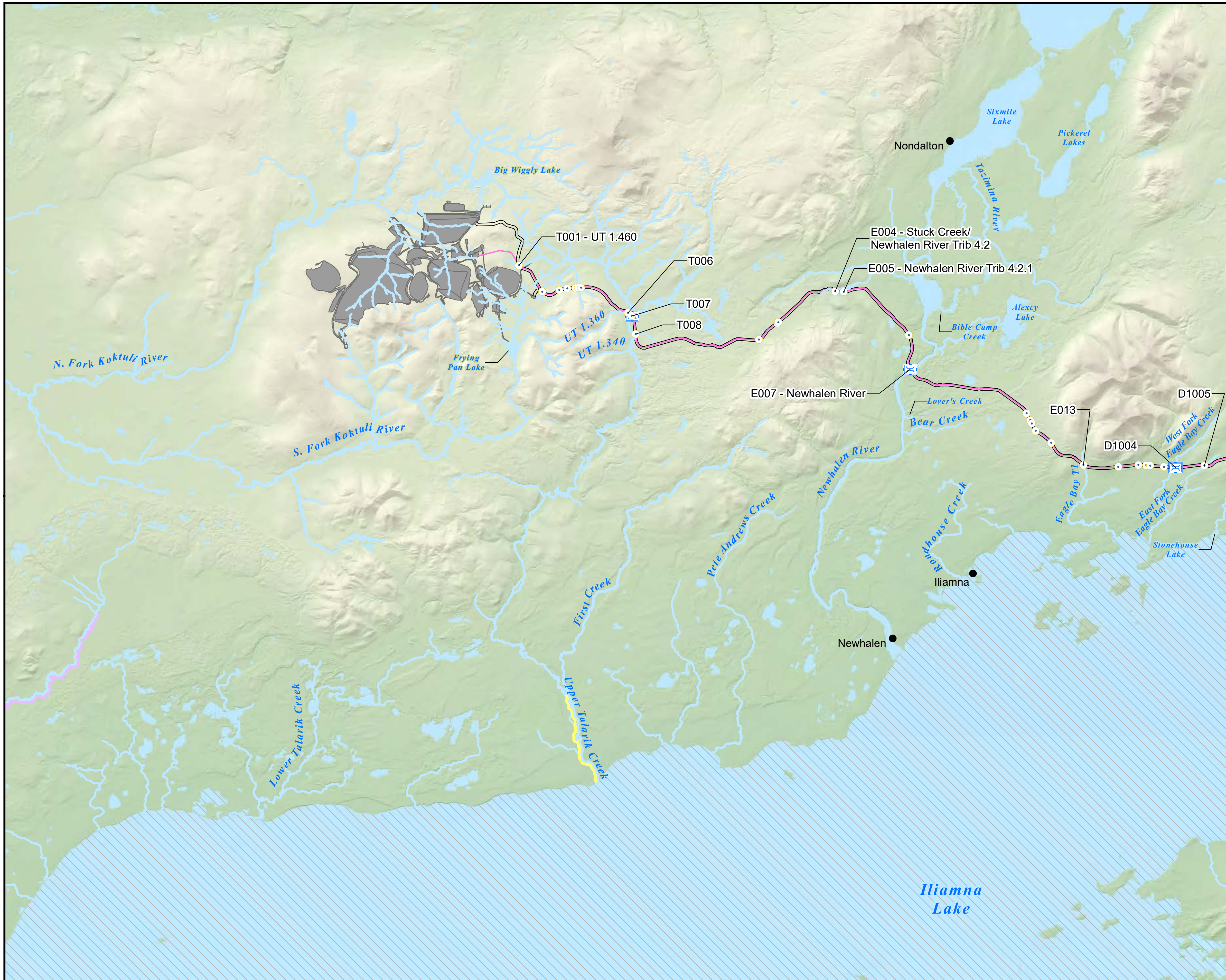
NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
4-9

Chum Salmon Distribution - East Transportation Corridor

Essential Fish Habitat Assessment
Pebble Project

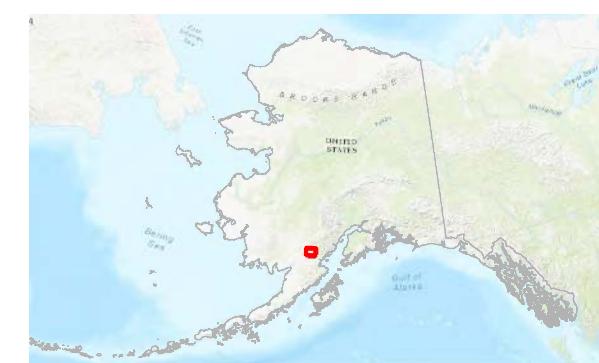
File: PLPEFH_005	Date: 5/27/2020
Revision: 00	Author: ORNRC



THE pebble PARTNERSHIP

Access Road
NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
Mine Site
Culvert
Bridge

Pink Salmon - Life Stage (AWC and PLP)
Present
Spawning
Early Juvenile/Adults



Miles
0 2 4 6 8 10
Scale 1:220,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
4-10

Pink Salmon Distribution - Mine Site and West Transportation Corridor

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_005 | Date: 5/27/2020
Revision: 00 | Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_005.mxd

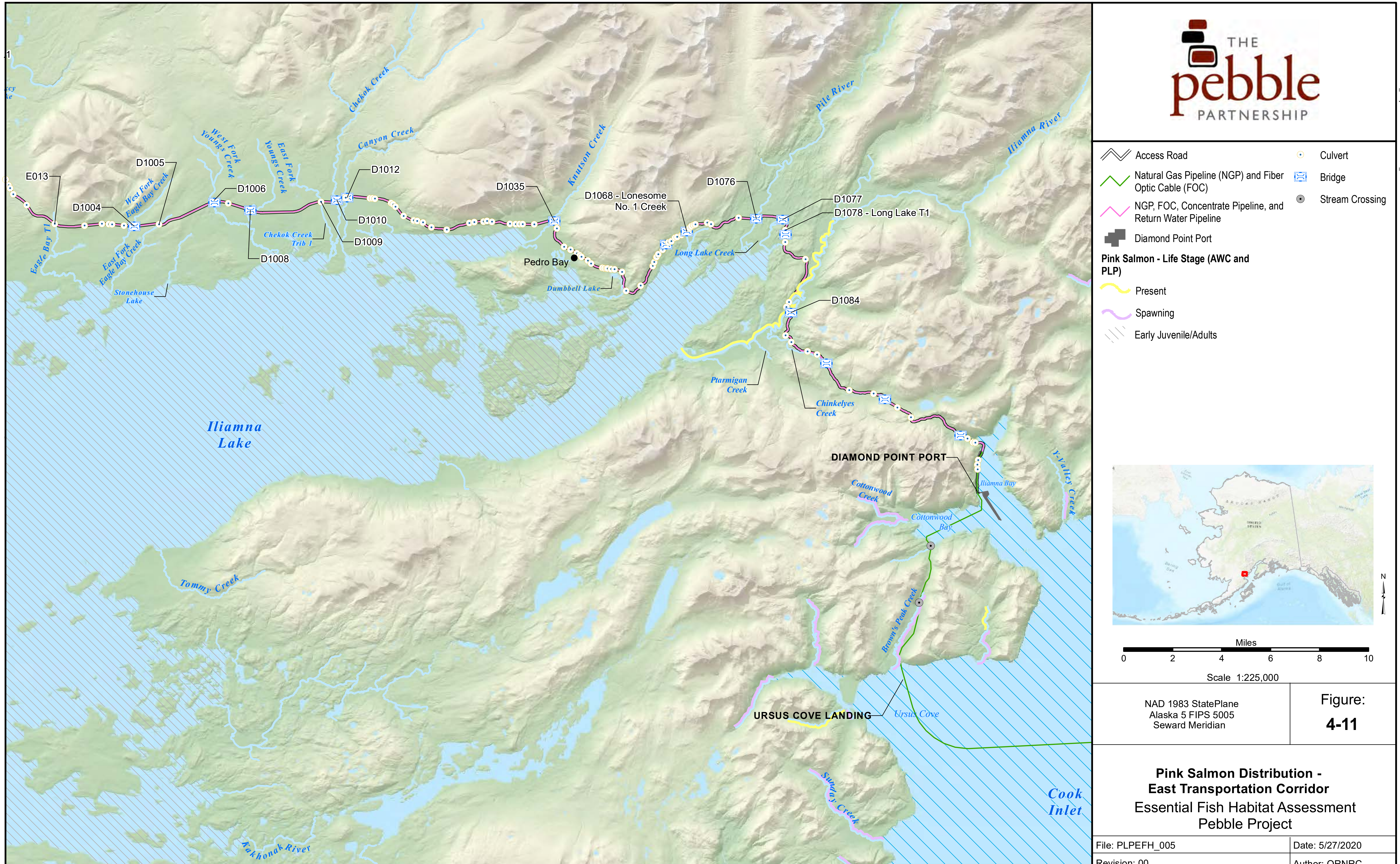
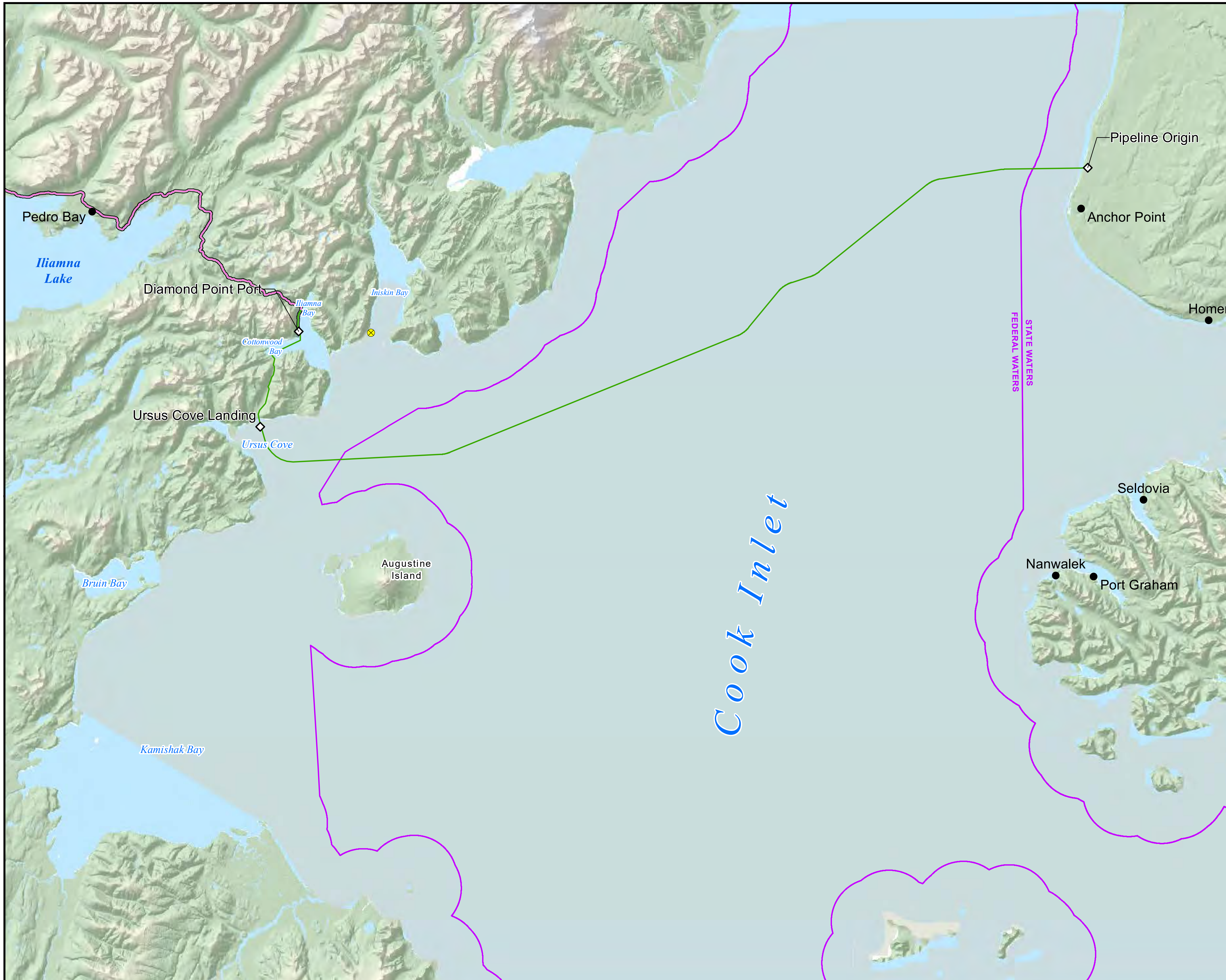


Figure: 4-11

Pink Salmon Distribution - East Transportation Corridor
Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_005	Date: 5/27/2020
Revision: 00	Author: ORNRC



Project Feature

Lightering Station

Access Road

Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)

NGP, FOC, Concentrate Pipeline, and Return Water Pipeline

State Seaward Boundary

Atka Mackerel EFH

Adult

Miles

0 5 10 15 20

Scale 1:500,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

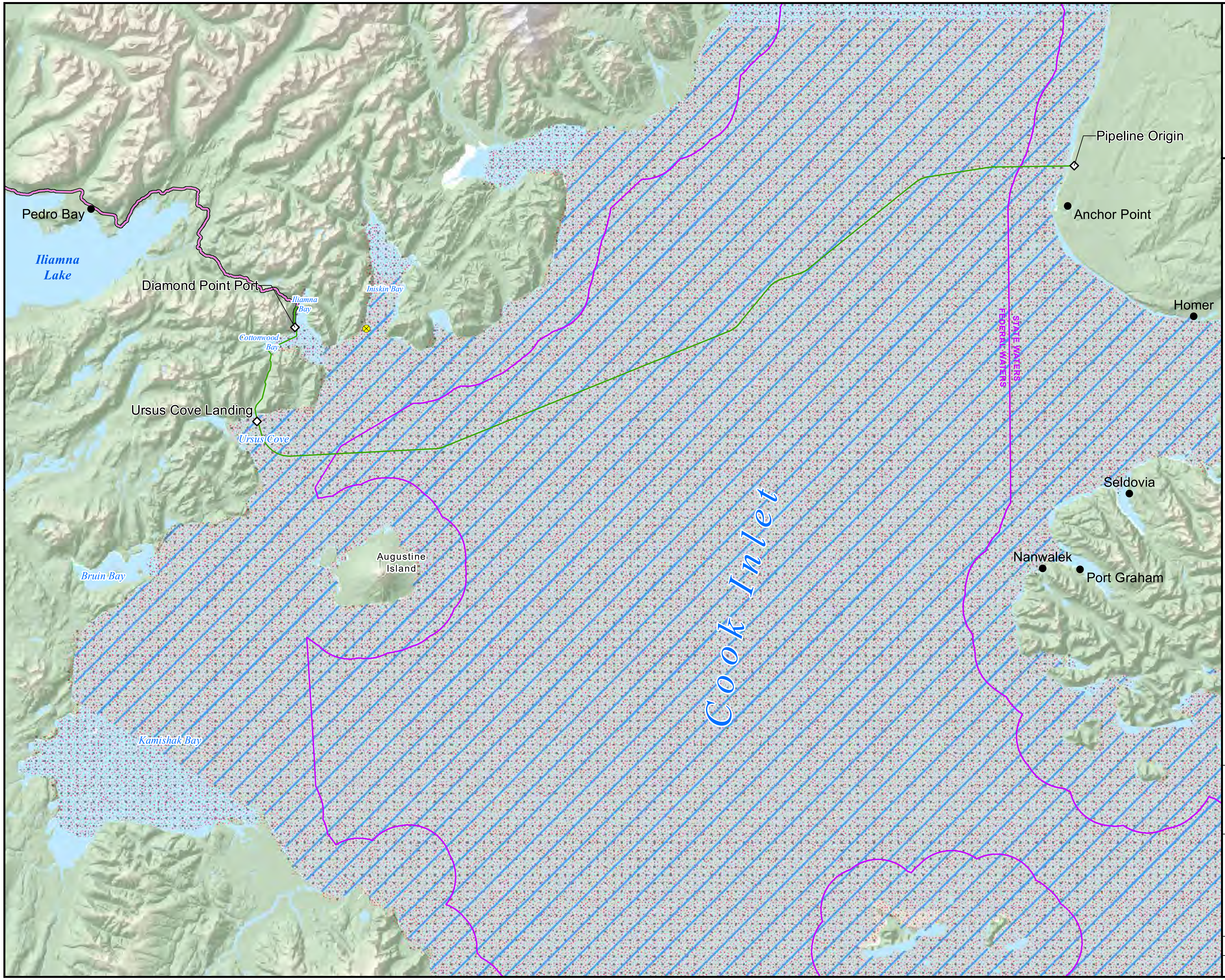
Figure:
4-12

Atka Mackerel EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_006	Date: 5/28/2020
Revision: 01	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_006.mxd



THE pebble PARTNERSHIP

Project Feature
Lightering Station
Access Road
Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)
NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
State Seaward Boundary

Flatfish EFH

Egg
Larvae
Juvenile
Adult

N

Miles
0 5 10 15 20

Scale 1:500,000

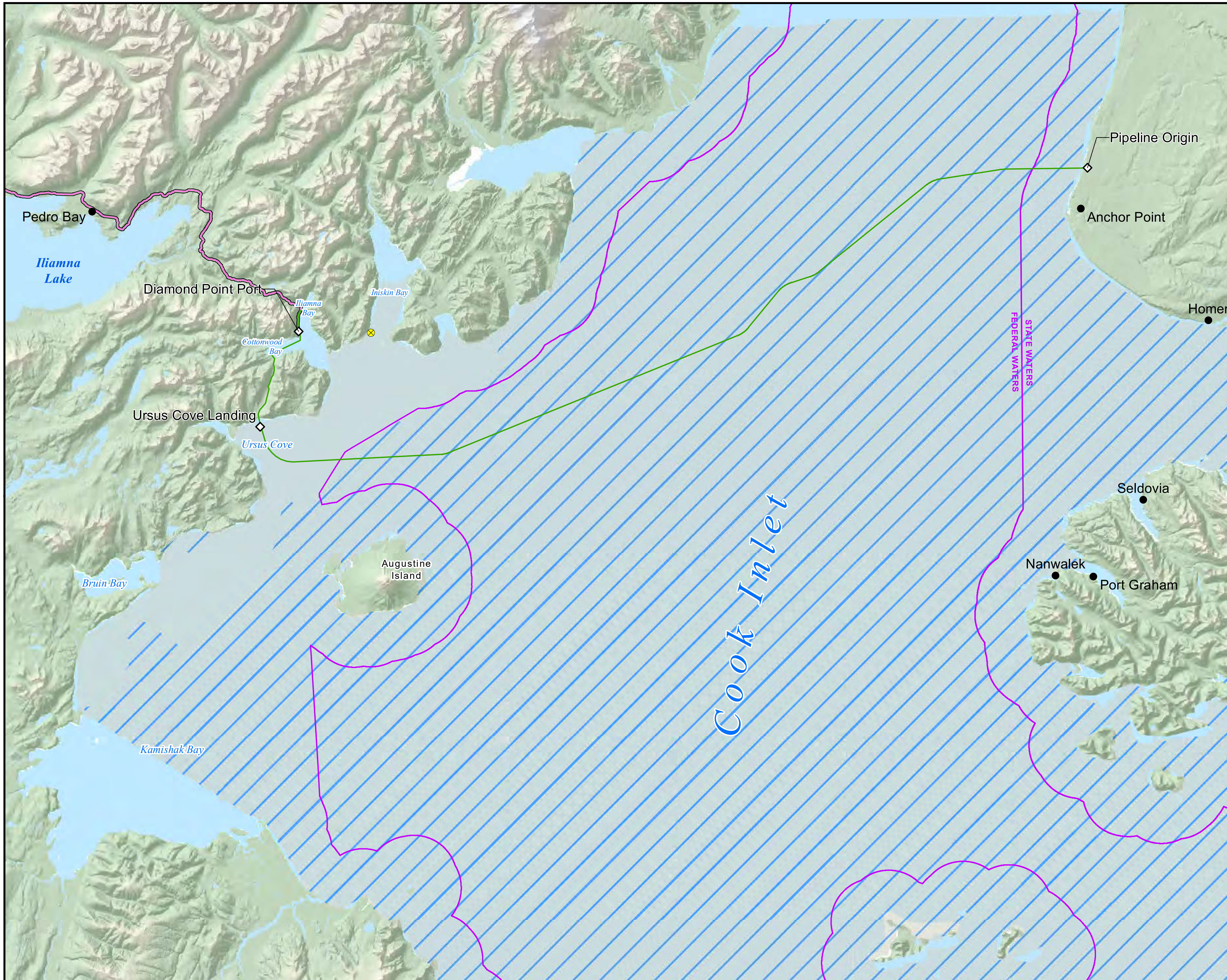
NAD 1983 StatePlane Alaska 5 FIPS 5005 Seward Meridian	Figure: **4-13**

Flatfish EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_006	Date: 5/28/2020
Revision: 01	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_006.mxd



THE pebble PARTNERSHIP

Project Feature
Lightering Station
Access Road
Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)
NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
State Seaward Boundary

GOA Skates (Rajidae) EFH

Juvenile
Adult

Miles
0 5 10 15 20

Scale 1:500,000

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

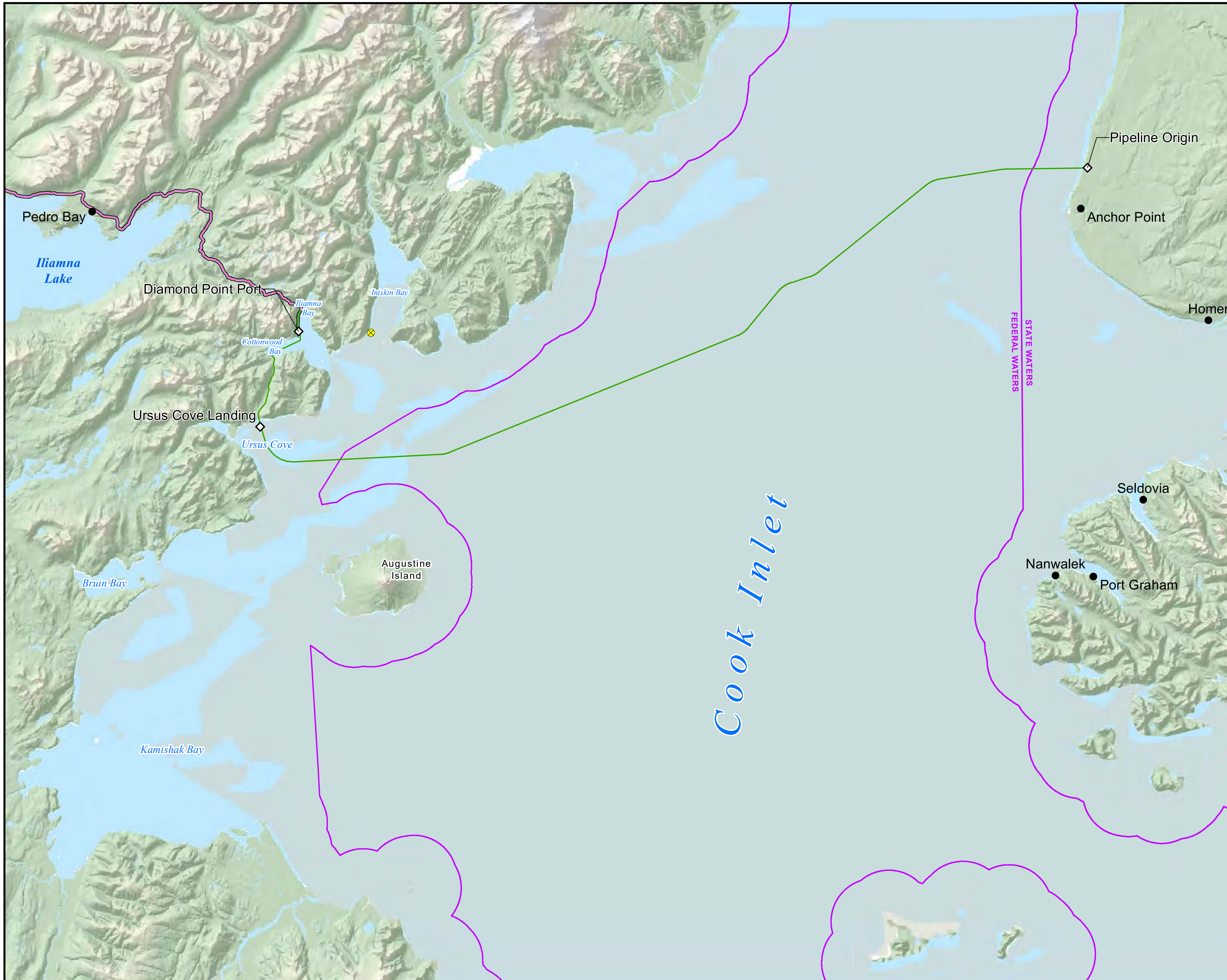
Figure:
4-14

GOA Skates (Rajidae) EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_006	Date: 5/28/2020
Revision: 01	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_006.mxd



THE pebble PARTNERSHIP

Project Feature
Lightering Station
Access Road
Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)
NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
State Seaward Boundary

Octopus EFH

Adult

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

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

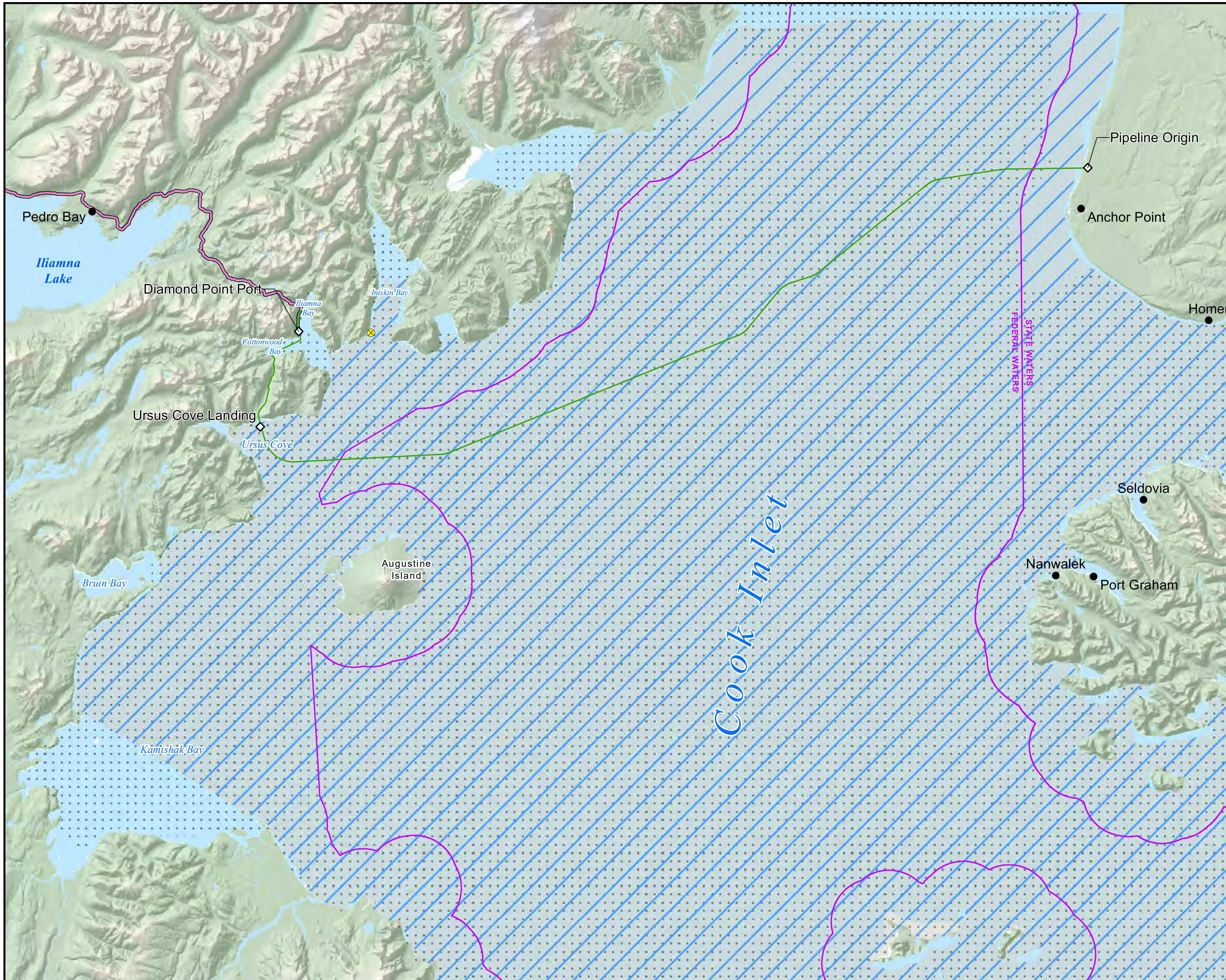
Figure:
4-15

Octopus EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_006	Date: 5/28/2020
Revision: 01	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_006.mxd



Project Feature
Lightering Station
Access Road
Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)
NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
State Seaward Boundary

Pacific Cod EFH

Larvae
Juvenile
Adult

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

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

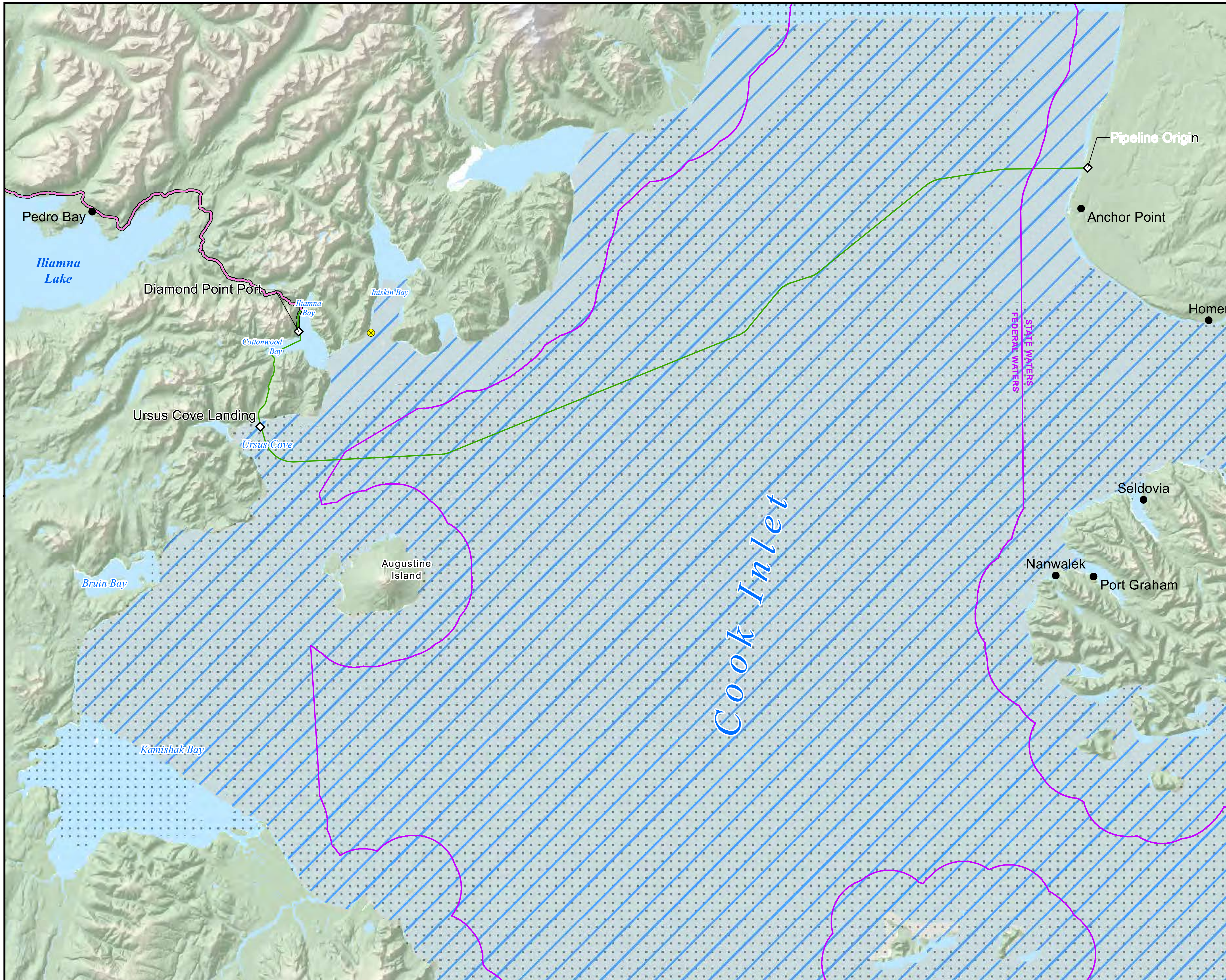
Figure:
4-16

Pacific Cod EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_006	Date: 5/28/2020
Revision: 01	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_006.mxd



THE pebble PARTNERSHIP

Project Feature

Lightering Station

Access Road

Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)

NGP, FOC, Concentrate Pipeline, and Return Water Pipeline

State Seaward Boundary

Rockfish (Sebastes) EFH

Larvae

Juvenile

Adult

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: PLPEFH_006 | Date: 5/28/2020
Revision: 01 | Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_006.mxd

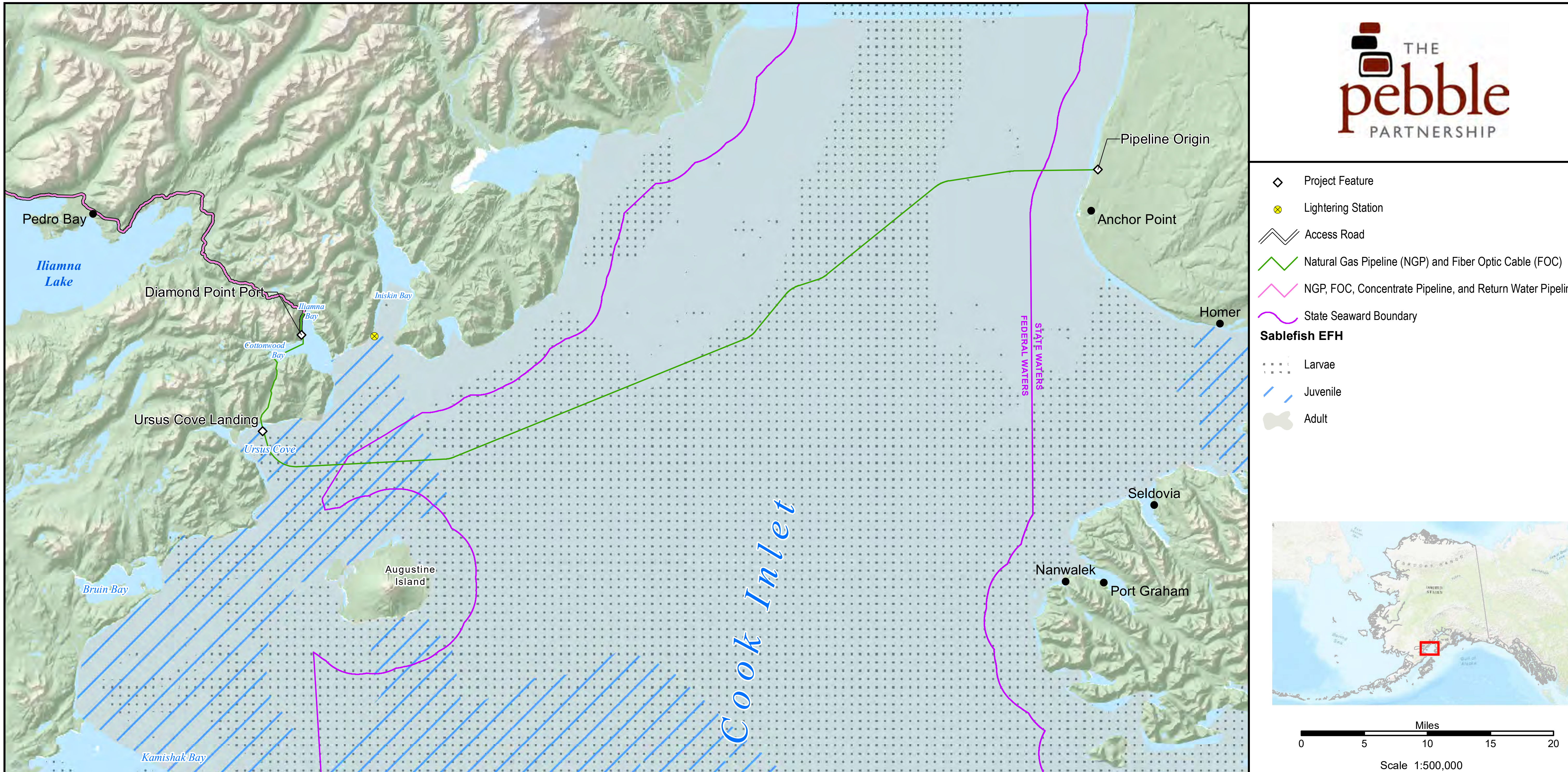


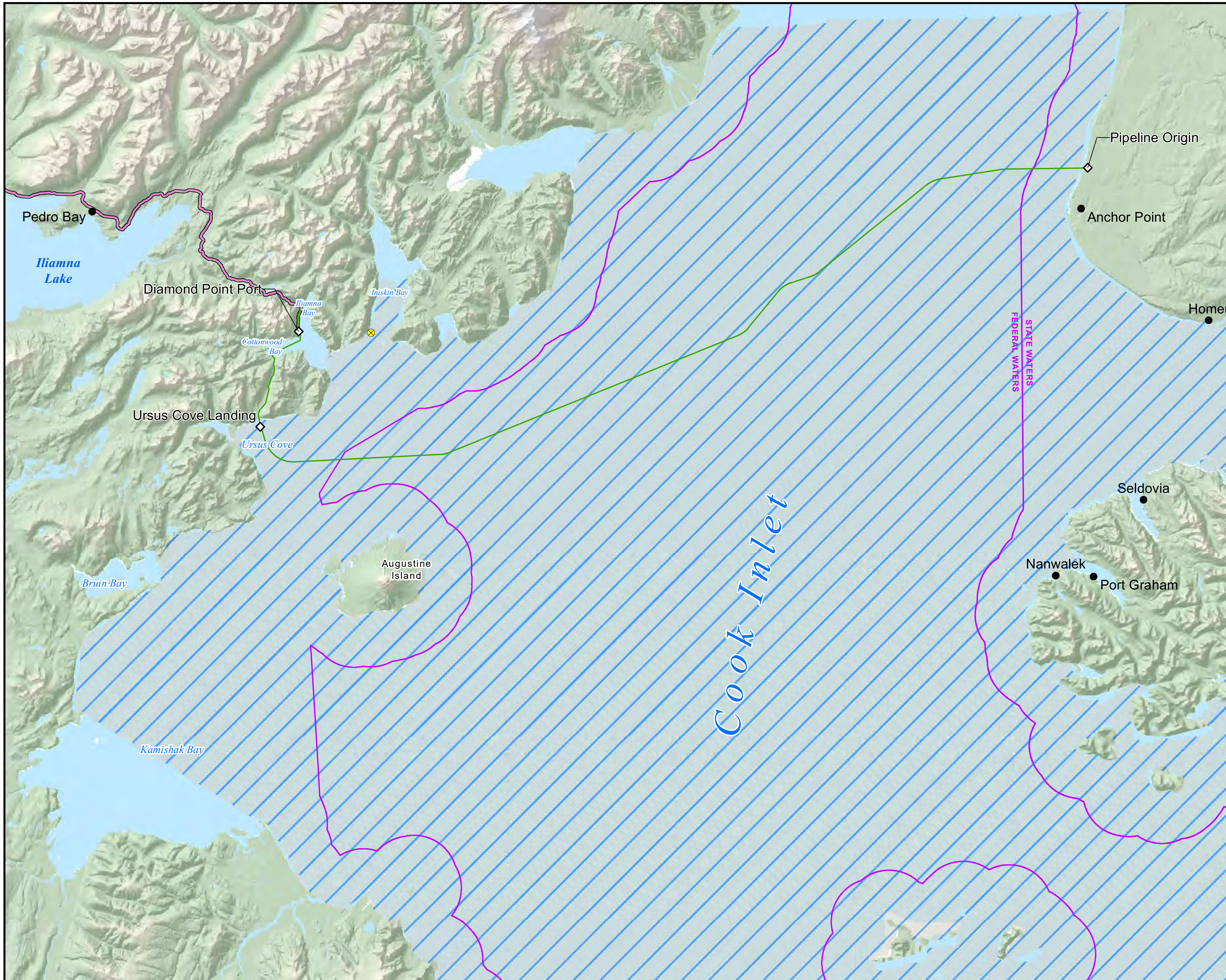
Figure: 4-18

Sablefish EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_006	Date: 5/28/2020
Revision: 01	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_006.mxd



Project Feature
Lightering Station
Access Road
Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)
NGP, FOC, Concentrate Pipeline, and Return Water Pipeline
State Seaward Boundary

Sculpins (Cottidae) EFH

Juvenile
Adult

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

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

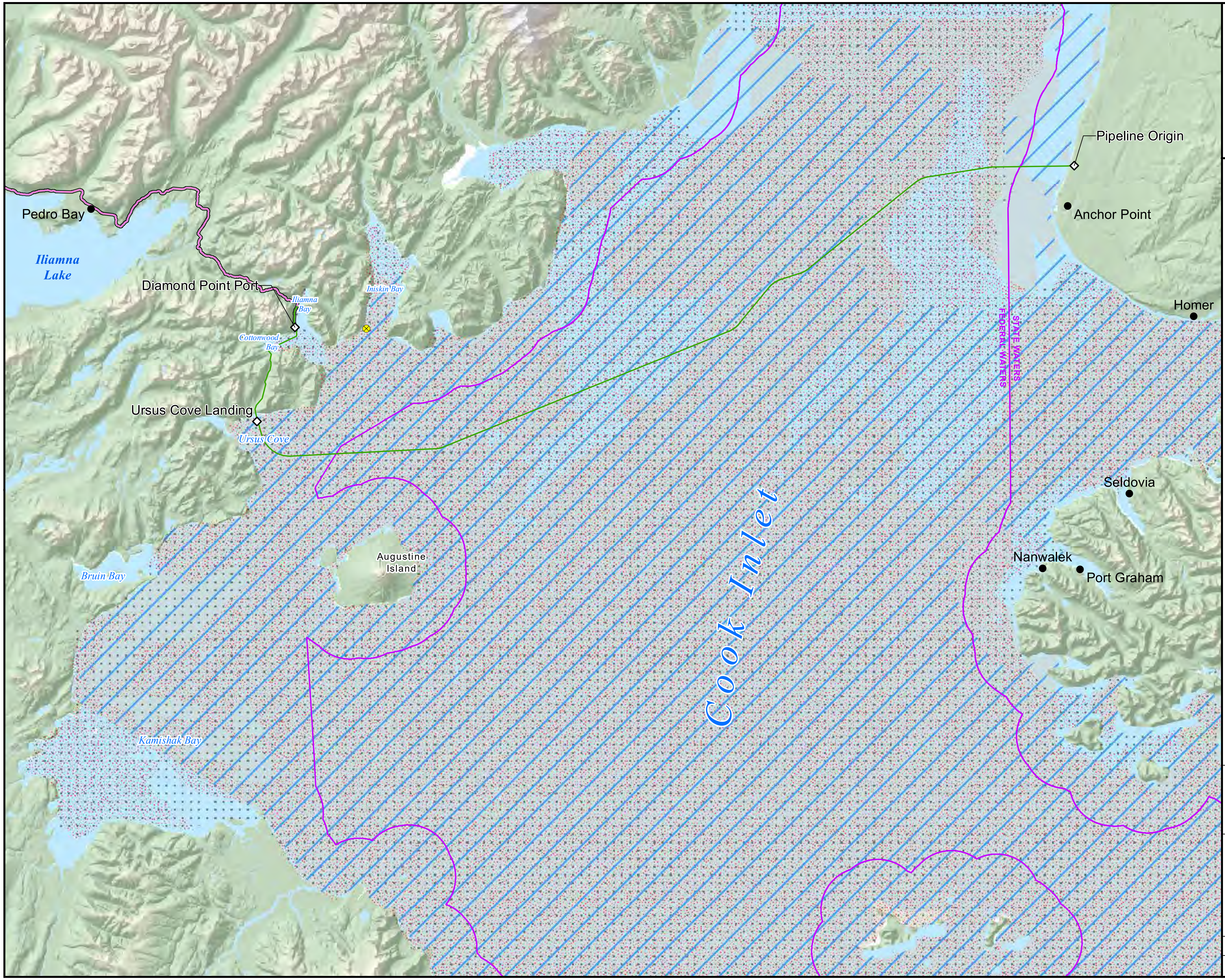
Figure:
4-19

Sculpins (Cottidae) EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_006	Date: 5/28/2020
Revision: 01	Author: ORNRC

Document Path: G:\Pebble\ARC_Proj\MXD\PLPEFH\PLPEFH_006.mxd



THE pebble PARTNERSHIP

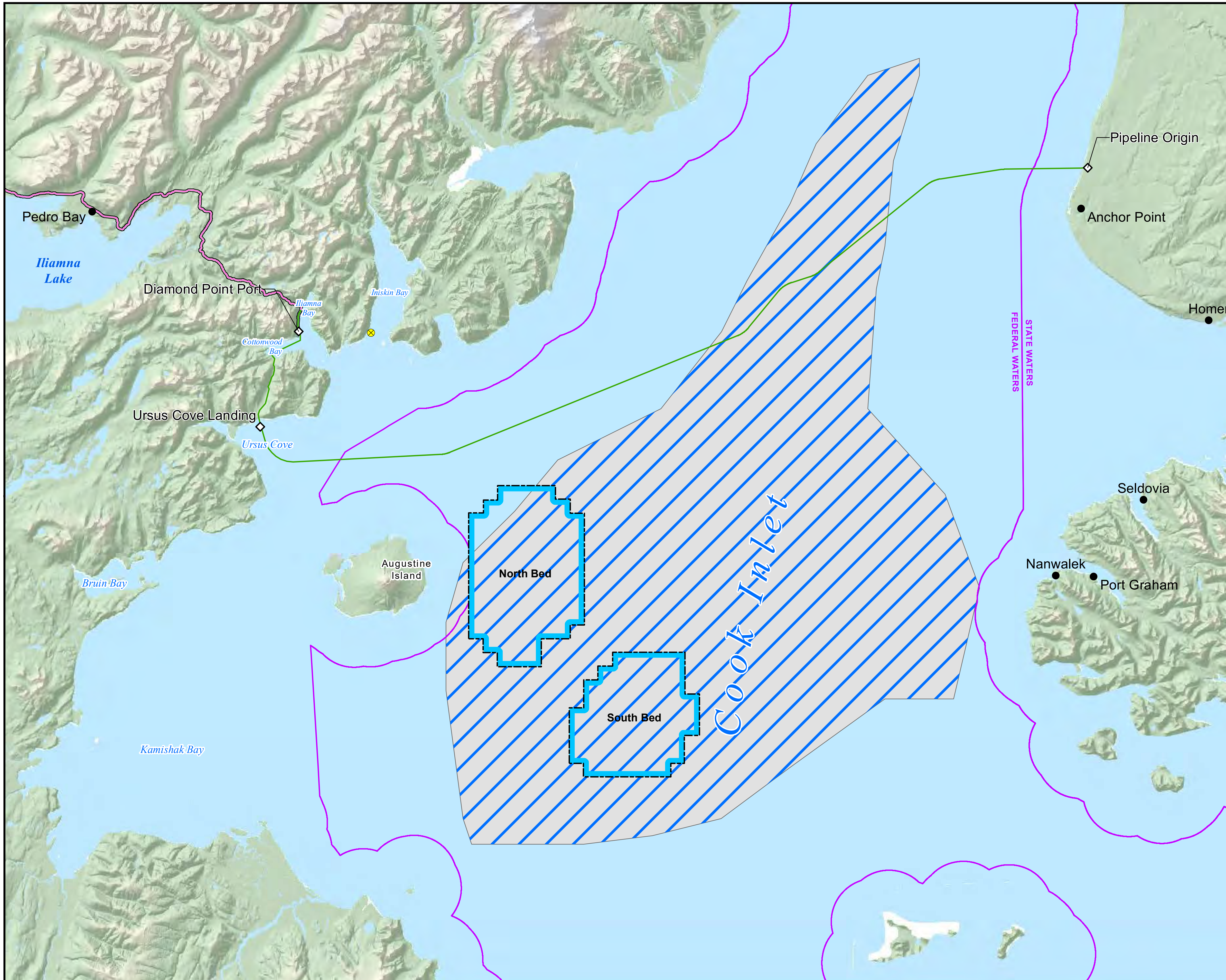
NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

Figure:
4-20

Walleye Pollock EFH

Essential Fish Habitat Assessment
Pebble Project

File: PLPEFH_006	Date: 5/28/2020
Revision: 01	Author: ORNRC



THE pebble PARTNERSHIP

Fished Weathervane Scallop Bed
Project Feature
Lightering Station
Access Road
Natural Gas Pipeline (NGP) and Fiber Optic Cable (FOC)
NGP, FOC, Concentrate Pipeline, and Return Water Pipeline

Weathervane Scallop EFH

Late Juvenile
Mature

Fished Weasthervane Scallop Bed Source: Figure 1, Fishery Data Series No. 12-62

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

NAD 1983 StatePlane
Alaska 5 FIPS 5005
Seward Meridian

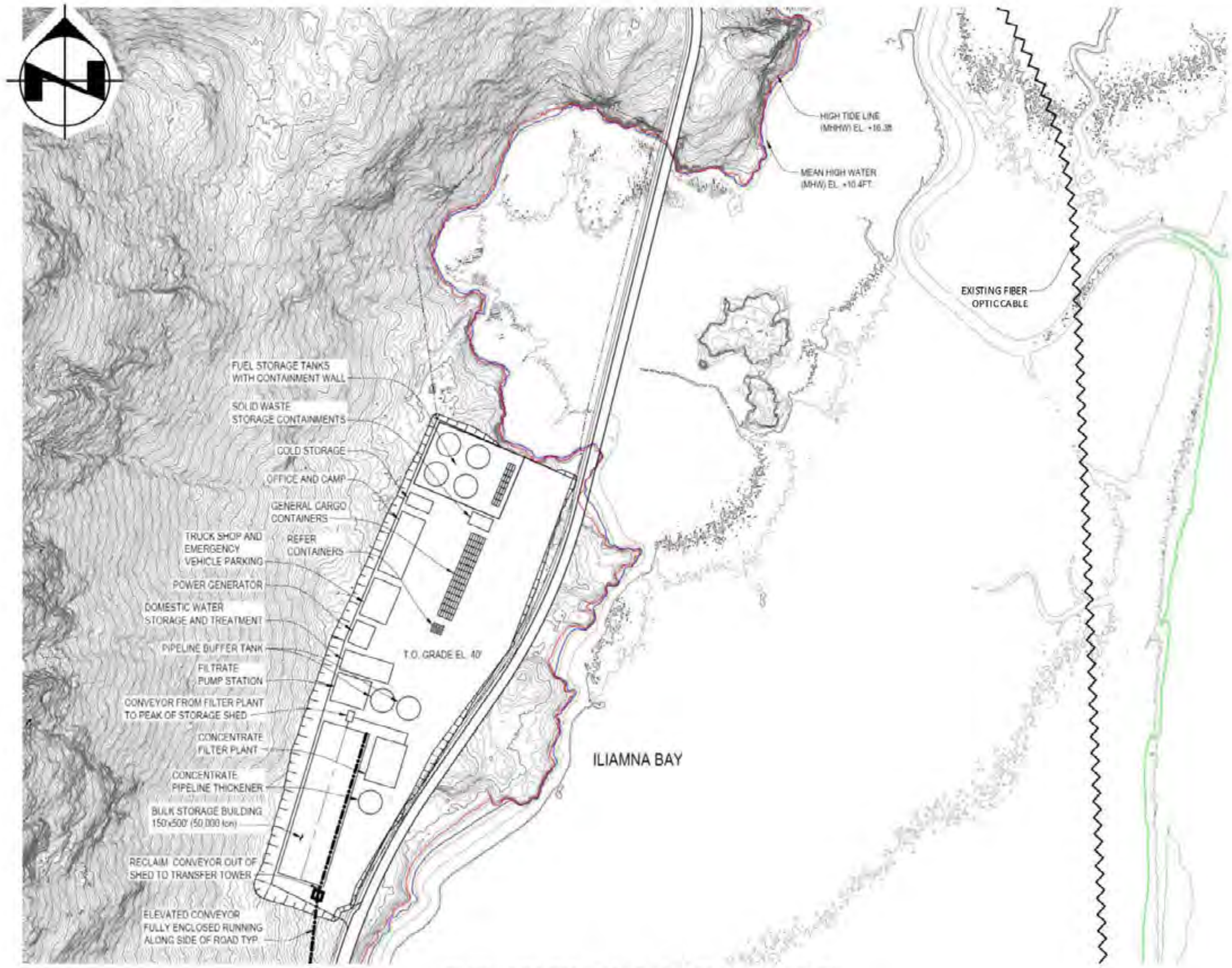
Figure: **4-21**

Weathervane Scallop EFH

Essential Fish Habitat Assessment
Pebble Project

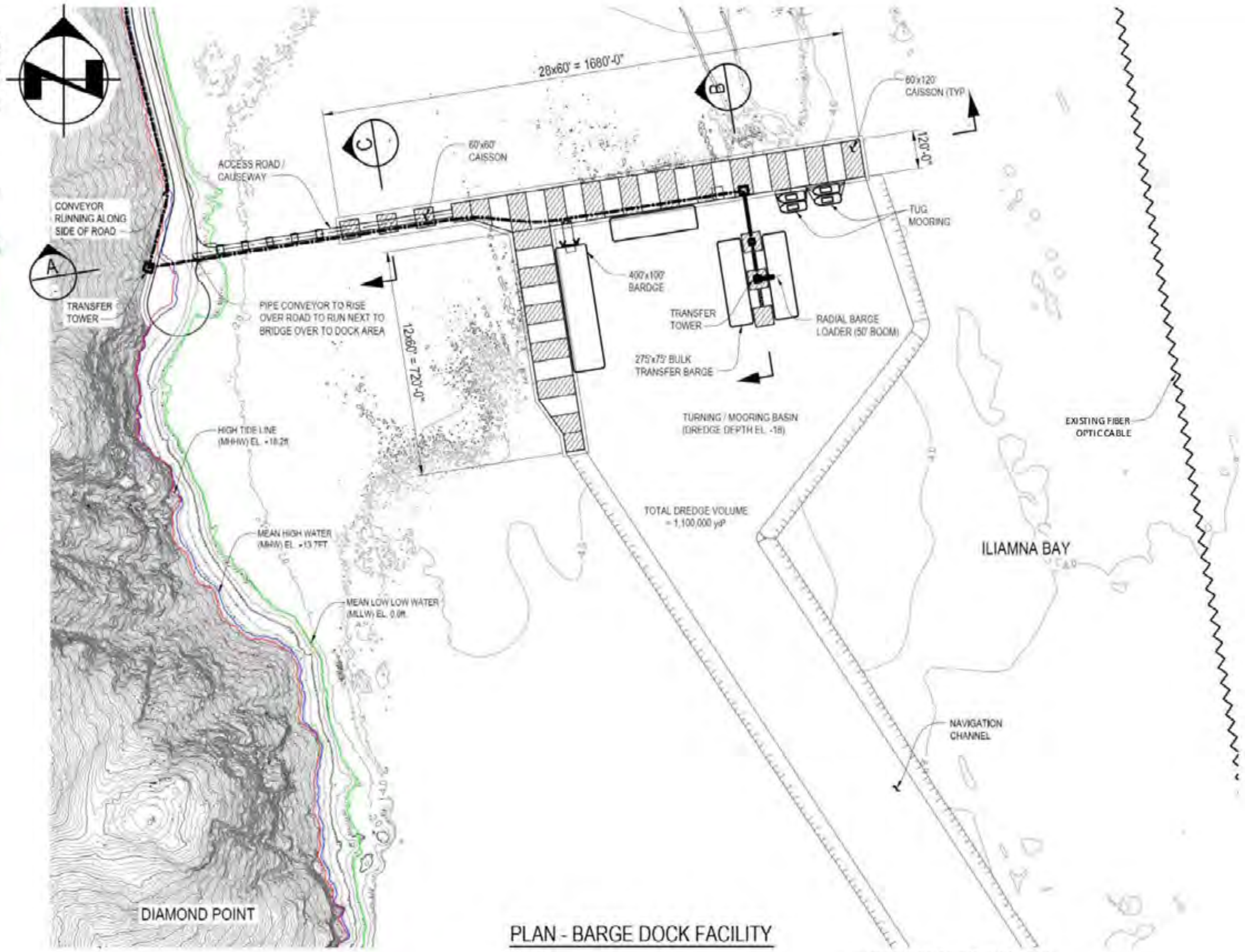
File: PLPEFH_007	Date: 5/28/2020
Revision: 01	Author: ORNRC

APPENDIX A
TYPICAL ENGINEERING DESIGNS



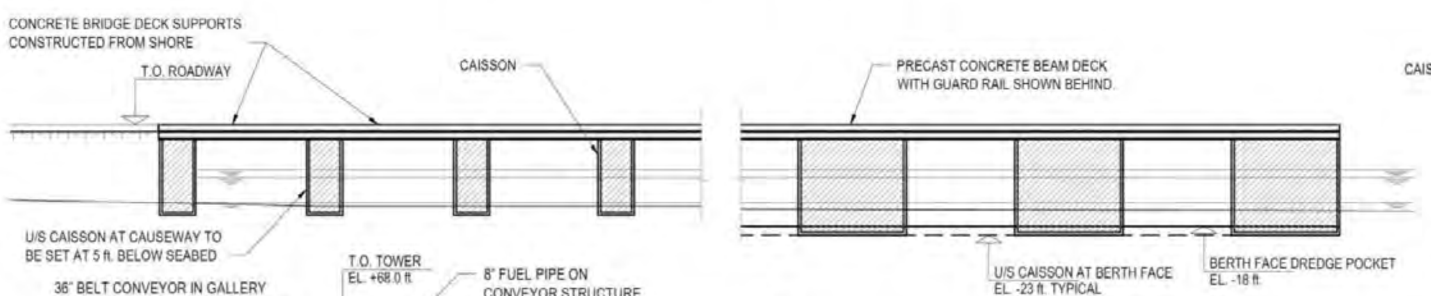
PLAN - CONCENTRATE TERMINAL FACILITIES

1" = 250'



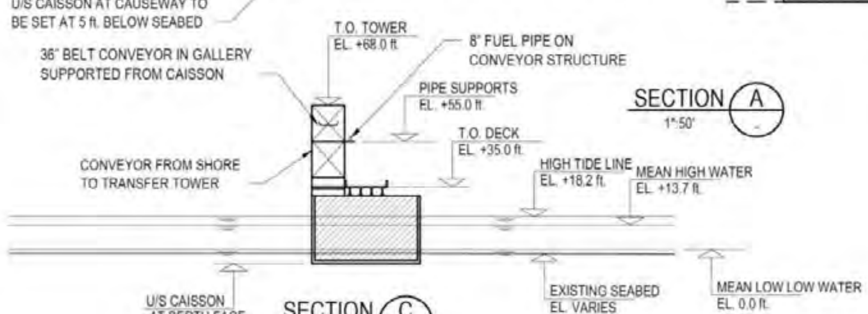
PLAN - BARGE DOCK FACILITY

1" = 250'



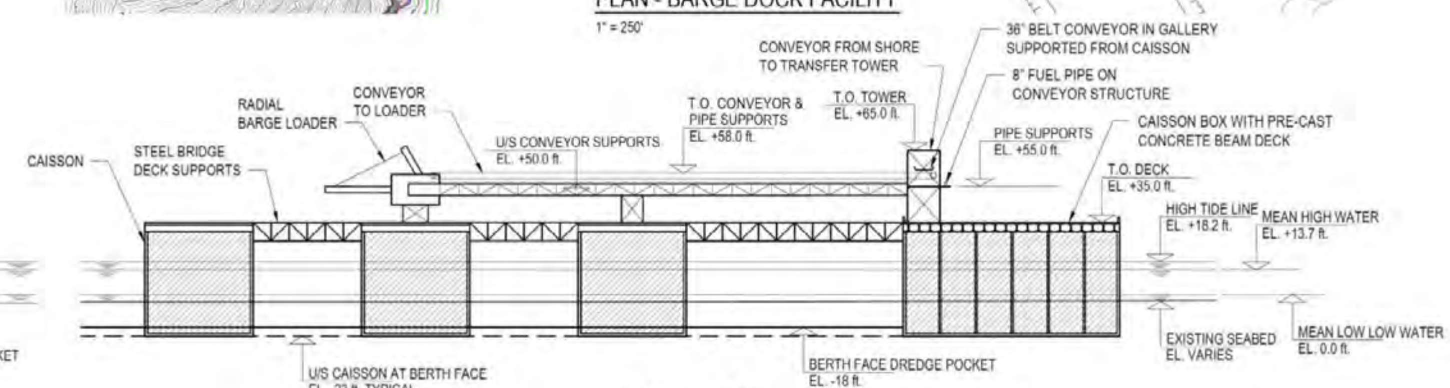
SECTION A

1":50'



SECTION C

1":50'



SECTION B

1":50'

NOTES:

1. DIMENSIONS AND DEPTHS ARE IN FEET, UNLESS NOTED OTHER
2. HORIZONTAL DATUM TO UTM NAD83, ALASKA STATE PLANE ZON

50' 0 50' 100' 150'

SCALE: 1"=50'

250' 0 250' 500' 750'

SCALE: 1"=250'

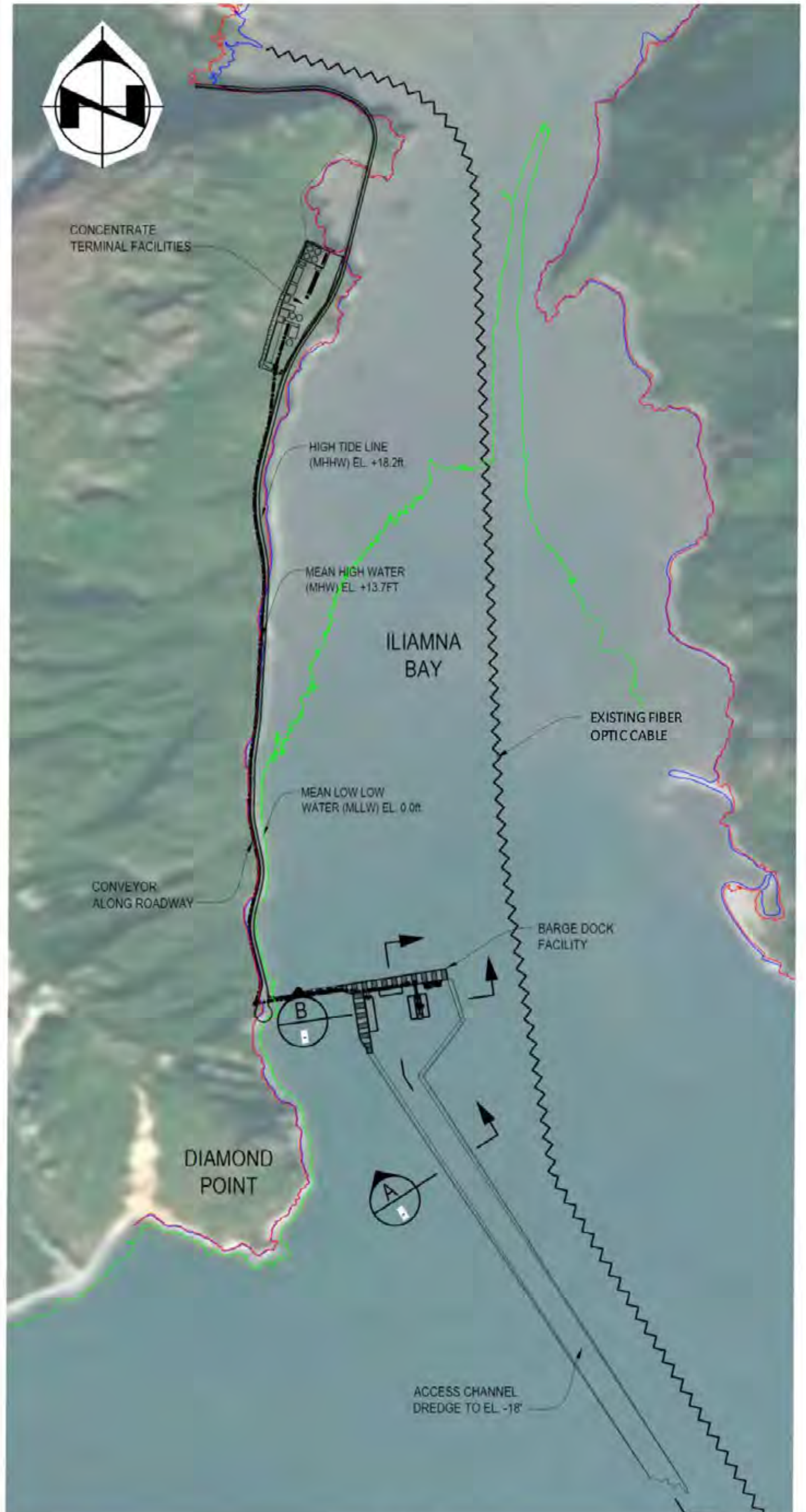
THE pebble PARTNERSHIP

Figure NO.
A - 1

DIAMOND POINT PORT PLAN AND CROSS SECTION VIEW

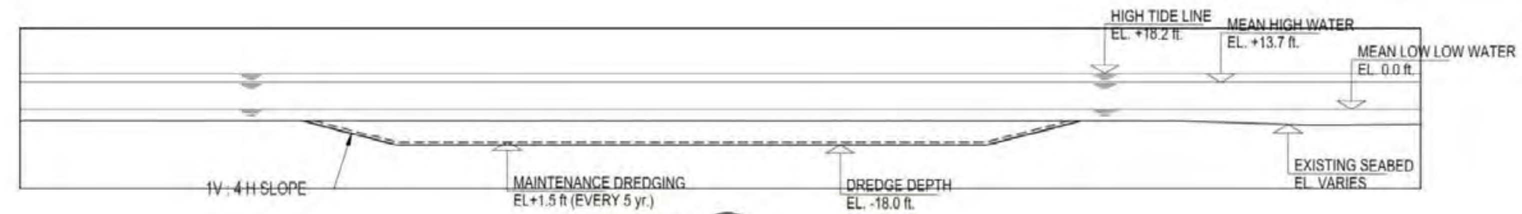
Essential Fish Habitat Assessment

File: PLPEFH_032	Date: 5/26/2020
Revision: 00	Author: ORNRC



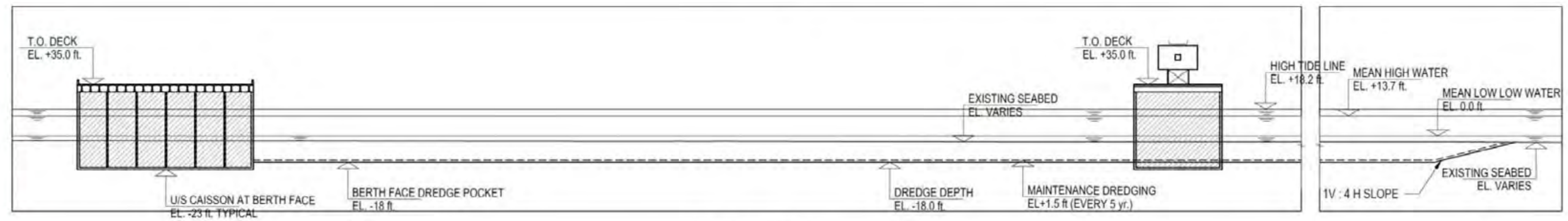
PLAN

1" = 1500'



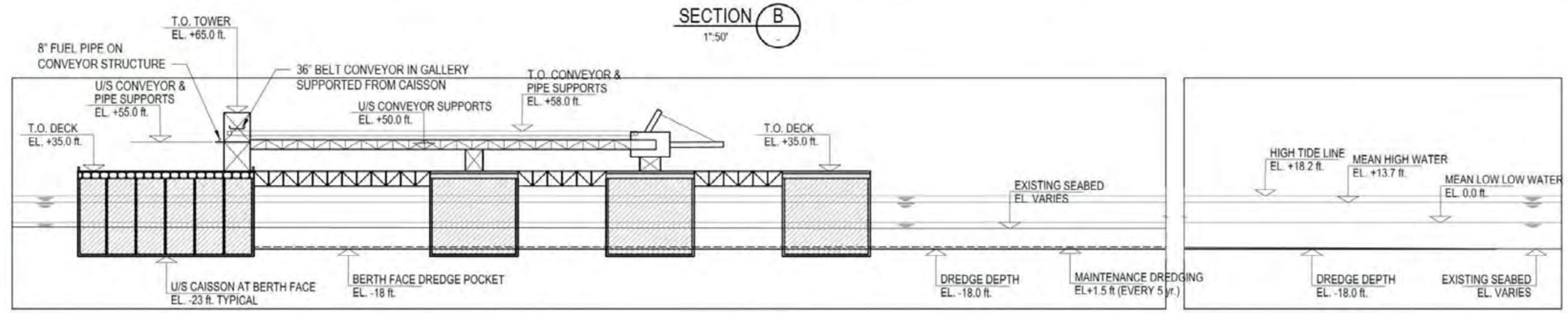
SECTION A

1"=50'



SECTION B

1"=50'

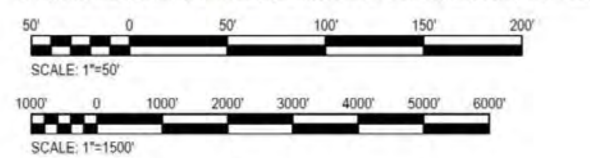


SECTION C

1"=50'

NOTES:

1. DIMENSIONS AND DEPTHS ARE IN FEET, UNLESS NOTED OTHERWISE.
2. HORIZONTAL DATUM TO UTM NAD83, ALASKA STATE PLANE ZONE 5, US SURVEY FEET.



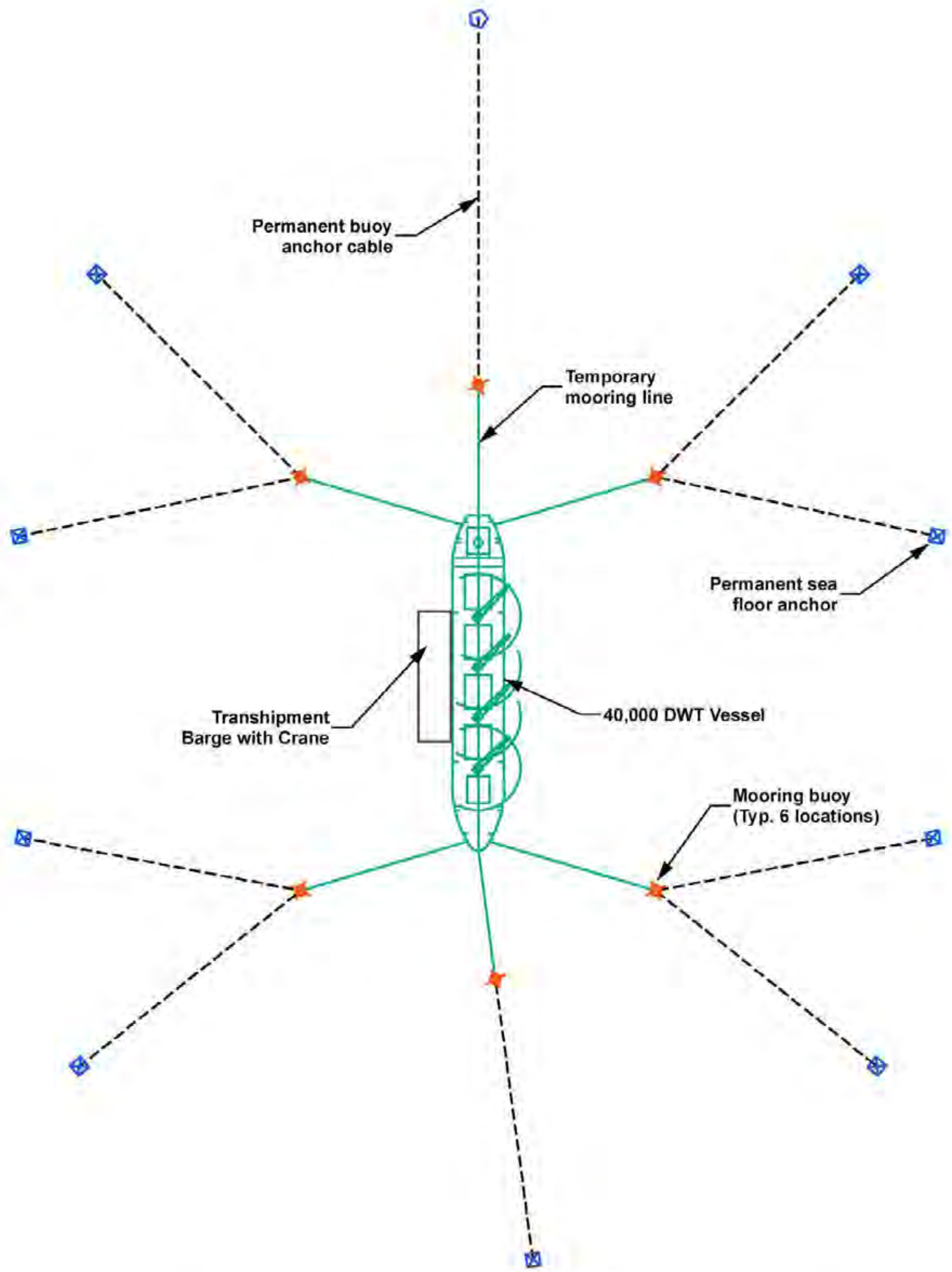
THE pebble PARTNERSHIP

Figure NO.
A - 2

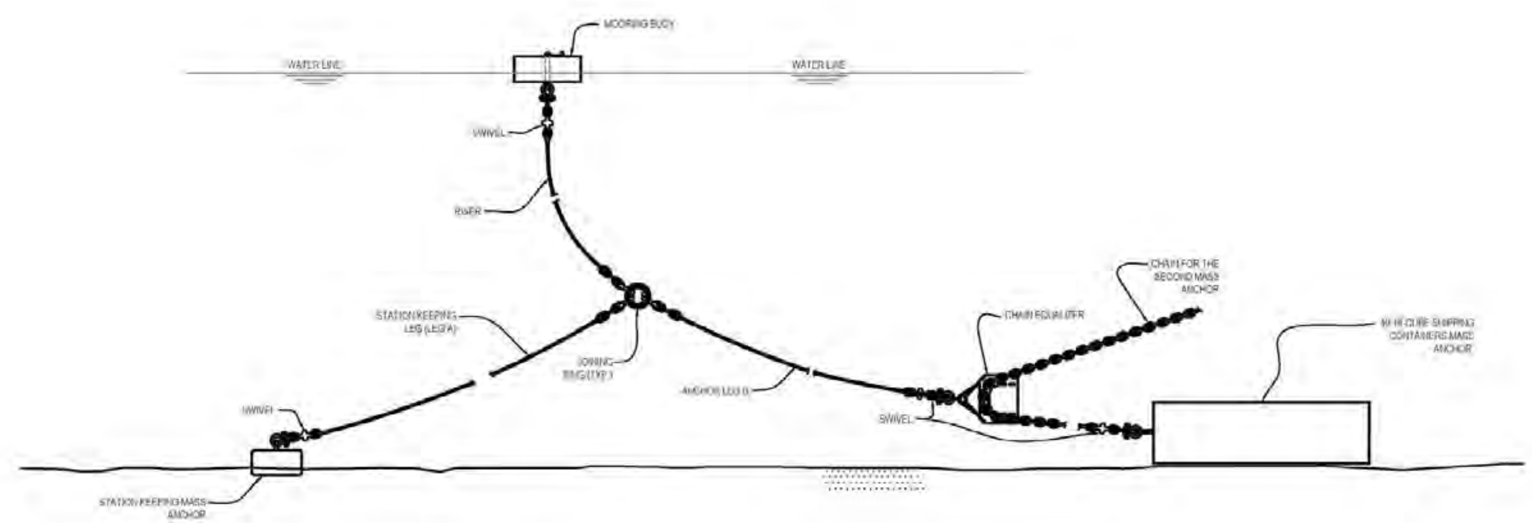
NAVIGATION CHANNEL AND BASIN PLAN AND CROSS SECTION VIEW

Essential Fish Habitat Assessment

File: PLPEFH_031	Date: 5/26/2020
Revision: 00	Author: ORNRC



LIGHTERING SPREAD MOORING SYSTEM ARRANGEMENT



TYPICAL ANCHOR DESIGN

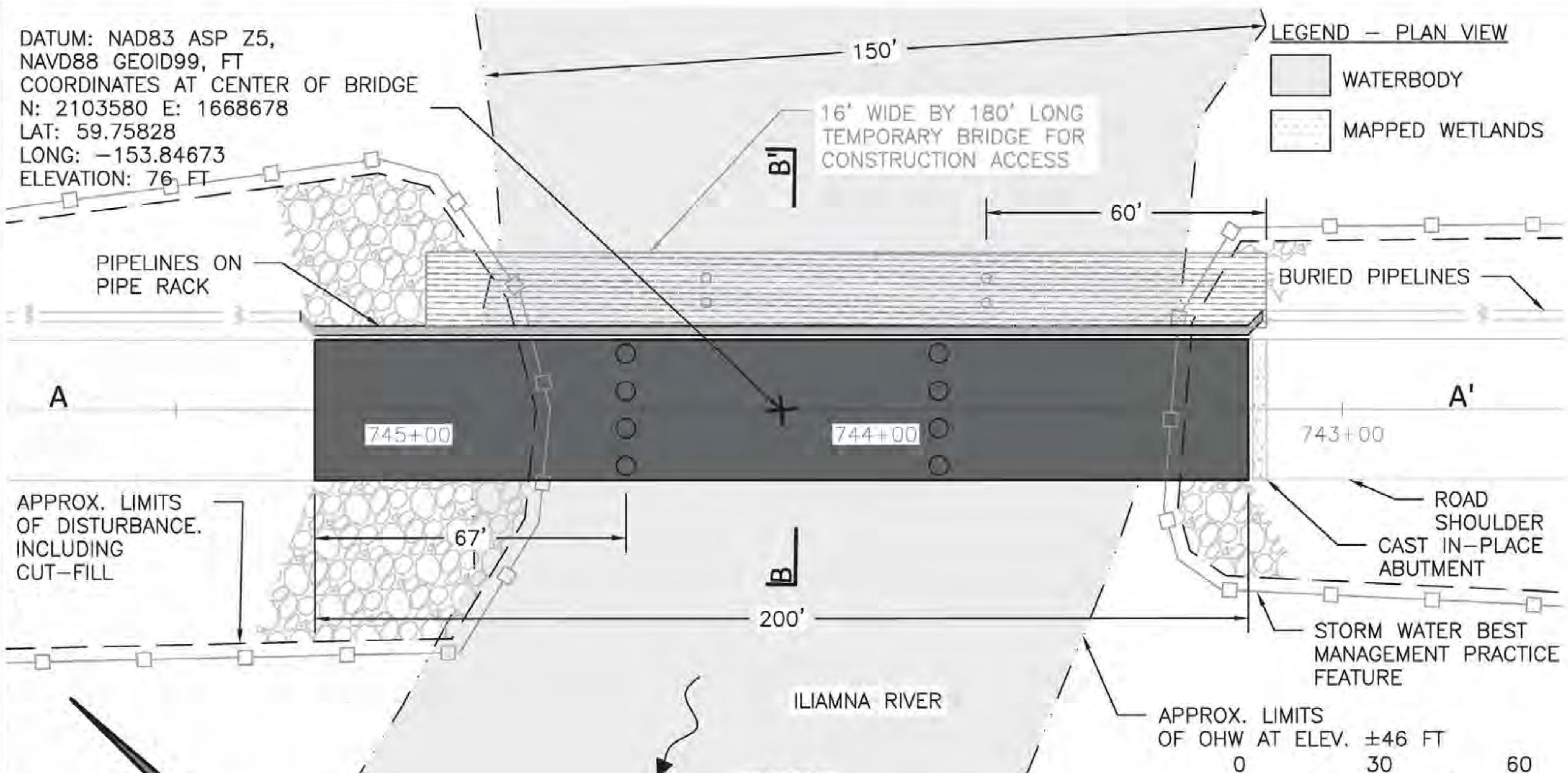
PEBBLE PROJECT

APPLICANT: **PEBBLE LIMITED PARTNERSHIP**

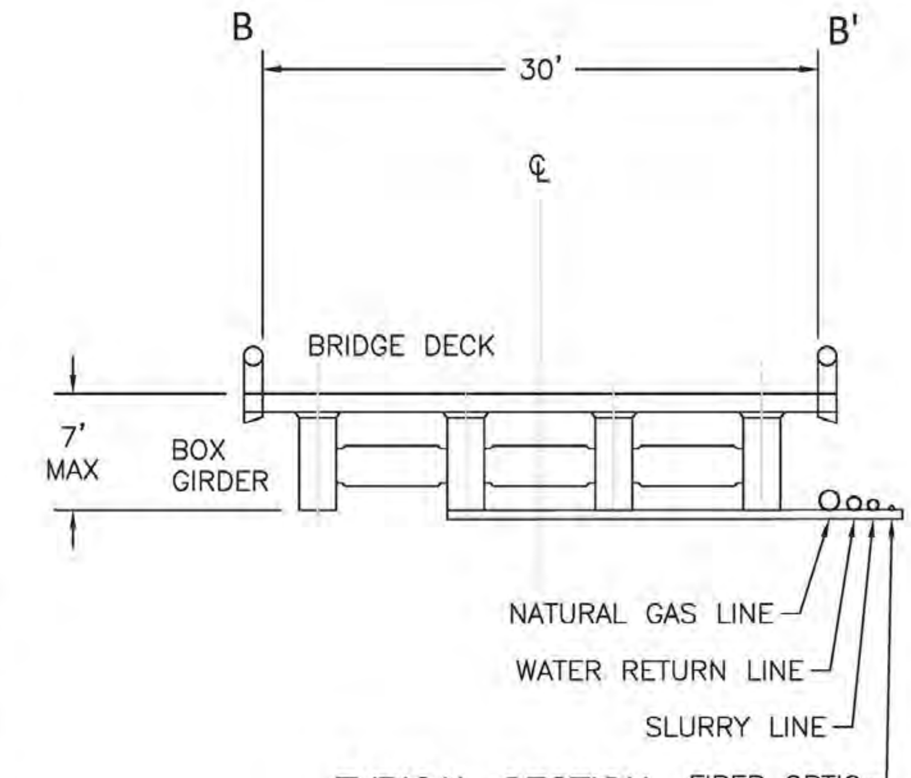
LAT., LONG. OF MINE	PROPOSED ACTIVITY:
59°53'51.29"N 155°18'2.83"W	**MINERAL DEVELOPMENT**
WATERWAY: **COOK INLET**	FILE NO. **POA-2017-271**

DRAWING TITLE:
LIGHTERING SPREAD MOORING SYSTEM ARRANGEMENT AND TYPICAL ANCHOR DESIGN

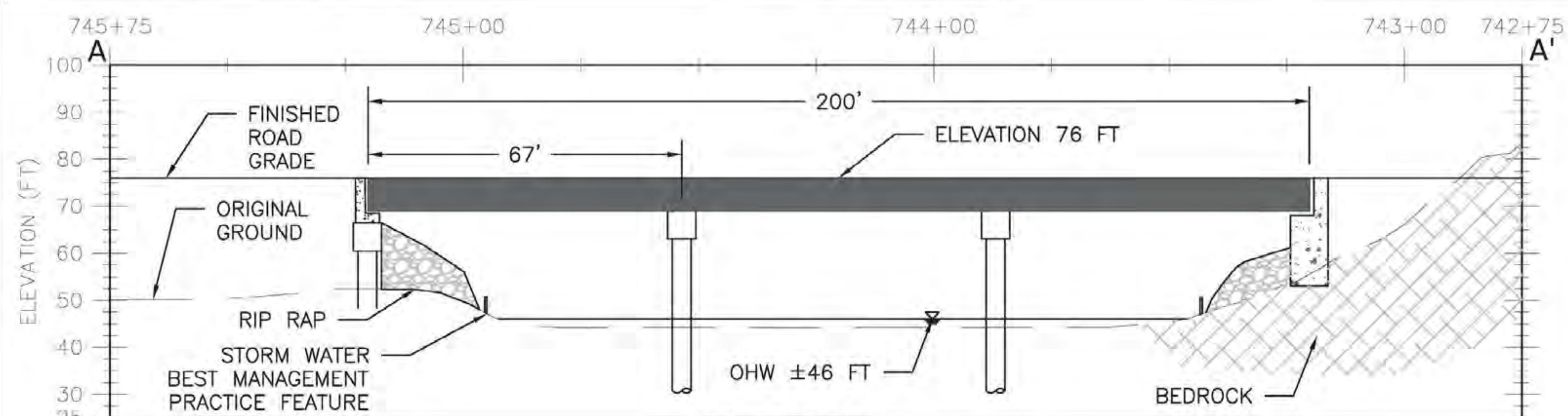
DATE:	FIGURE NO.
JANUARY 2019	**A - 3**



PLAN
1" = 30'



TYPICAL SECTION
1" = 10'

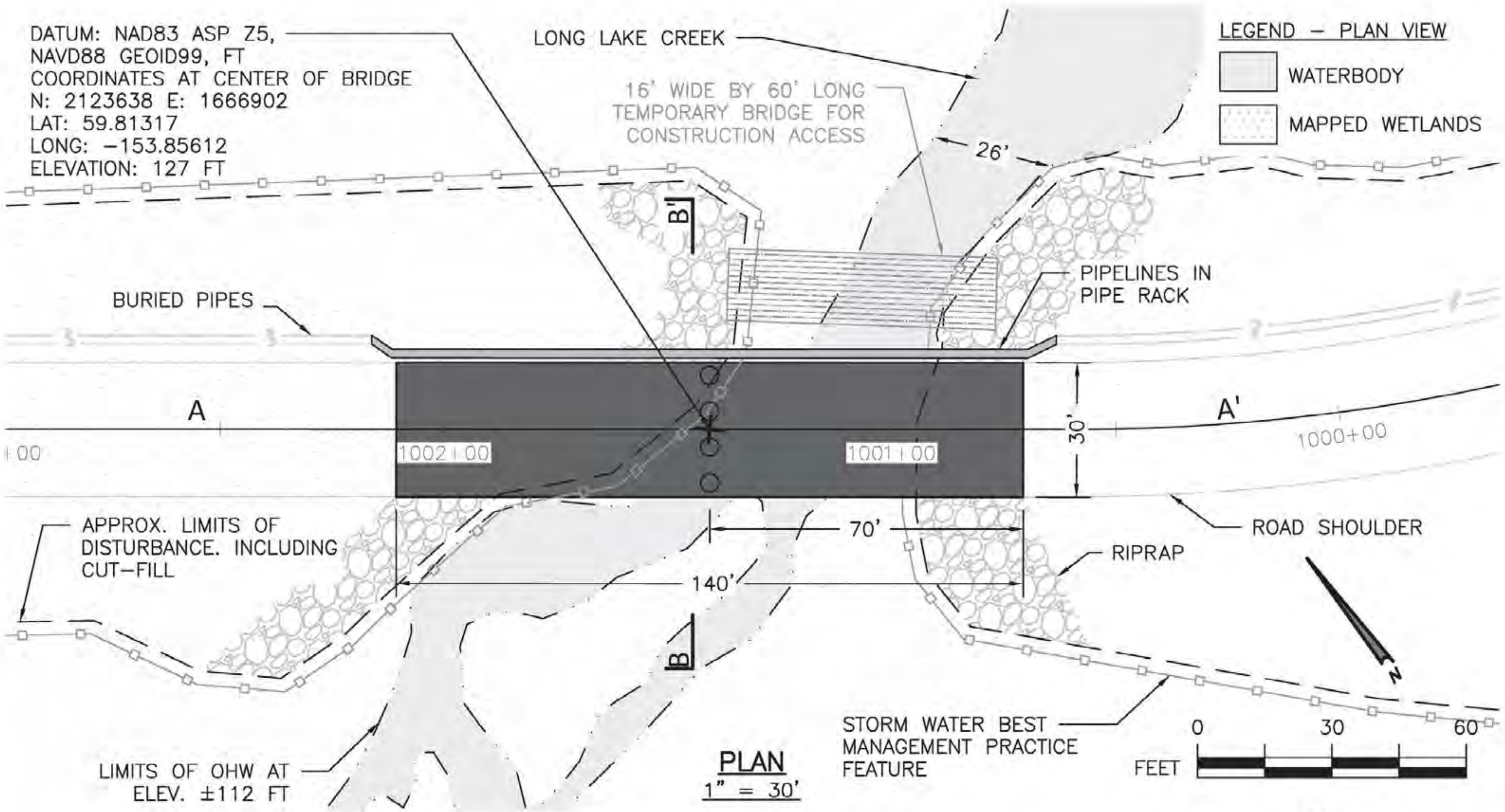


ELEVATION
1" = 30' HORZ. & VERT. 1:1

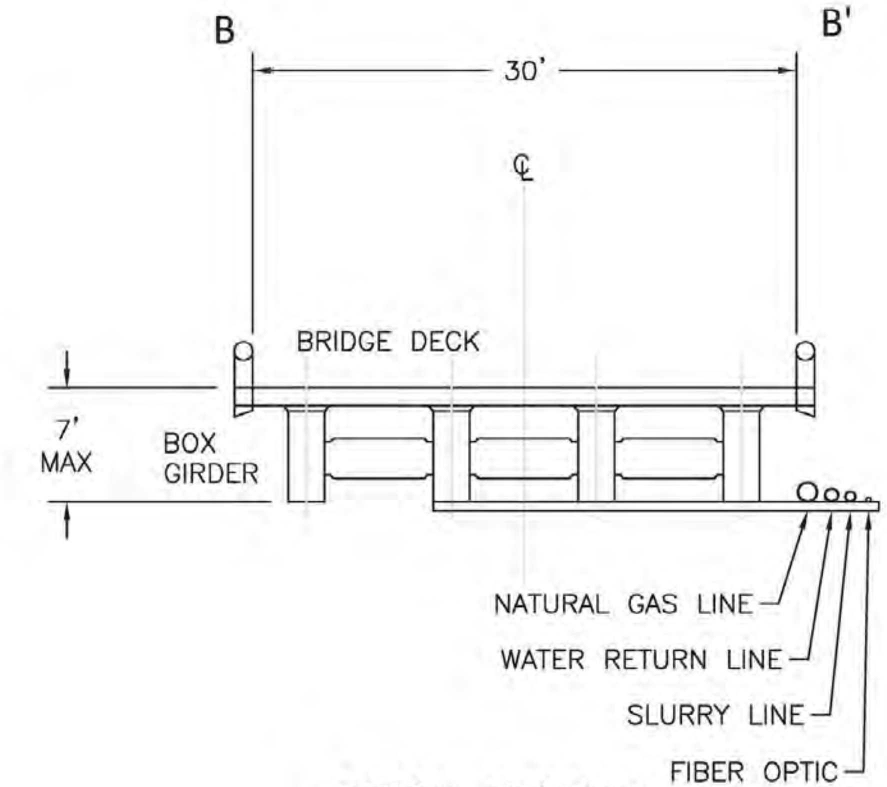
NOTES:

1. CONCEPTUAL PLANS BASED ON 2004 & 2008 LIDAR AND 2004 IMAGERY PROVIDED BY THE STATE OF ALASKA
2. STATIONING CURRENT AS OF 04/09/2020
3. OHW IS APPROXIMATE. OHW TO BE VERIFIED BY FUTURE STREAM CROSSING SURVEYS.
3. STORMWATER BEST MANAGEMENT PRACTICE FEATURES TO BE APPLIED AS APPROPRIATE FOR SITE CONDITIONS. FEATURES MAY INCLUDE: SILT FENCE, STRAW WATTLES, EROSION CONTROL MATS, OR SURFACE ARMORING WITH ROCK
4. TEMPORARY CONSTRUCTION ACCESS ROAD TO UTILIZE 16 FT WIDTH SINGLE LANE, THREE SPAN TEMPORARY BRIDGE WITH TIMBER PAD ABUTMENTS, FIELD LOCATED BY THE ENGINEER.
5. ILIAMNA RIVER BRIDGE IS PROPOSED LENGTH IS 200 FT WITH THREE SPANS AT 67 FT EACH. NORTH ABUTMENT PROPOSED AS SPILL THROUGH WITH PILE SUBSTRUCTURE. SOUTH ABUTMENT AND SUBSTRUCTURE PROPOSED AS CAST IN–PLACE.

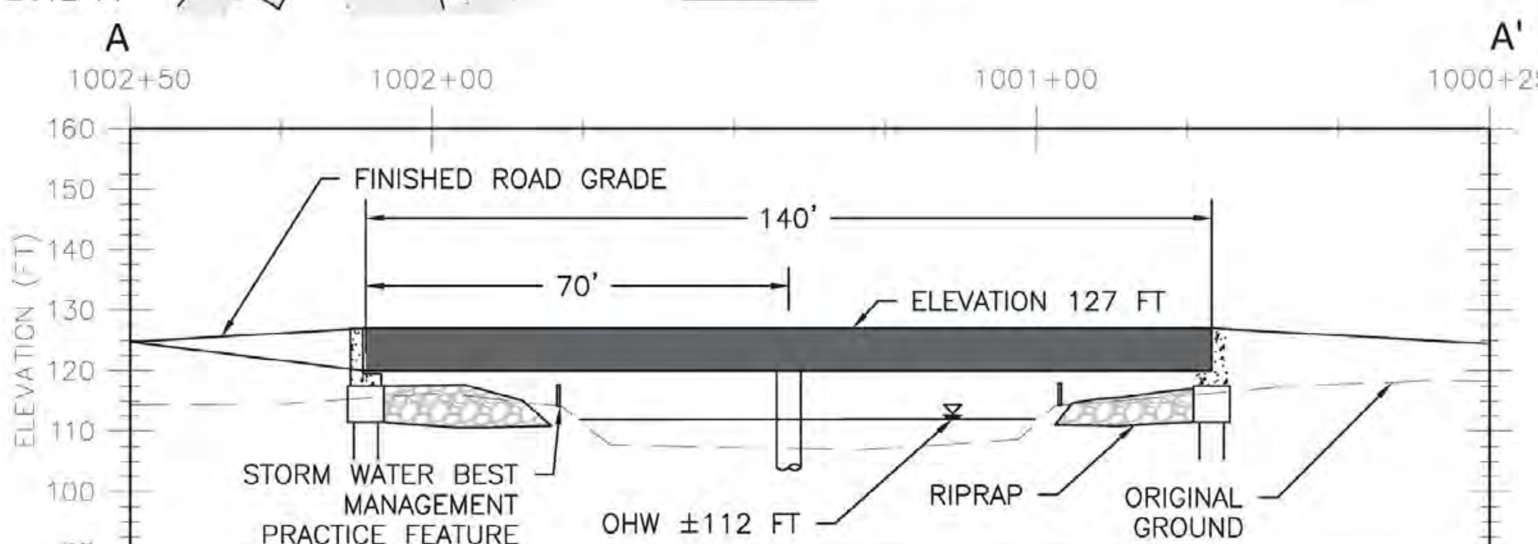
PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **ILIAMNA RIVER BRIDGE PLAN, PROFILE, AND TYPICAL SECTION**	
LAT., LONG. OF MINE 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: MINERAL DEVELOPMENT		
WATERWAY: ILIAMNA RIVER	FILE NO. POA-2017-271	DATE: JUNE 2020	FIGURE NO. A-4



PLAN
1" = 30'



TYPICAL SECTION
1" = 10'

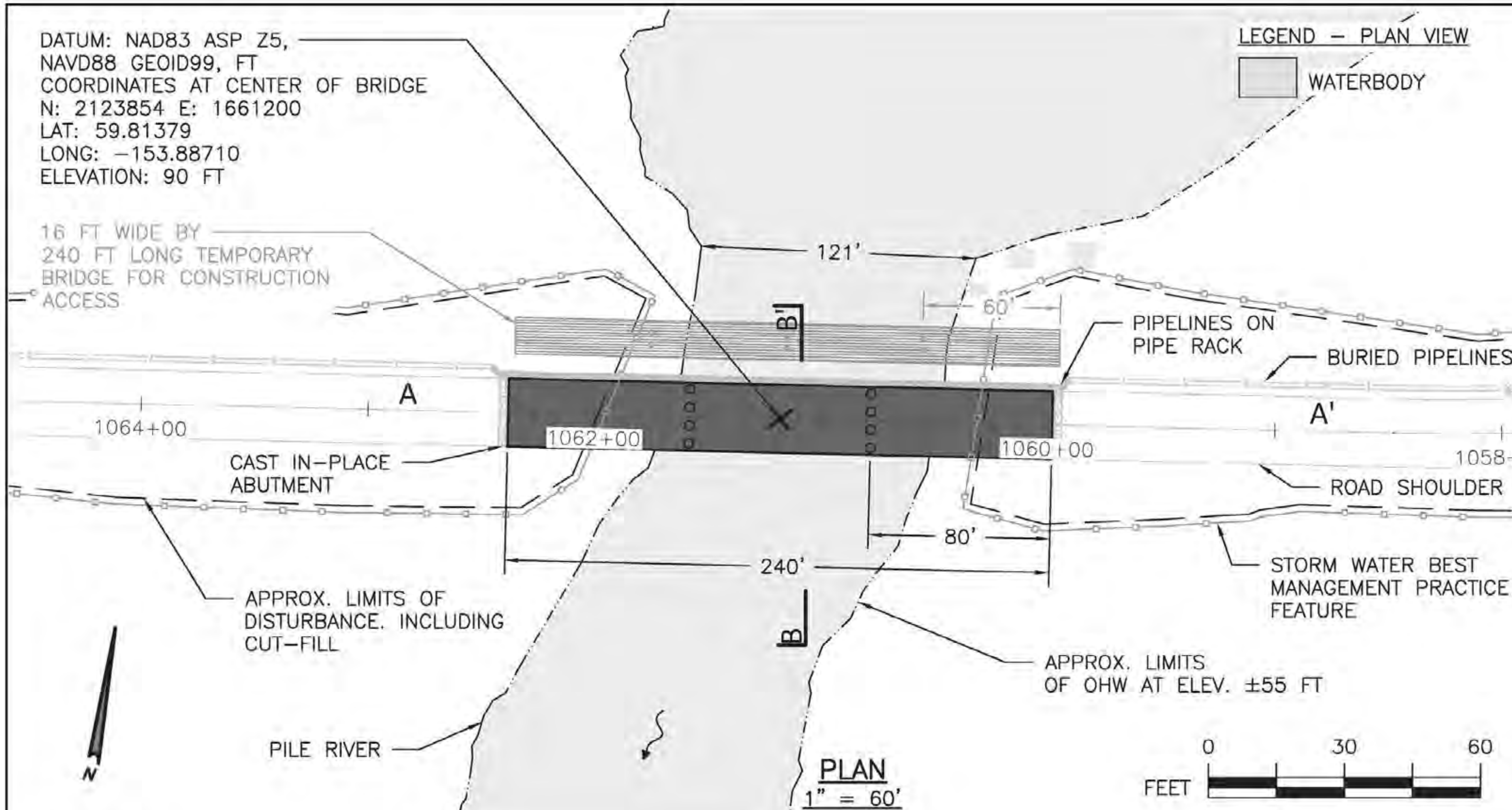


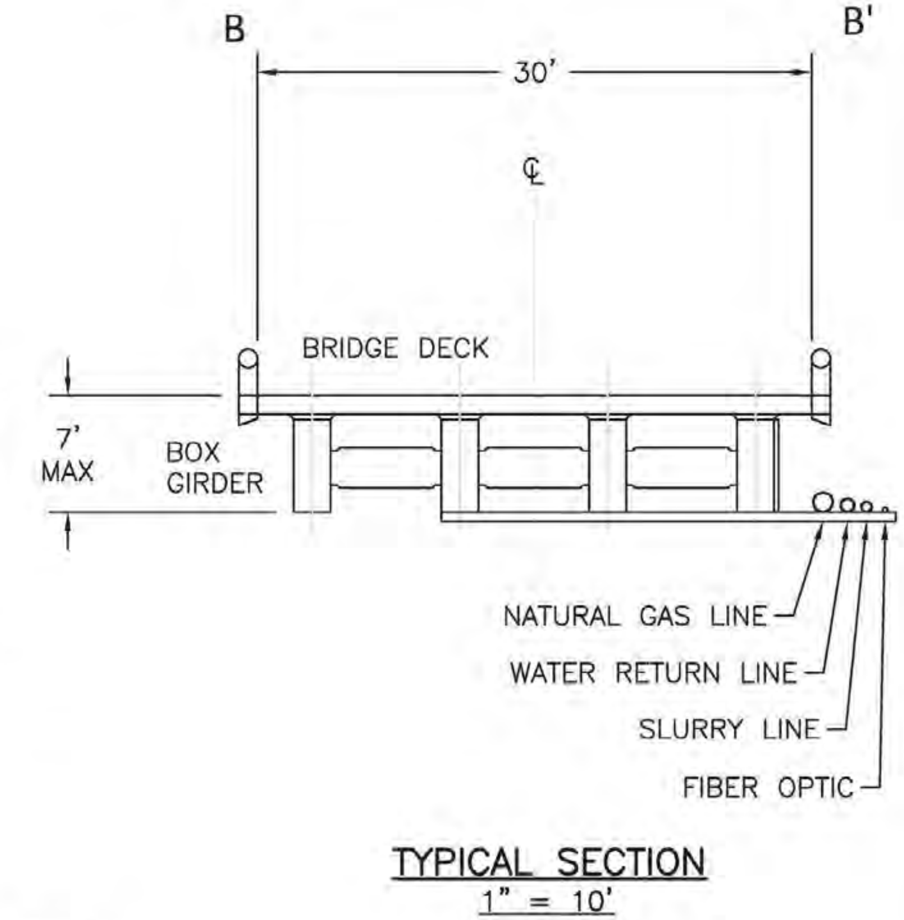
ELEVATION
1" = 30' HORIZ. & VERT. 1:1

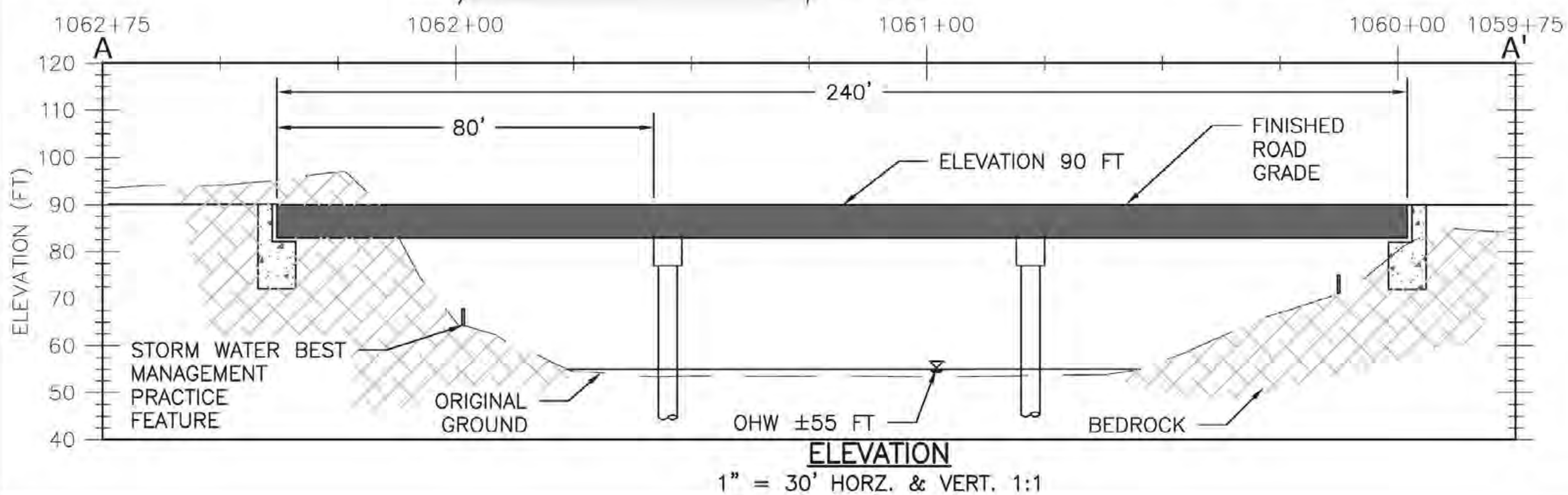
NOTES:

1. CONCEPTUAL PLANS BASED ON 2004 & 2008 LIDAR AND 2004 IMAGERY PROVIDED BY THE STATE OF ALASKA.
2. STATIONING CURRENT AS OF 04/09/2020
3. OHW IS APPROXIMATE. OHW TO BE VERIFIED BY FUTURE STREAM CROSSING SURVEYS.
4. TEMPORARY CONSTRUCTION ACCESS ROAD TO UTILIZE 16 FT WIDTH SINGLE LANE CLEAR SPAN TEMPORARY BRIDGE WITH TIMBER PAD ABUTMENTS, FIELD LOCATED BY THE ENGINEER. NO CONSTRUCTION BELOW OHW.
3. STORMWATER BEST MANAGEMENT PRACTICE FEATURES TO BE APPLIED AS APPROPRIATE FOR SITE CONDITIONS. FEATURES MAY INCLUDE: SILT FENCE, STRAW WATTLES, EROSION CONTROL MATS, OR SURFACE ARMORING WITH ROCK
4. LONG LAKE CREEK BRIDGE PROPOSED LENGTH IS 140 FT WITH TWO SPANS OF 70 FT EACH. PROPOSED ABUTMENTS TO BE SPILL THROUGH AND SUBSTRUCTURE TO BE PILE.

PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **LONG LAKE CREEK BRIDGE PLAN, PROFILE, AND TYPICAL SECTION**	
LAT., LONG. OF MINE 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: **MINERAL DEVELOPMENT**		
WATERWAY: PILE RIVER	FILE NO. **POA-2017-271**	DATE: **JUNE 2020**	FIGURE NO. **A-5**



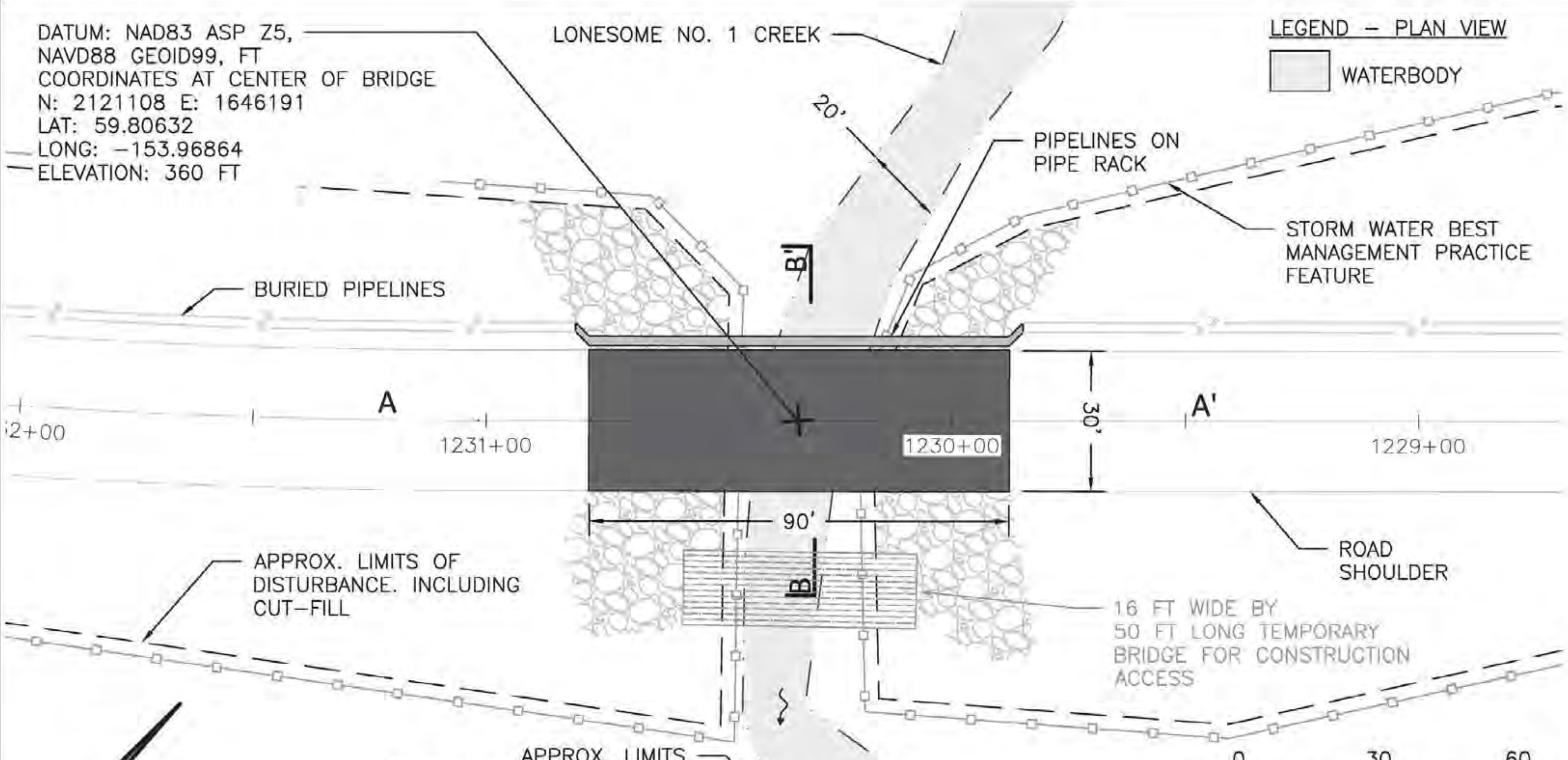




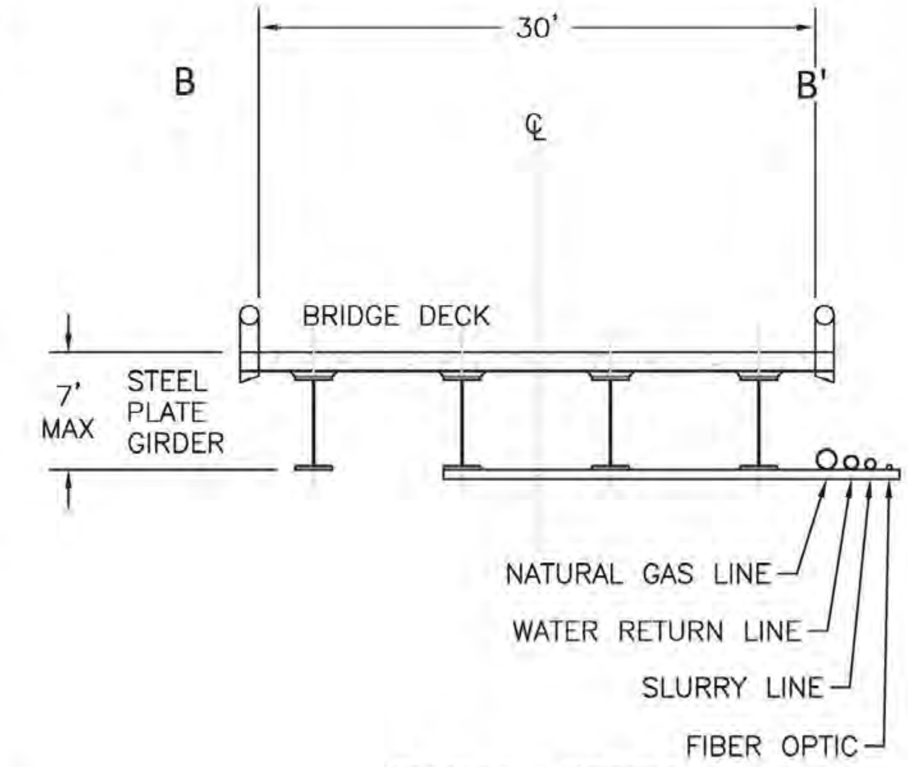
NOTES:

1. CONCEPTUAL PLANS BASED ON 2004 & 2008 LIDAR AND 2004 IMAGERY PROVIDED BY THE STATE OF ALASKA
2. STATIONING CURRENT AS OF 04/09/2020
3. OHW IS APPROXIMATE. OHW TO BE VERIFIED BY FUTURE STREAM CROSSING SURVEYS.
3. STORMWATER BEST MANAGEMENT PRACTICE FEATURES TO BE APPLIED AS APPROPRIATE FOR SITE CONDITIONS. FEATURES MAY INCLUDE: SILT FENCE, STRAW WATTLES, EROSION CONTROL MATS, OR SURFACE ARMORING WITH ROCK
4. TEMPORARY CONSTRUCTION ACCESS ROAD TO UTILIZE 16 FT WIDTH SINGLE LANE FOUR SPAN TEMPORARY BRIDGE WITH TIMBER PAD ABUTMENTS, FIELD LOCATED BY THE ENGINEER.
5. PILE RIVER BRIDGE PROPOSED LENGTH IS 240 FT WITH THREE SPANS AT 80 FT EACH. PROPOSED ABUTMENTS TO BE CAST IN–PLACE ON BEDROCK AND SUBSTRUCTURE TO BE CAST IN–PLACE.

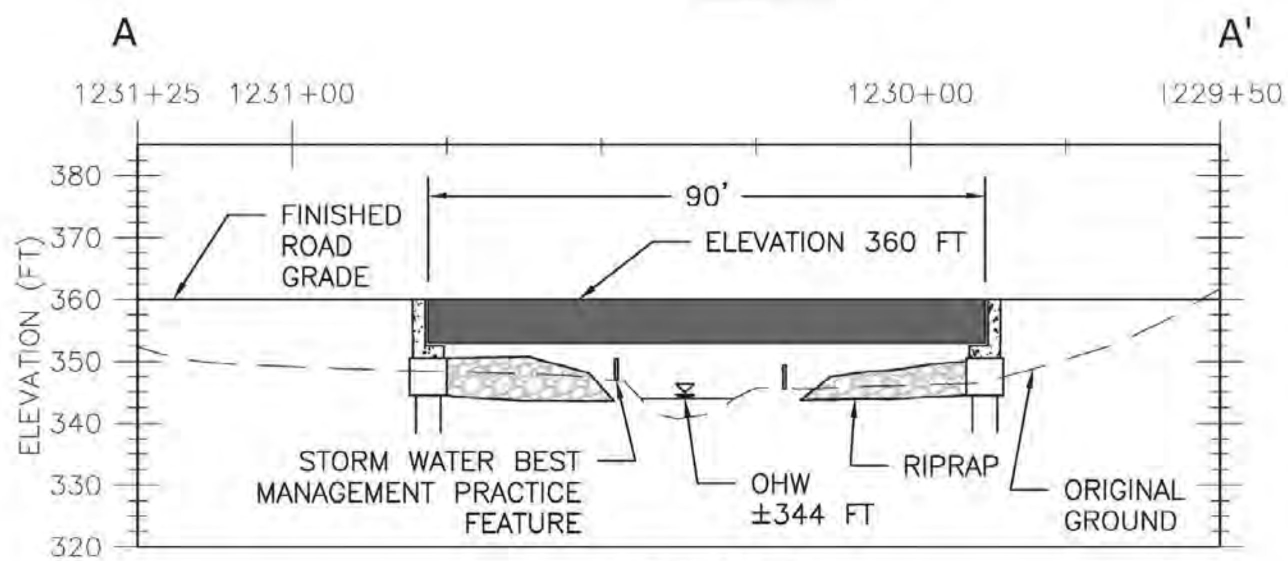
PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **PILE RIVER BRIDGE PLAN, PROFILE, AND TYPICAL SECTION**	
LAT., LONG. OF MINE 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: **MINERAL DEVELOPMENT**		
WATERWAY: **PILE RIVER**	FILE NO. **POA-2017-271**	DATE: **JUNE 2020**	FIGURE NO. **A-6**



PLAN
1" = 30'



TYPICAL SECTION
1" = 10'

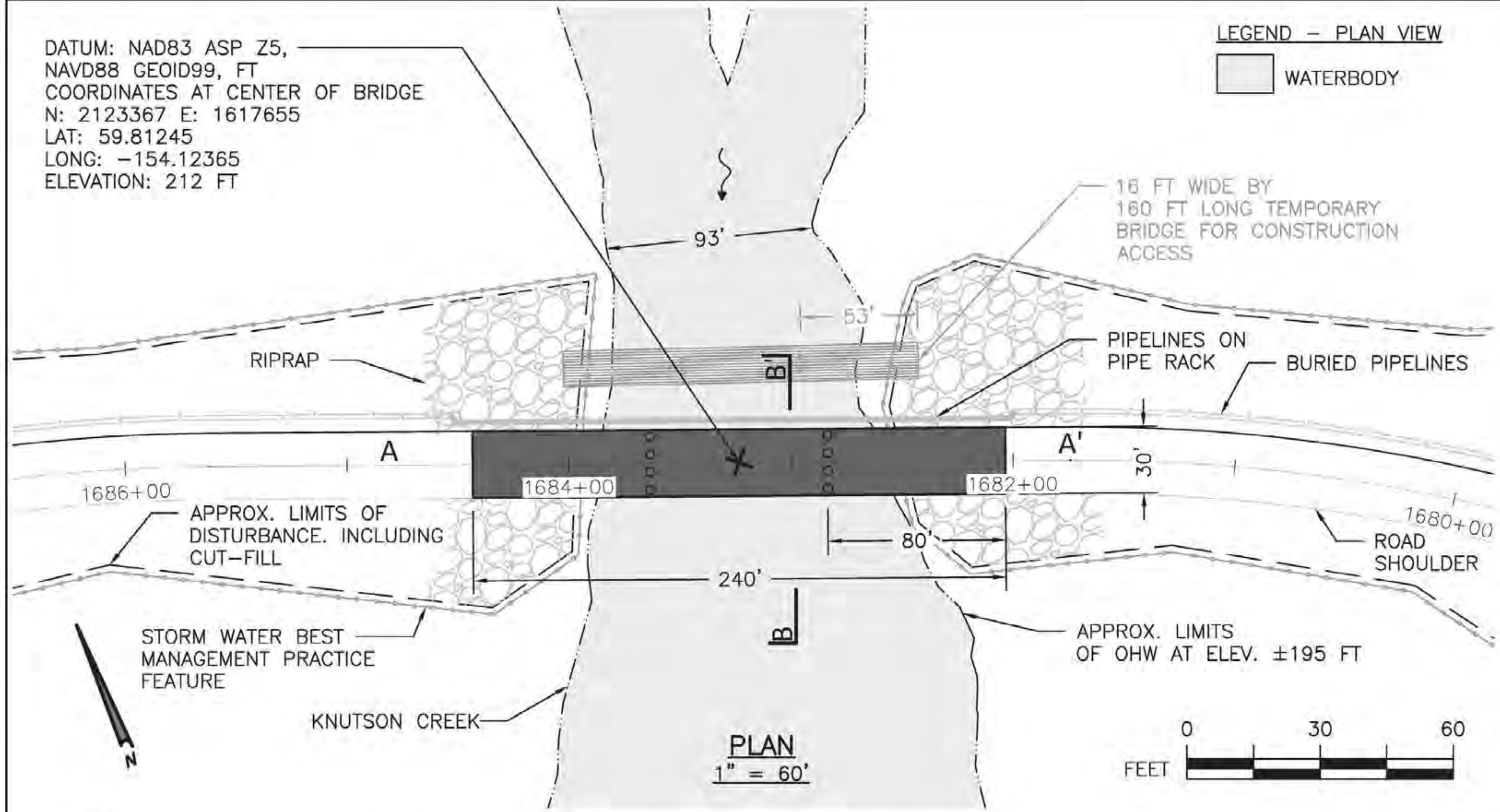


ELEVATION
1" = 30' HORZ. & VERT. 1:1

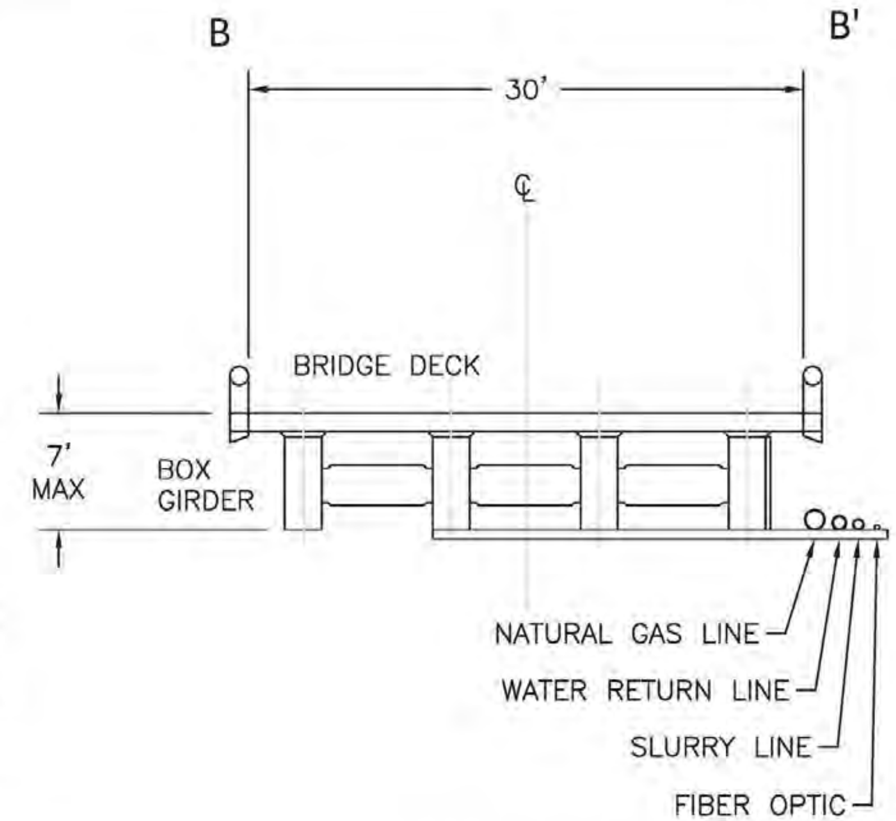
NOTES:

1. CONCEPTUAL PLANS BASED ON 2004 & 2008 LIDAR AND 2004 IMAGERY PROVIDED BY THE STATE OF ALASKA
2. STATIONING CURRENT AS OF 04/09/2020
3. OHW IS APPROXIMATE. OHW TO BE VERIFIED BY FUTURE STREAM CROSSING SURVEYS.
3. STORMWATER BEST MANAGEMENT PRACTICE FEATURES TO BE APPLIED AS APPROPRIATE FOR SITE CONDITIONS. FEATURES MAY INCLUDE: SILT FENCE, STRAW WATTLES, EROSION CONTROL MATS, OR SURFACE ARMORING WITH ROCK
4. TEMPORARY CONSTRUCTION ACCESS ROAD TO UTILIZE 16 FT WIDTH SINGLE LANE CLEAR SPAN TEMPORARY BRIDGE WITH TIMBER PAD ABUTMENTS, FIELD LOCATED BY THE ENGINEER. NO CONSTRUCTION BELOW OHW.
5. LONESOME NO. 1 CREEK BRIDGE IS PROPOSED TO BE SINGLE SPAN, 90 FT. PROPOSED ABUTMENTS TO BE SPILL THROUGH AND SUBSTRUCTURE TO BE PILE

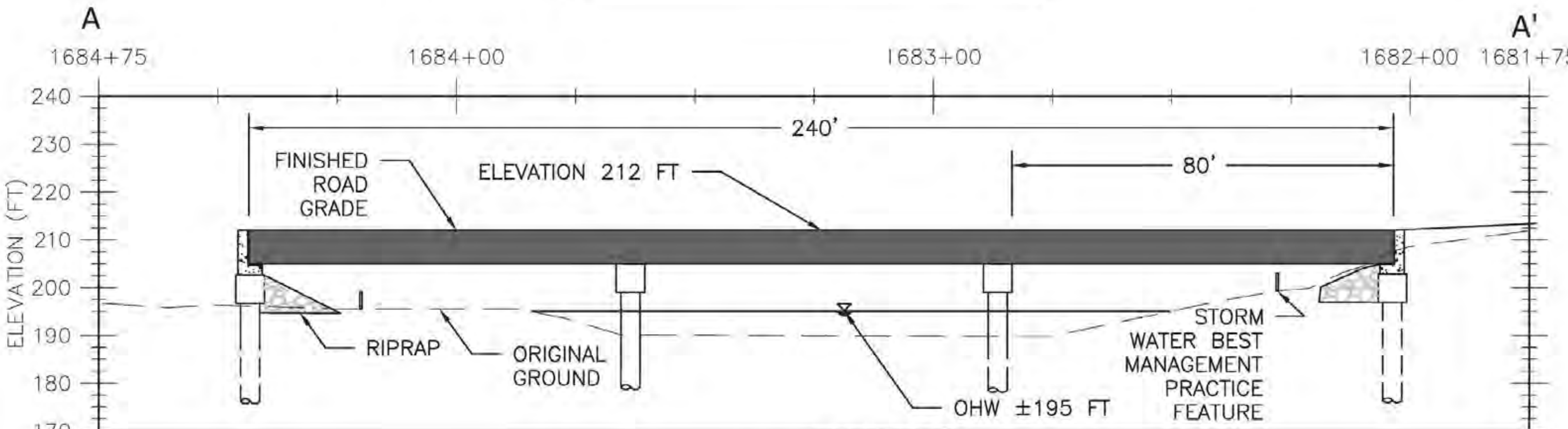
PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **LONESOME NO. 1 CREEK BRIDGE PLAN, PROFILE, AND TYPICAL SECTION**
LAT., LONG. OF MINE 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: **MINERAL DEVELOPMENT**	
WATERWAY: **ILIAMNA LAKE**	FILE NO. **POA-2017-271**	DATE: **JUNE 2020** / FIGURE NO. **A-7**



PLAN
1" = 60'



TYPICAL SECTION
1" = 10'

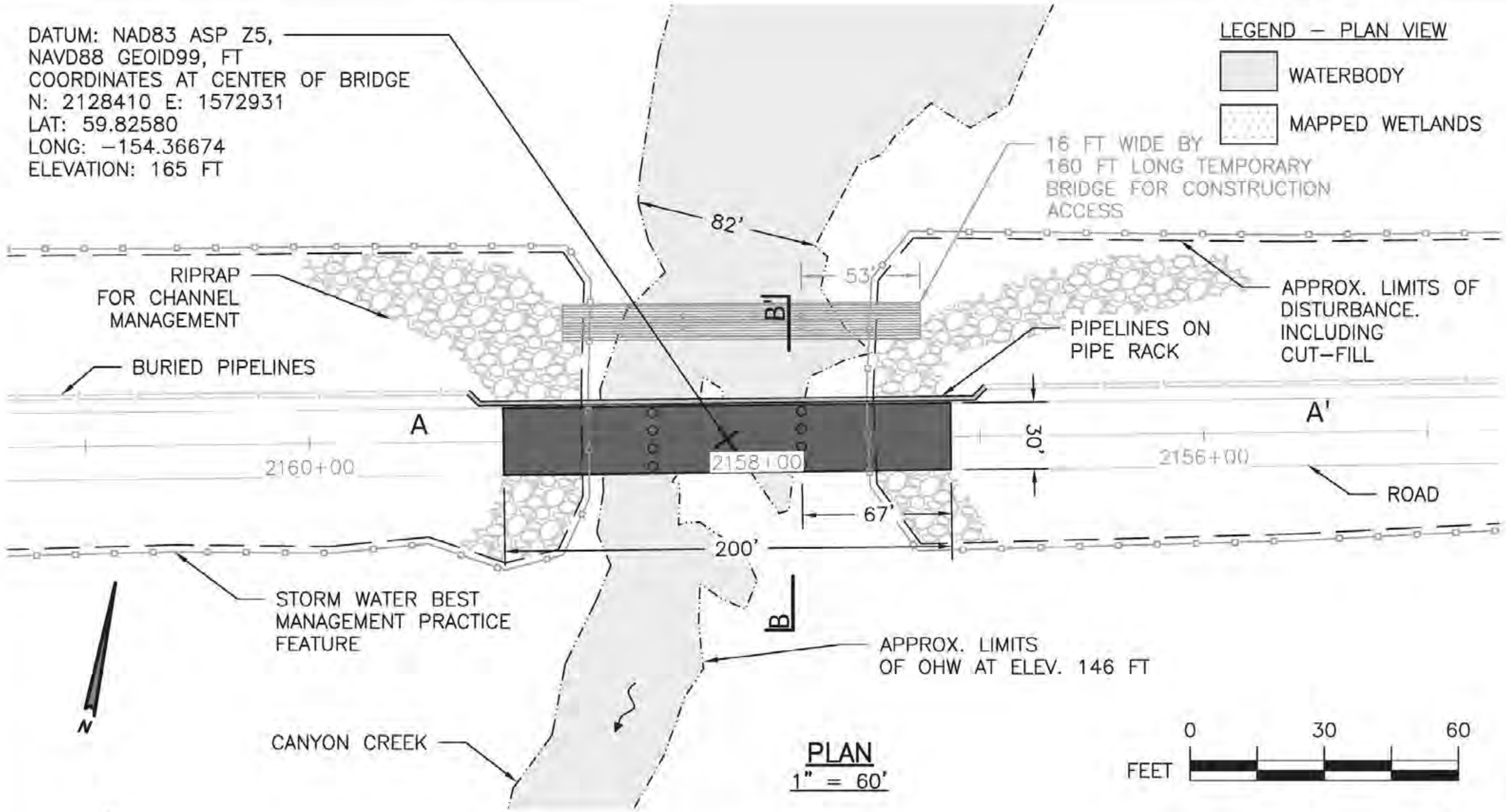


ELEVATION
1" = 30' HORZ. & VERT. 1:1

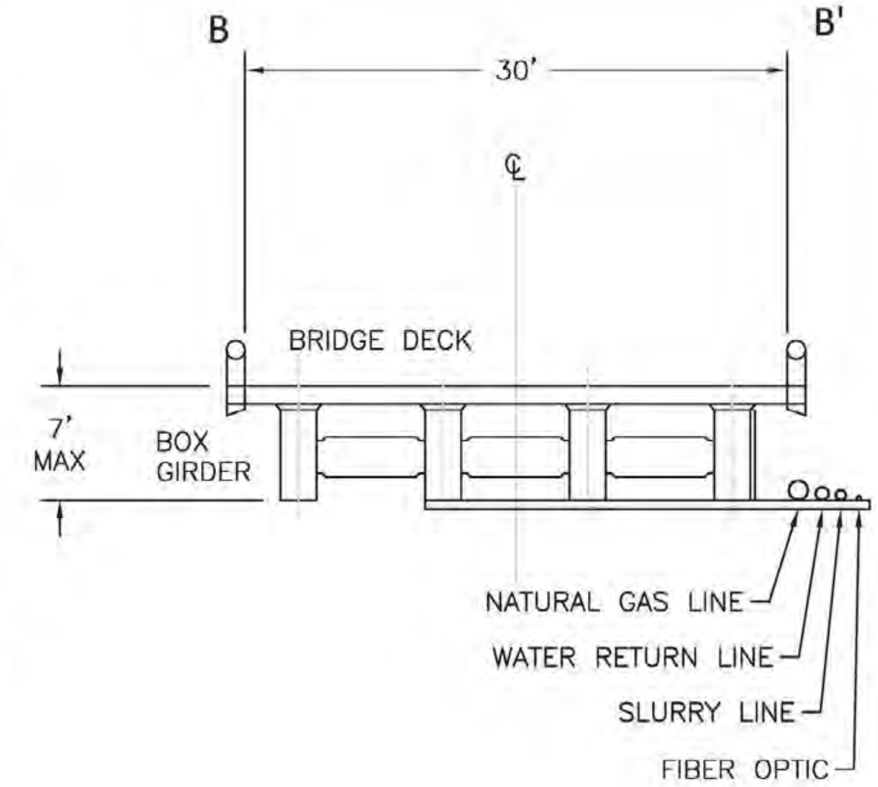
NOTES:

1. CONCEPTUAL PLANS BASED ON 2004 & 2008 LIDAR AND 2004 IMAGERY PROVIDED BY THE STATE OF ALASKA
2. STATIONING CURRENT AS OF 04/09/2020
3. OHW IS APPROXIMATE. OHW TO BE VERIFIED BY FUTURE STREAM CROSSING SURVEYS.
4. TEMPORARY CONSTRUCTION ACCESS ROAD TO UTILIZE 16 FT WIDTH SINGLE LANE, THREE SPAN TEMPORARY BRIDGE WITH TIMBER PAD ABUTMENTS, FIELD LOCATED BY THE ENGINEER.
3. STORMWATER BEST MANAGEMENT PRACTICE FEATURES TO BE APPLIED AS APPROPRIATE FOR SITE CONDITIONS. FEATURES MAY INCLUDE: SILT FENCE, STRAW WATTLES, EROSION CONTROL MATS, OR SURFACE ARMORING WITH ROCK
4. KNUTSON CREEK BRIDGE PROPOSED LENGTH IS 240 FT WITH THREE SPANS AT 80 FT EACH. PROPOSED ABUTMENTS TO BE SPILL THROUGH AND SUBSTRUCTURE TO BE PILE OR PRECAST CONCRETE PAD.

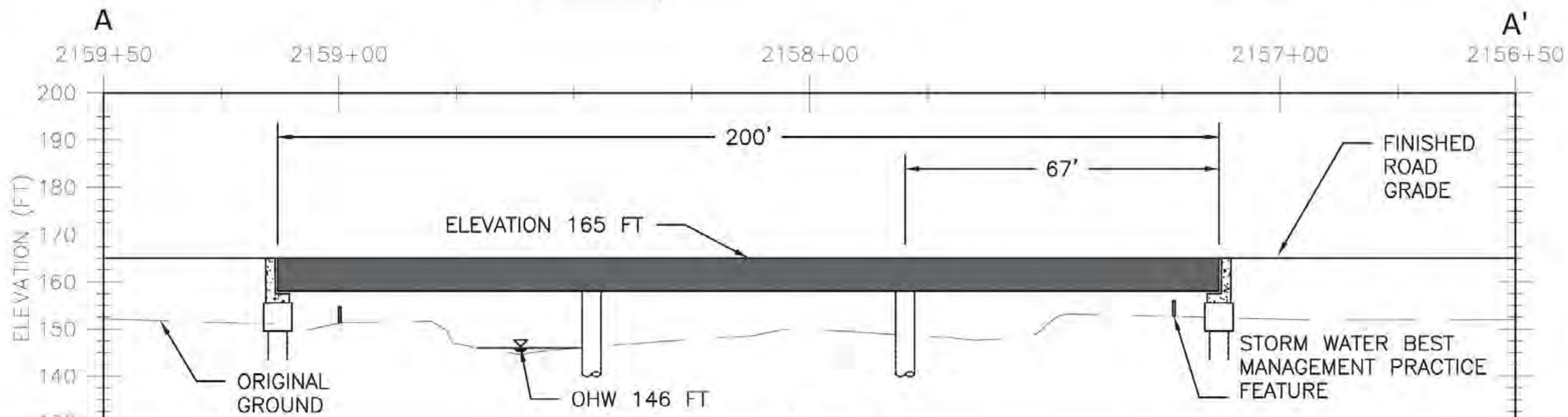
PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **KNUTSON CREEK BRIDGE PLAN, PROFILE, AND TYPICAL SECTION**	
LAT., LONG. OF MINE 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: **MINERAL DEVELOPMENT**		
WATERWAY: **ILIAMNA LAKE**	FILE NO. **POA-2017-271**	DATE: **JUNE 2020**	FIGURE NO. **A-8**



PLAN
1" = 60'



TYPICAL SECTION
1" = 10'

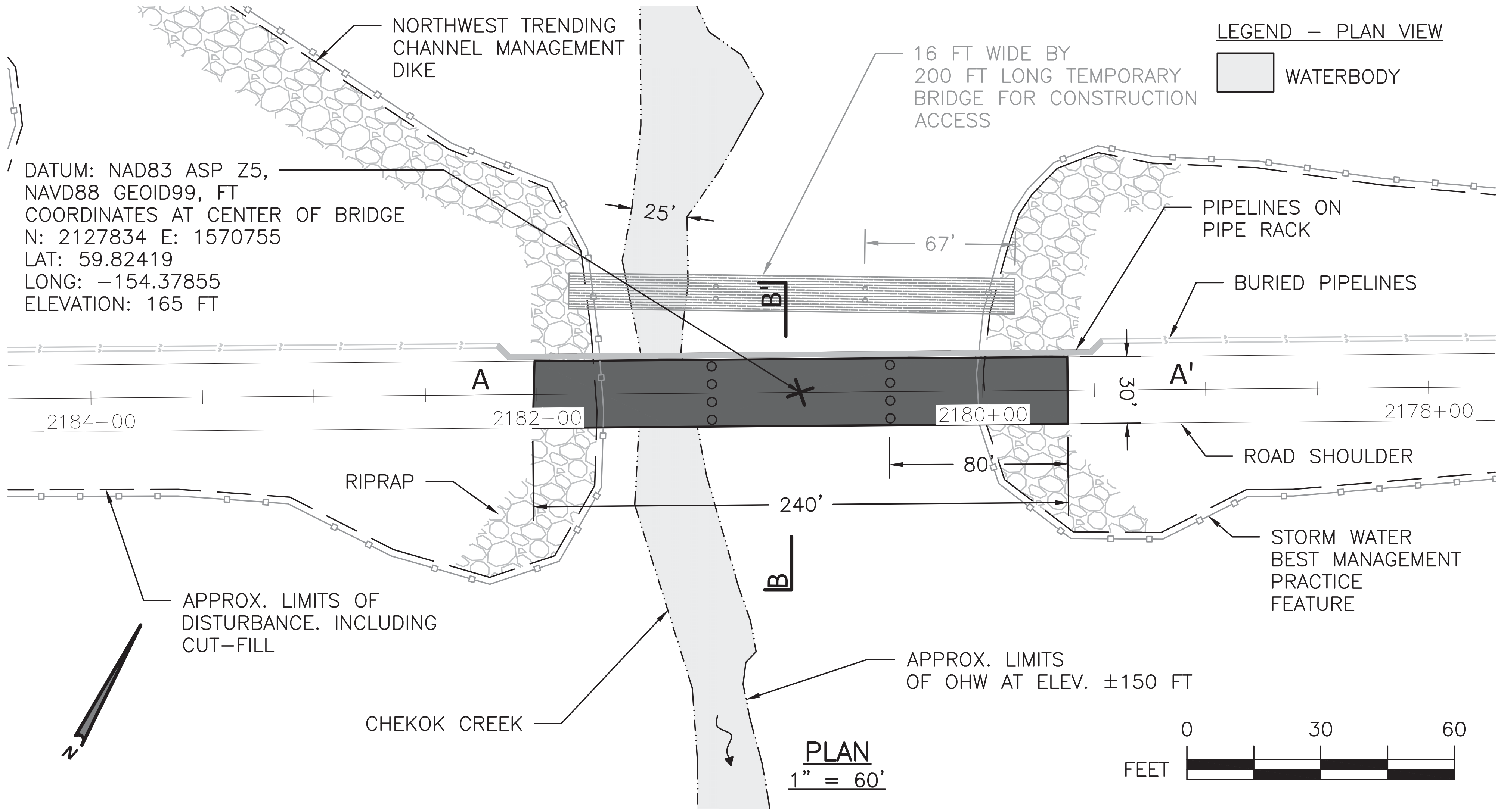


ELEVATION
1" = 30' HORZ. & VERT. 1:1

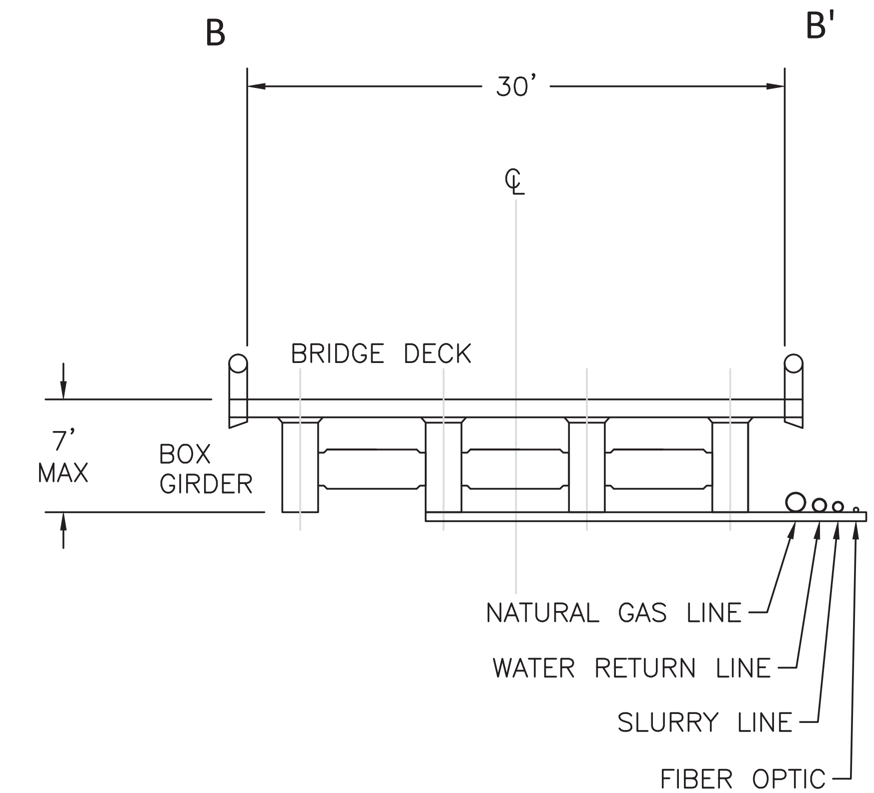
NOTES:

1. CONCEPTUAL PLANS BASED ON 2010 HYDRO SURVEY BY RECON LLC.
2. STATIONING CURRENT AS OF 04/09/2020
3. STORMWATER BEST MANAGEMENT PRACTICE FEATURES TO BE APPLIED AS APPROPRIATE FOR SITE CONDITIONS. FEATURES MAY INCLUDE: SILT FENCE, STRAW WATTLES, EROSION CONTROL MATS, OR SURFACE ARMORING WITH ROCK
4. TEMPORARY CONSTRUCTION ACCESS ROAD TO UTILIZE 16 FT WIDTH SINGLE LANE, THREE SPAN TEMPORARY BRIDGE WITH TIMBER PAD ABUTMENTS, FIELD LOCATED BY THE ENGINEER.
5. CANYON CREEK BRIDGE PROPOSED LENGTH IS 200 FT WITH THREE SPANS OF 67 FT EACH. PROPOSED ABUTMENTS TO BE SPILL THROUGH AND SUBSTRUCTURE TO BE PILE OR PRECAST CONCRETE PADS.

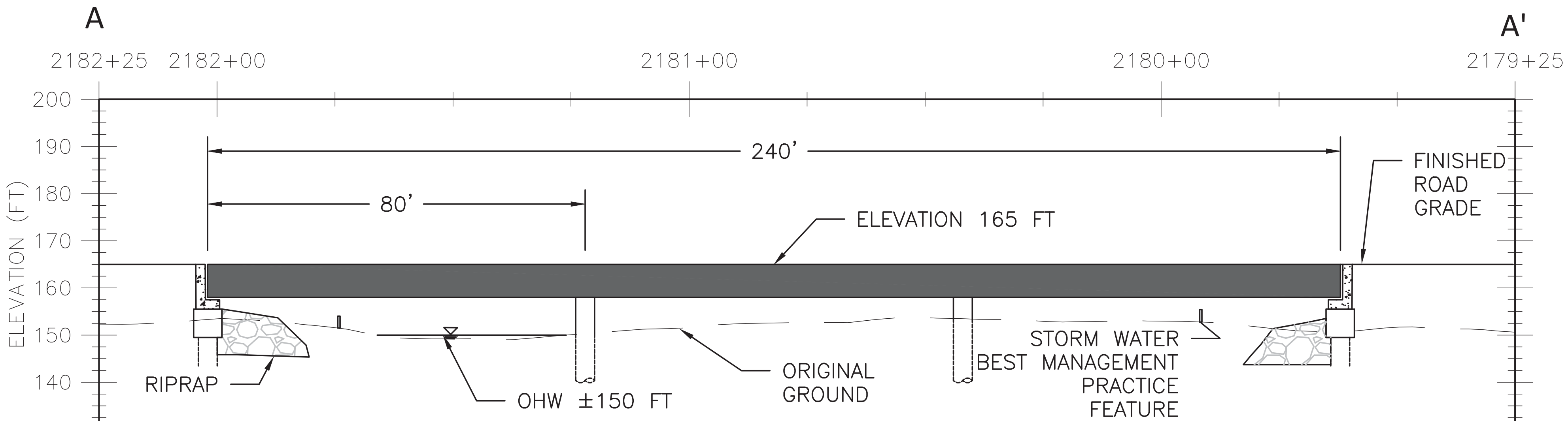
PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **CANYON CREEK BRIDGE PLAN, PROFILE, AND TYPICAL SECTION**	
LAT., LONG. OF MINE 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: **MINERAL DEVELOPMENT**		
WATERWAY: **ILIAMNA LAKE**	FILE NO. **POA-2017-271**	DATE: **JUNE 2020**	FIGURE NO. **A-9**



PLAN
1" = 60'



TYPICAL SECTION
1" = 10'

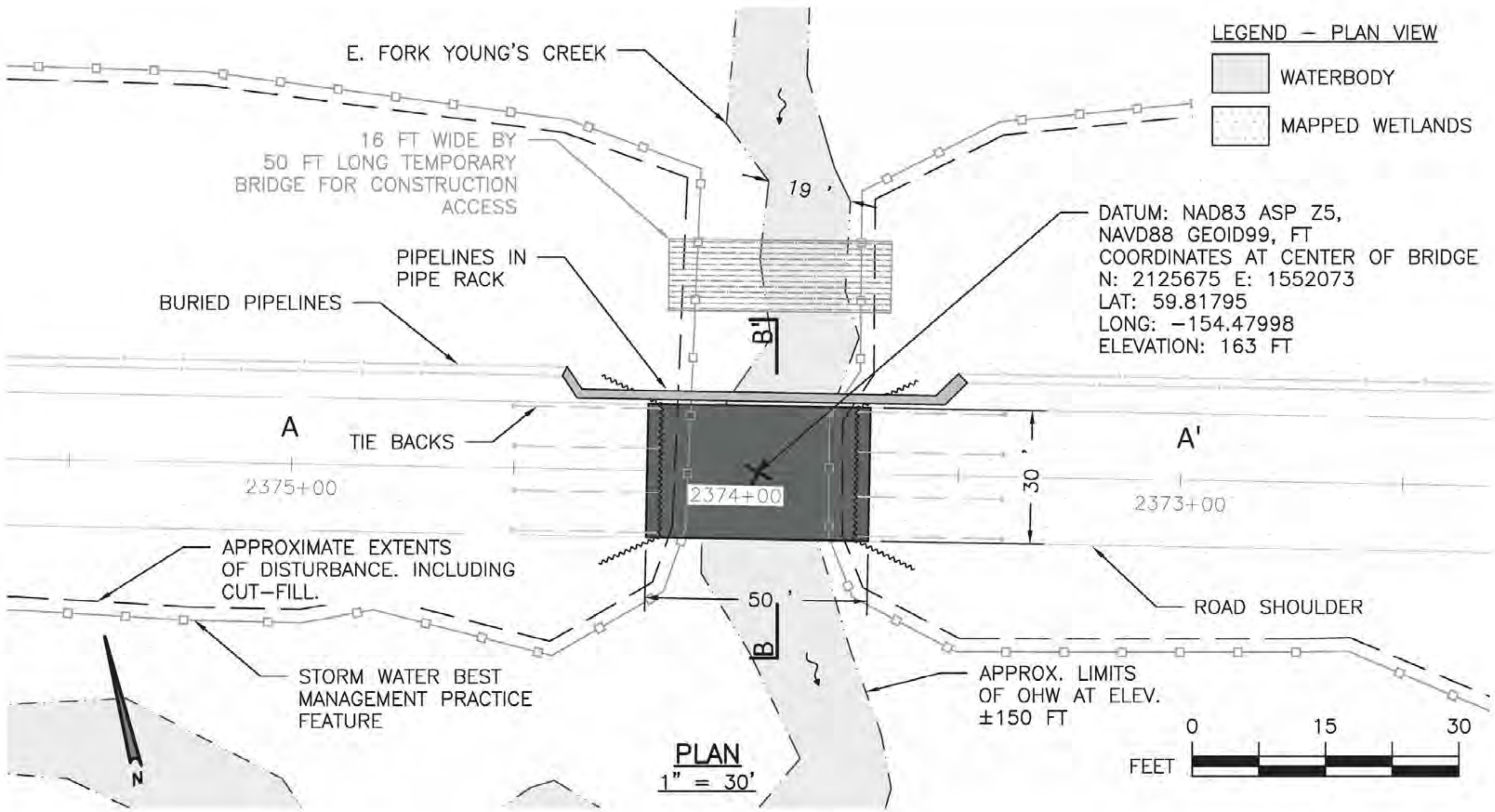


ELEVATION
1" = 30' HORZ. & VERT. 1:1

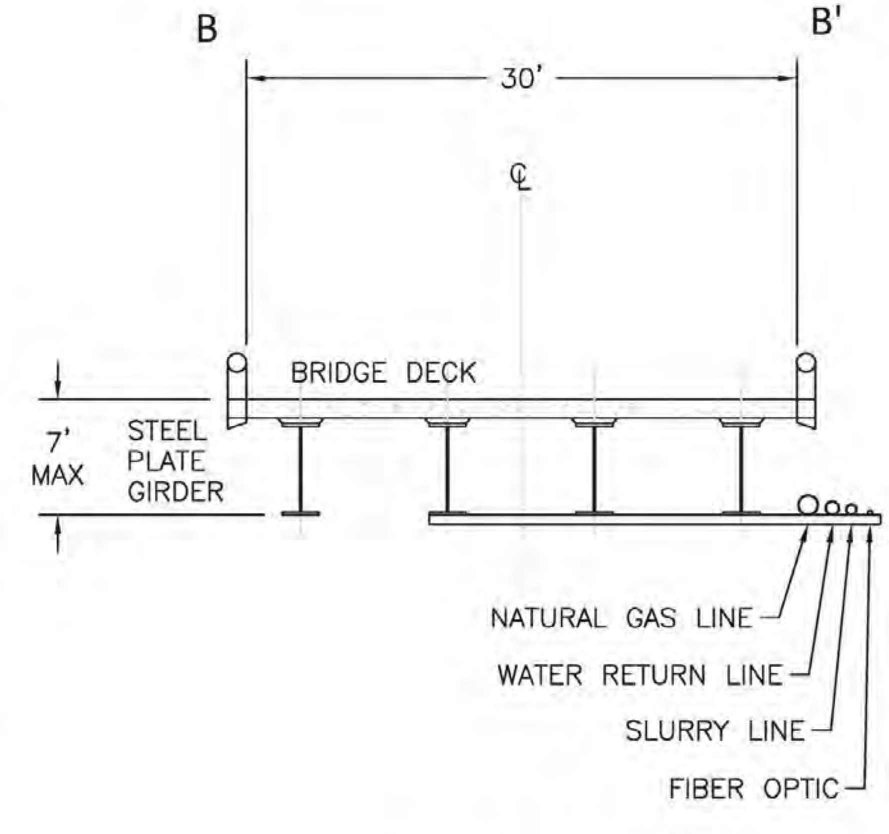
NOTES:

1. CONCEPTUAL PLANS BASED ON 2004 & 2008 LIDAR AND 2004 IMAGERY PROVIDED BY THE STATE OF ALASKA
2. STATIONING CURRENT AS OF 04/09/2020
3. OHW IS APPROXIMATE. OHW TO BE VERIFIED BY FUTURE STREAM CROSSING SURVEYS.
3. STORMWATER BEST MANAGEMENT PRACTICE FEATURES TO BE APPLIED AS APPROPRIATE FOR SITE CONDITIONS. FEATURES MAY INCLUDE: SILT FENCE, STRAW WATTLES, EROSION CONTROL MATS, OR SURFACE ARMORING WITH ROCK
4. TEMPORARY CONSTRUCTION ACCESS ROAD TO UTILIZE 16 FT WIDTH SINGLE LANE CLEAR SPAN TEMPORARY BRIDGE WITH TIMBER PAD ABUTMENTS, FIELD LOCATED BY THE ENGINEER.
5. CHEKOK CREEK BRIDGE PROPOSED LENGTH IS 240 FT WITH THREE SPANS AT 80 FT EACH. PROPOSED ABUTMENTS TO BE SPILL THROUGH AND SUBSTRUCTURE TO BE PILE OR PRECAST CONCRETE PAD.

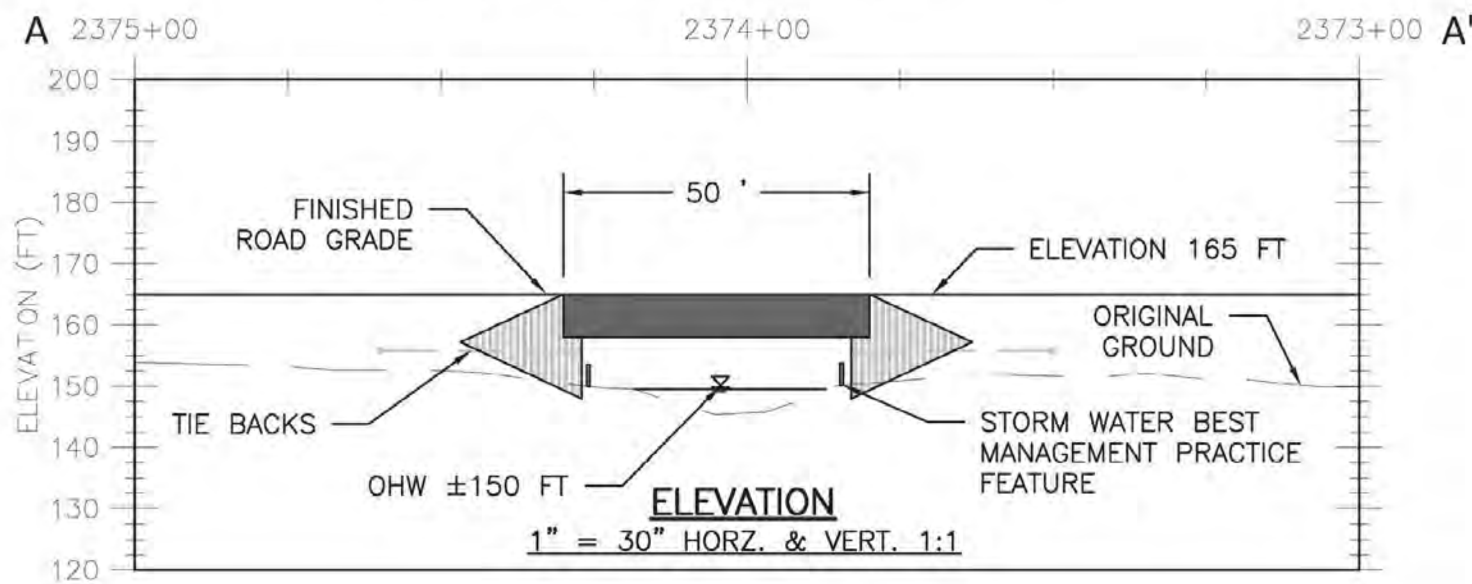
PEBBLE PROJECT		DRAWING TITLE:	
APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		**CHEKOK CREEK BRIDGE PLAN, PROFILE, AND TYPICAL SECTION**	
LAT., LONG. OF MINE 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: MINERAL DEVELOPMENT		
WATERWAY: CHEKOK CREEK	FILE NO. POA-2017-271	DATE: JUNE 2020	FIGURE NO. A-10



PLAN
1" = 30'



TYPICAL SECTION
1" = 10'

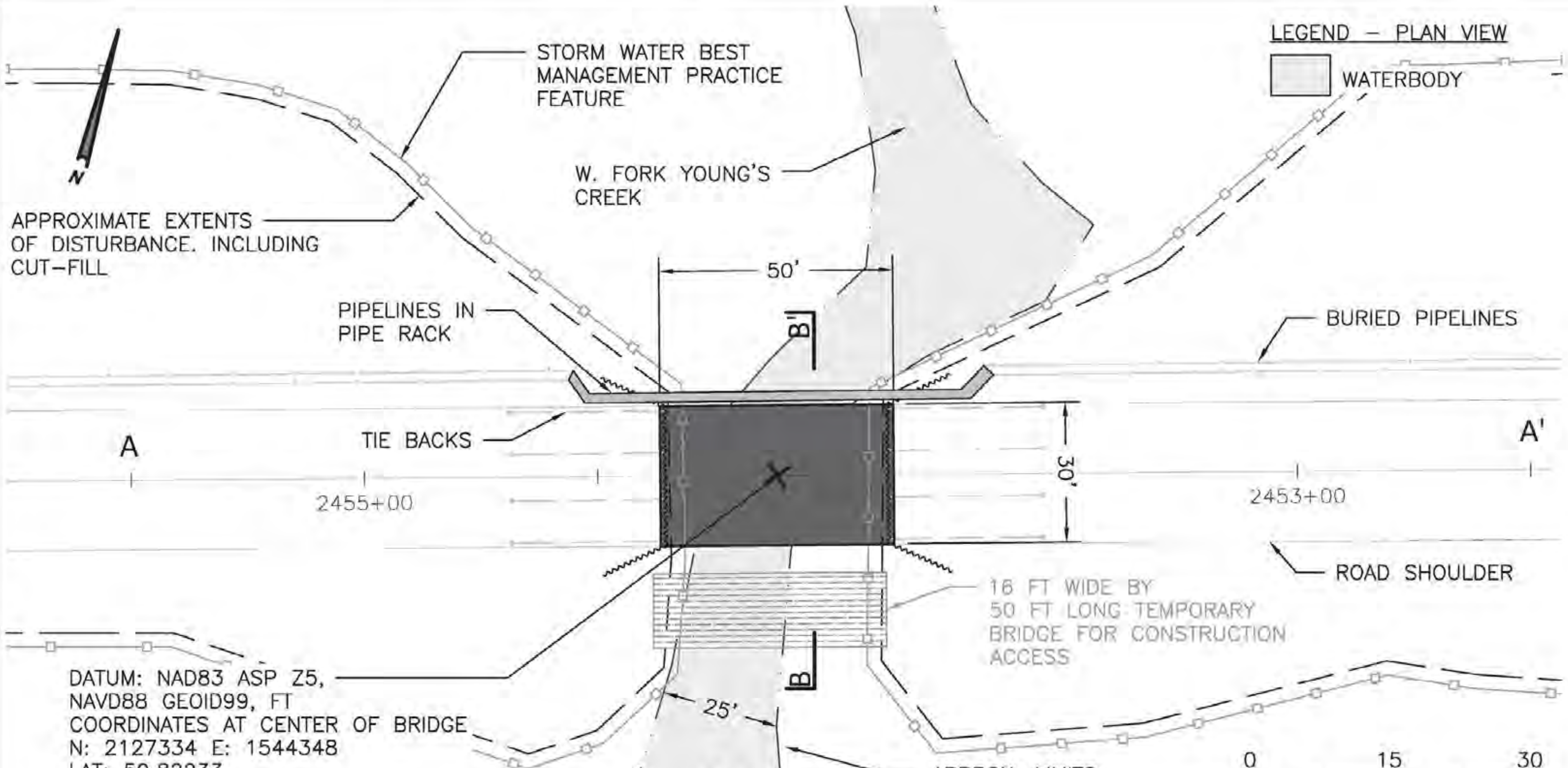


ELEVATION
1" = 30" HORZ. & VERT. 1:1

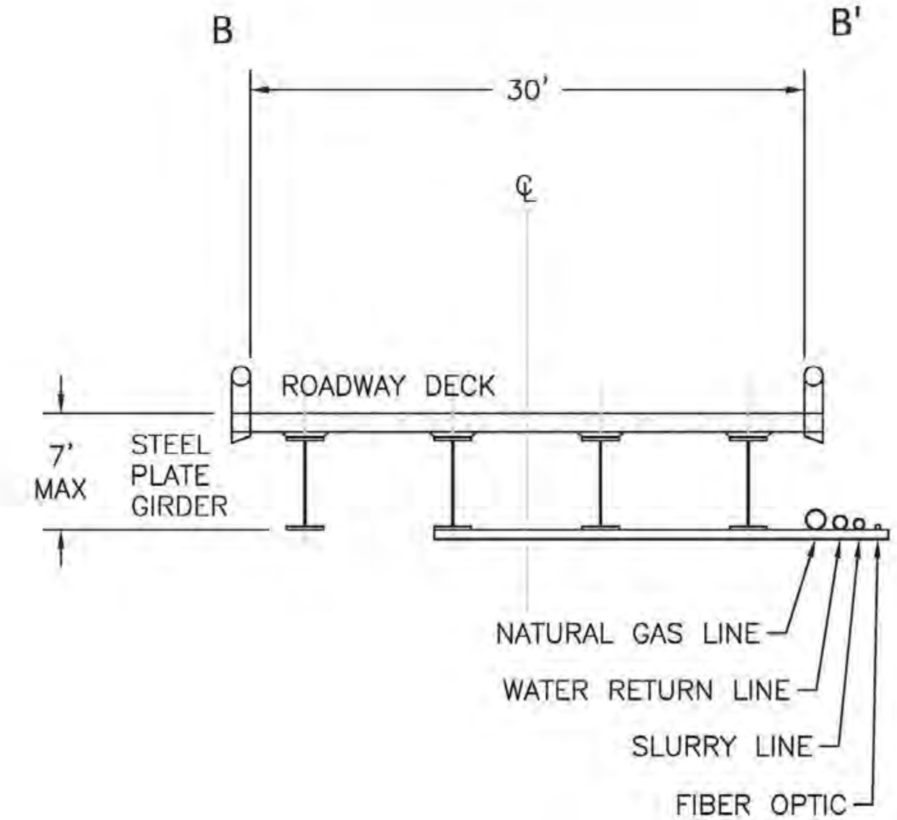
NOTES:

1. CONCEPTUAL PLANS BASED ON 2004 & 2008 LIDAR AND 2004 IMAGERY PROVIDED BY THE STATE OF ALASKA.
4. STATIONING CURRENT AS OF 04/09/2020
5. OHW IS APPROXIMATE. OHW TO BE VERIFIED BY FUTURE STREAM CROSSING SURVEYS.
3. STORMWATER BEST MANAGEMENT PRACTICE FEATURES TO BE APPLIED AS APPROPRIATE FOR SITE CONDITIONS. FEATURES MAY INCLUDE: SILT FENCE, STRAW WATTLES, EROSION CONTROL MATS, OR SURFACE ARMORING WITH ROCK
4. TEMPORARY CONSTRUCTION ACCESS ROAD TO UTILIZE 16 FT WIDTH SINGLE LANE CLEAR SPAN TEMPORARY BRIDGE WITH TIMBER PAD ABUTMENTS, FIELD LOCATED BY THE ENGINEER. NO CONSTRUCTION BELOW OHW.
5. E. FORK YOUNG'S CREEK BRIDGE IS PROPOSED AS A SINGLE 50 FT SPAN. PROPOSED ABUTMENTS TO BE SHEET–PILE AND SUBSTRUCTURE TO BE PILE OR PRECAST CONCRETE PAD.

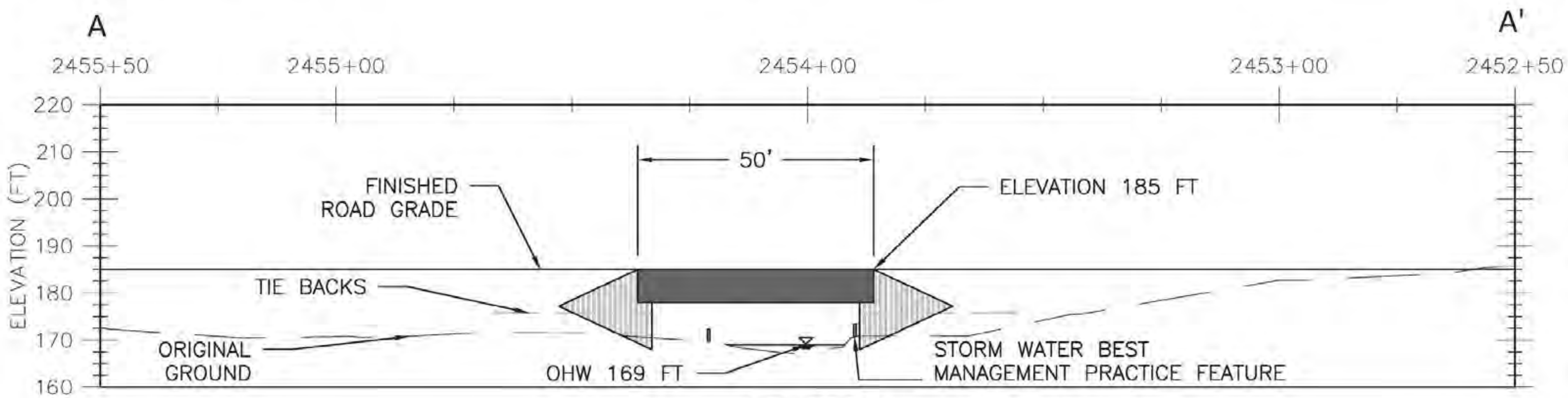
PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **E. FORK YOUNGS CREEK BRIDGE PLAN, PROFILE, AND TYPICAL SECTION**	
LAT., LONG. OF MINE 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: **MINERAL DEVELOPMENT**		
WATERWAY: ILIAMNA LAKE	FILE NO. **POA-2017-271**	DATE: **JUNE 2020**	FIGURE NO. **A-11**



PLAN
1" = 30'



TYPICAL SECTION
1" = 10'

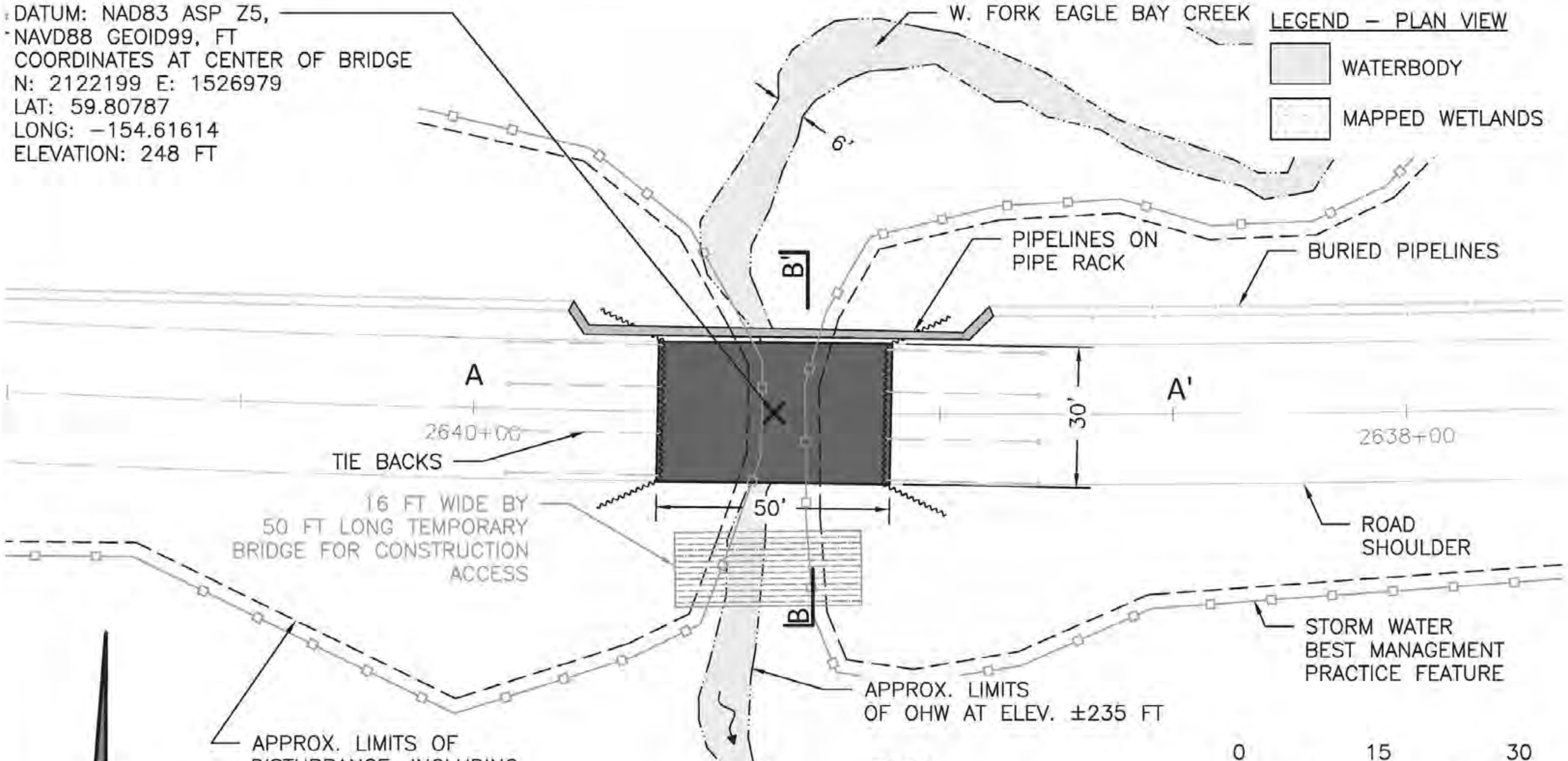


ELEVATION
1" = 30' HORIZ. & VERT. 1:1

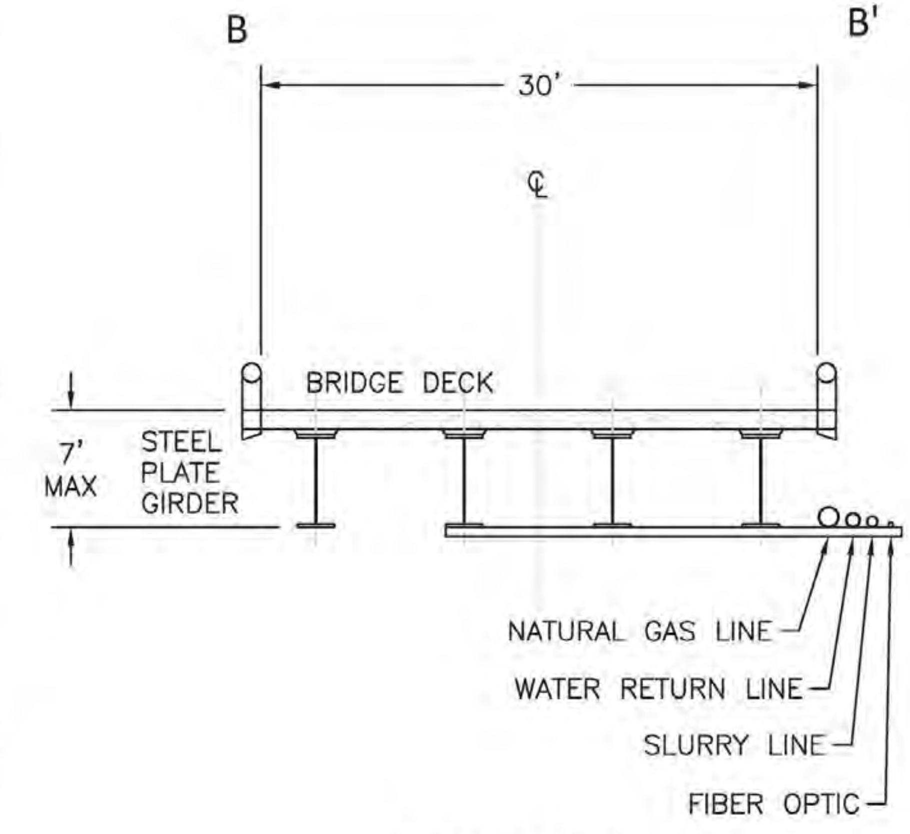
NOTES:

1. CONCEPTUAL PLANS BASED ON 2010 HYDRO SURVEY BY RECON LLC.
2. STATIONING CURRENT AS OF 04/09/2020
3. STORMWATER BEST MANAGEMENT PRACTICE FEATURES TO BE APPLIED AS APPROPRIATE FOR SITE CONDITIONS. FEATURES MAY INCLUDE: SILT FENCE, STRAW WATTLES, EROSION CONTROL MATS, OR SURFACE ARMORING WITH ROCK
4. TEMPORARY CONSTRUCTION ACCESS ROAD TO UTILIZE 16 FT WIDTH SINGLE LANE CLEAR SPAN TEMPORARY BRIDGE WITH TIMBER PAD ABUTMENTS, FIELD LOCATED BY THE ENGINEER. NO CONSTRUCTION BELOW OHW.
5. W. FORK YOUNG'S CREEK BRIDGE IS PROPOSED AS A SINGLE 50 FT SPAN. PROPOSED ABUTMENTS TO BE SHEET–PILE AND SUBSTRUCTURE TO BE PILE OR PRECAST CONCRETE PAD.

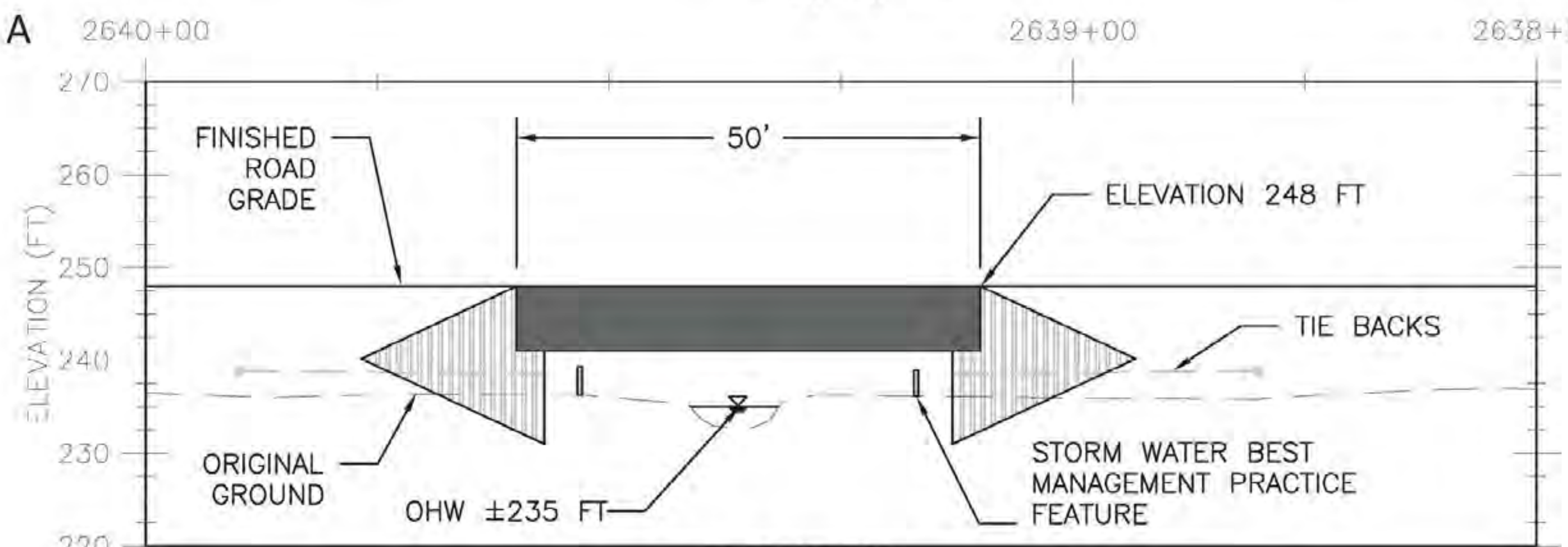
PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **W. FORK YOUNGS CREEK BRIDGE PLAN, PROFILE, AND TYPICAL SECTION**	
LAT., LONG. OF MINE 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: **MINERAL DEVELOPMENT**		
WATERWAY: **ILIAMNA LAKE**	FILE NO. **POA-2017-271**	DATE: **JUNE 2020**	FIGURE NO. **A-12**



PLAN
1" = 30'



TYPICAL SECTION
1" = 10'

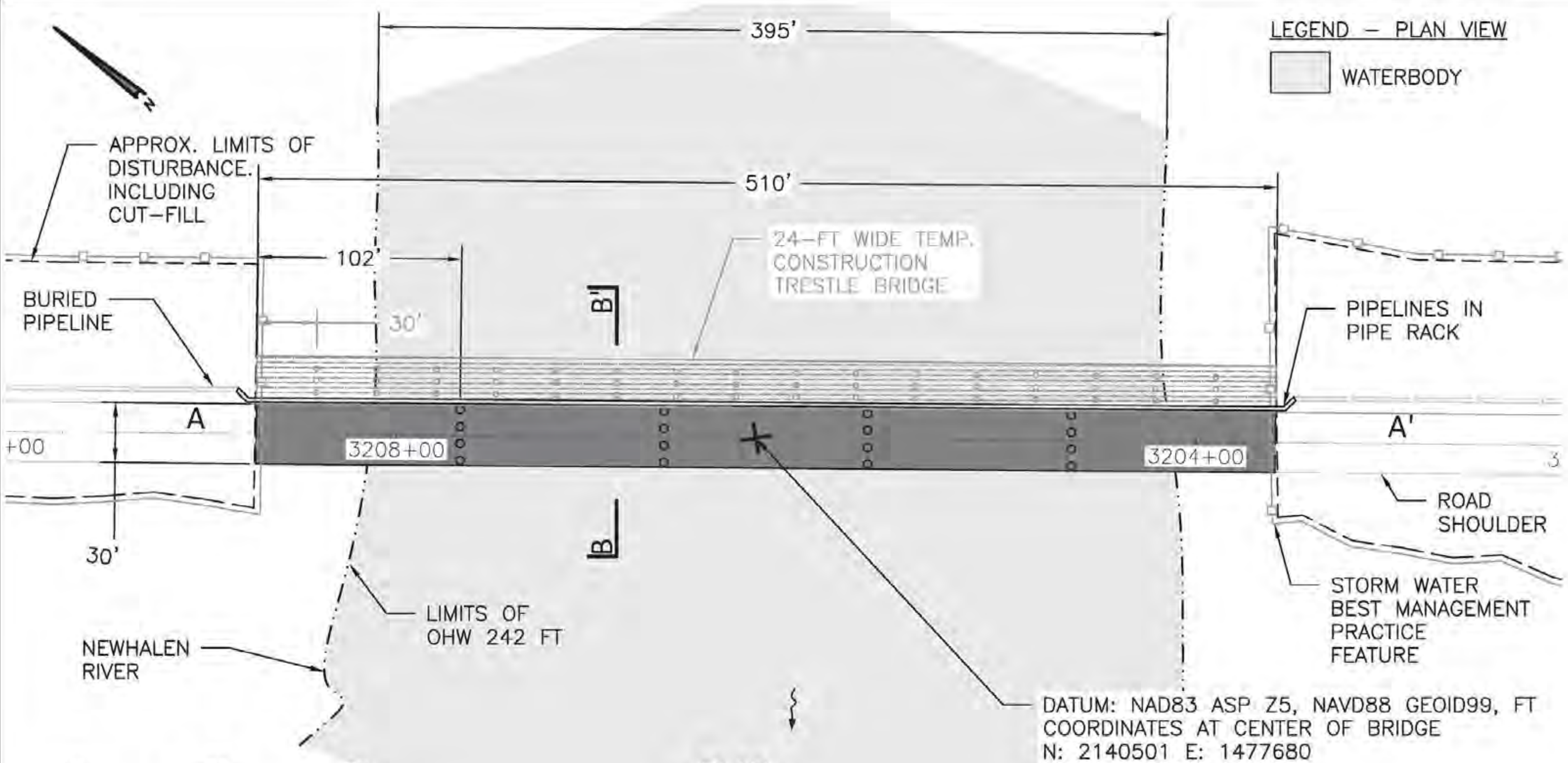


ELEVATION
1" = 20' HORZ. & VERT. 1:1

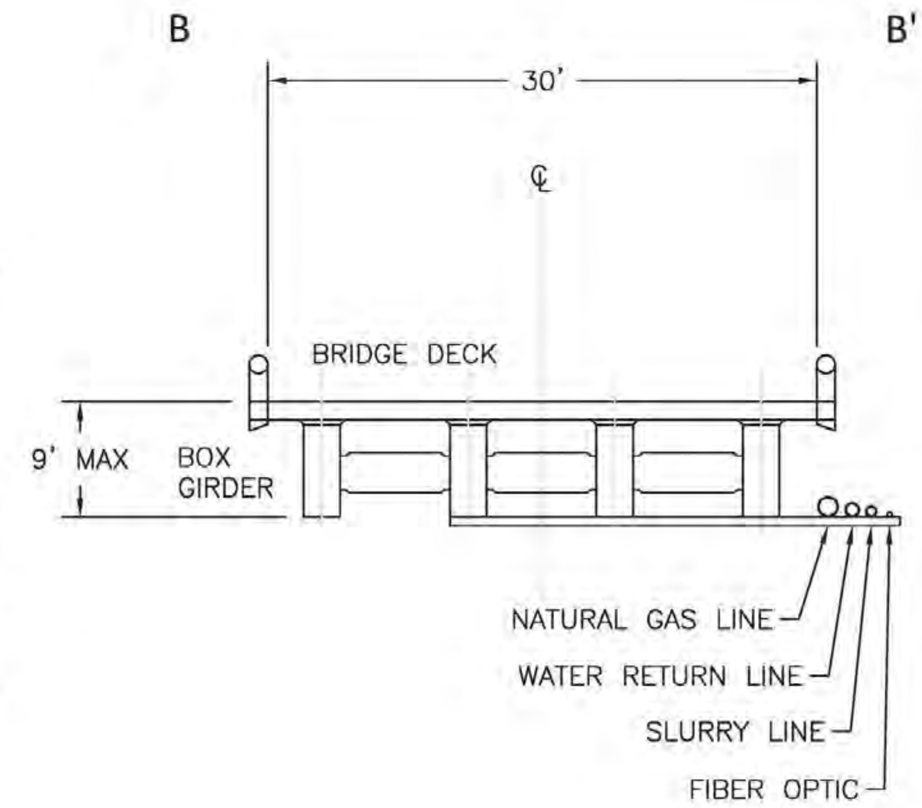
NOTES:

1. CONCEPTUAL PLANS BASED ON 2004 & 2008 LIDAR AND 2004 IMAGERY PROVIDED BY THE STATE OF ALASKA
2. STATIONING CURRENT AS OF 04/09/2020
3. OHW IS APPROXIMATE. OHW TO BE VERIFIED BY FUTURE STREAM CROSSING SURVEYS.
3. STORMWATER BEST MANAGEMENT PRACTICE FEATURES TO BE APPLIED AS APPROPRIATE FOR SITE CONDITIONS. FEATURES MAY INCLUDE: SILT FENCE, STRAW WATTLES, EROSION CONTROL MATS, OR SURFACE ARMORING WITH ROCK
4. TEMPORARY CONSTRUCTION ACCESS ROAD TO UTILIZE 16 FT WIDTH SINGLE LANE CLEAR SPAN TEMPORARY BRIDGE WITH TIMBER PAD ABUTMENTS, FIELD LOCATED BY THE ENGINEER. NO CONSTRUCTION BELOW OHW.
5. W. FORK EAGLE BAY CREEK BRIDGE IS PROPOSED AS A SINGLE 50 FT SPAN. PROPOSED ABUTMENTS TO BE SHEET–PILE AND SUBSTRUCTURE TO BE PILE OR PRECAST CONCRETE PAD.

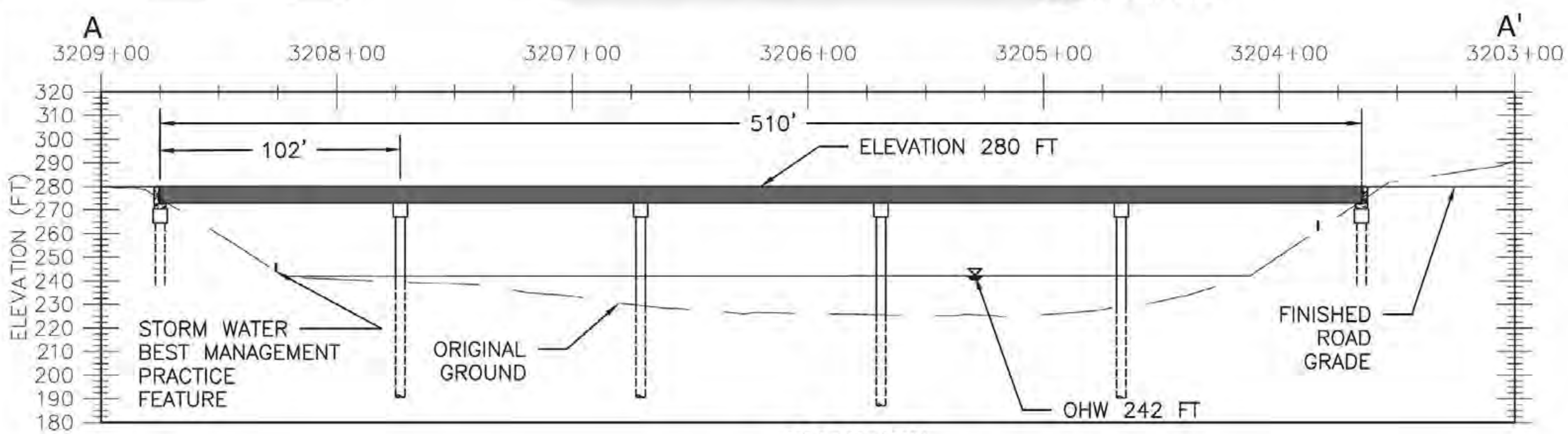
PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **W. FORK EAGLE BAY CREEK BRIDGE PLAN, PROFILE, AND TYPICAL SECTION**	
LAT., LONG. OF MINE 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: **MINERAL DEVELOPMENT**		
WATERWAY: ILIAMNA LAKE	FILE NO. **POA-2017-271**	DATE: **JUNE 2020**	FIGURE NO. **A-13**



PLAN
1" = 70'



TYPICAL SECTION
1" = 10'

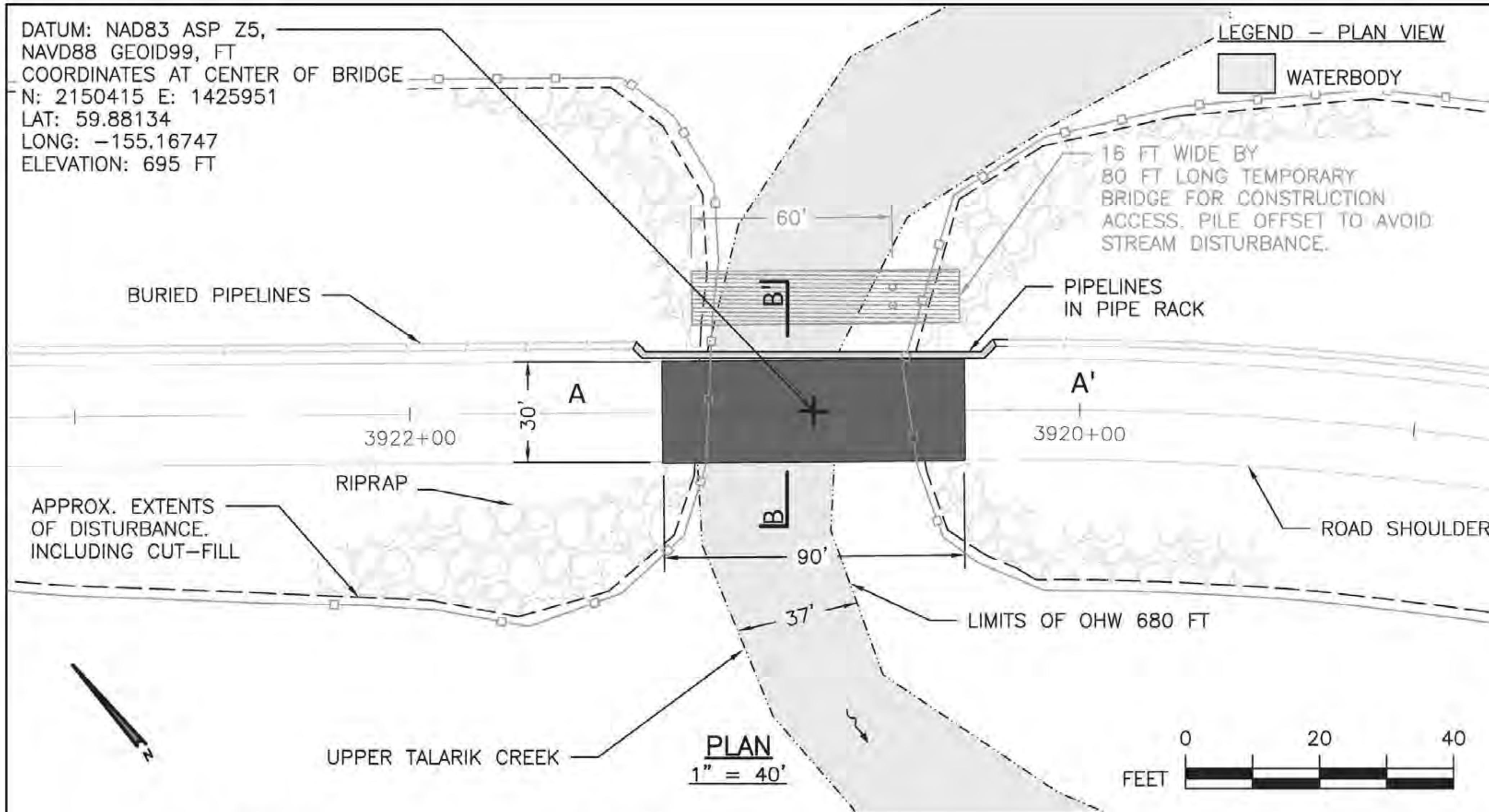


ELEVATION
1" = 60' HORZ. & VERT. 1:1

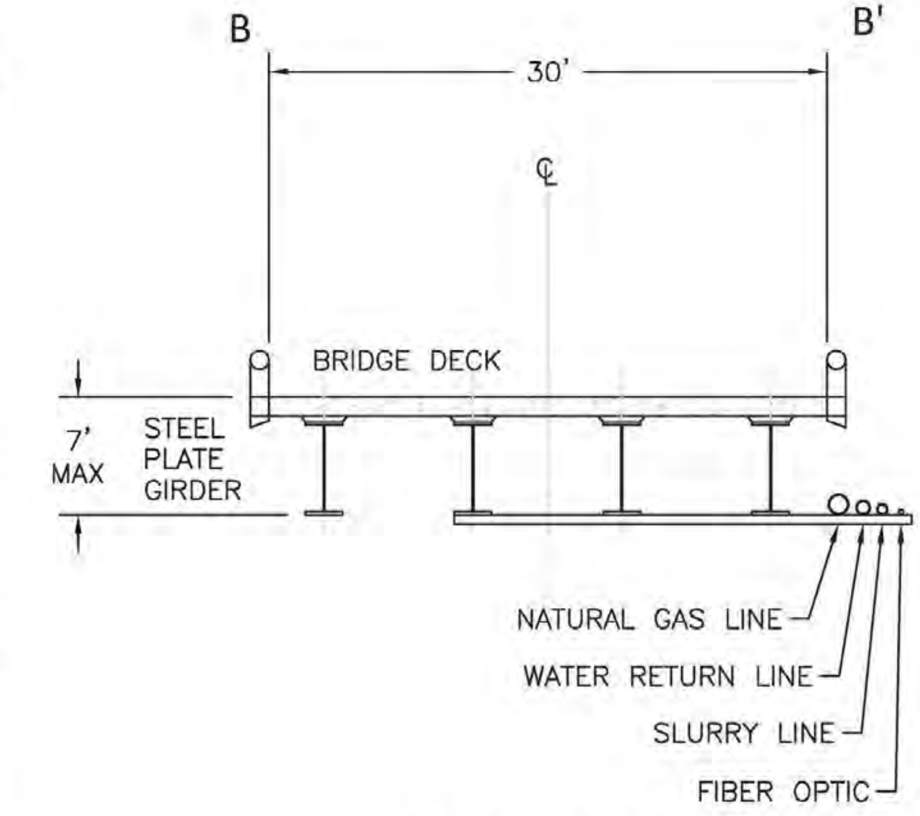
NOTES:

1. CONCEPTUAL PLANS BASED ON 2019 GROUND SURVEY BY RECON AND 2019 HYDROLOGICAL REPORT BY HYDRAULIC MAPPING AND MODELING.
2. STATIONING CURRENT AS OF 04/09/2020
3. STORMWATER BEST MANAGEMENT PRACTICE FEATURES TO BE APPLIED AS APPROPRIATE FOR SITE CONDITIONS. FEATURES MAY INCLUDE: SILT FENCE, STRAW WATTLES, EROSION CONTROL MATS, OR SURFACE ARMORING WITH ROCK
4. TEMPORARY CONSTRUCTION ACCESS ROAD TO UTILIZE 24 FT WIDTH SINGLE LANE, 17 SPAN TEMPORARY BRIDGE WITH TIMBER PAD ABUTMENTS. FIELD LOCATED BY THE ENGINEER.
5. NEWHALEN RIVER BRIDGE PROPOSED LENGTH IS 510 FT WITH 5 SPANS AT 102 FT. PROPOSED SUBSTRUCTURE IS PILE.

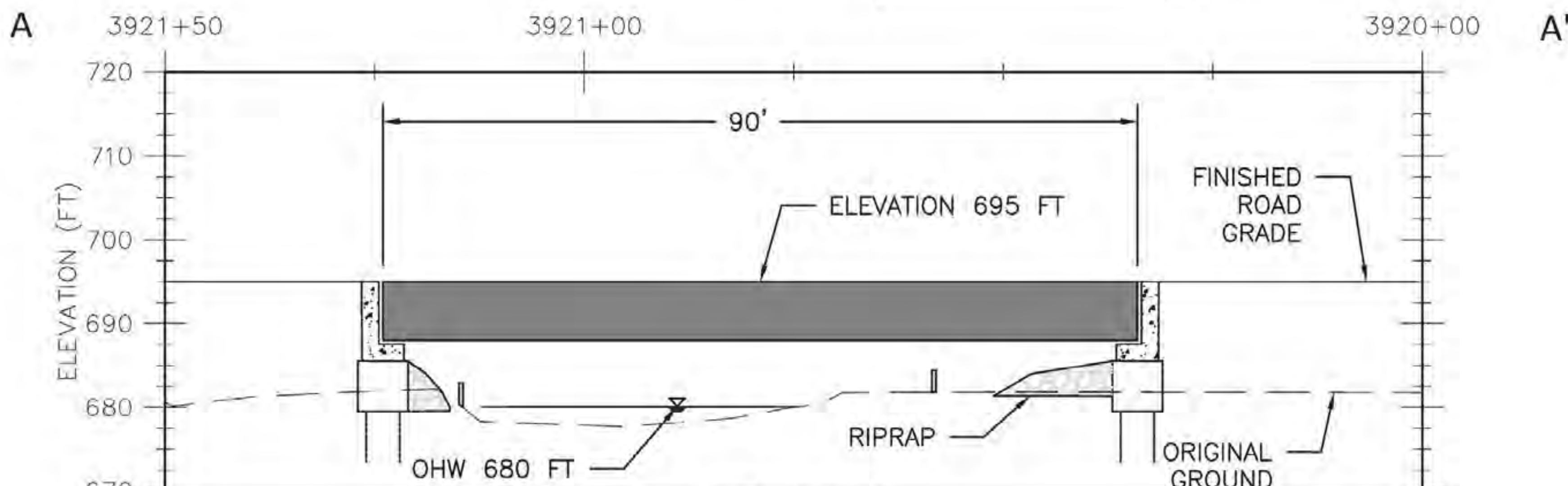
PEBBLE PROJECT		DRAWING TITLE: NEWHALEN RIVER BRIDGE PLAN, PROFILE, AND TYPICAL SECTION	
APPLICANT: PEBBLE LIMITED PARTNERSHIP			
LAT., LONG. OF MINE: 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: MINERAL DEVELOPMENT		
WATERWAY: NEWHALEN RIVER	FILE NO: POA-2017-271	DATE: JUNE 2020	FIGURE NO. A-14



PLAN
1" = 40'



TYPICAL SECTION
1" = 10'



ELEVATION
1" = 20' HORZ. & VERT. 1:1

NOTES:

1. CONCEPTUAL PLANS BASED ON 2019 GROUND SURVEY BY RECON AND 2019 HYDROLOGICAL REPORT BY HYDRAULIC MAPPING AND MODELING.
2. STATIONING CURRENT AS OF 04/09/2020
3. STORMWATER BEST MANAGEMENT PRACTICE FEATURES TO BE APPLIED AS APPROPRIATE FOR SITE CONDITIONS. FEATURES MAY INCLUDE: SILT FENCE, STRAW WATTLES, EROSION CONTROL MATS, OR SURFACE ARMORING WITH ROCK
4. TEMPORARY CONSTRUCTION ACCESS ROAD TO UTILIZE 16 FT WIDTH SINGLE LANE, TWO SPAN TEMPORARY BRIDGE WITH TIMBER PAD ABUTMENTS, FIELD LOCATED BY THE ENGINEER. NO CONSTRUCTION BELOW OHW. TEMPORARY PILE TO BE OFFSET TO AVOID STREAM DISTURBANCE.
5. UPPER TALARIK CREEK BRIDGE IS PROPOSED AS A SINGLE 90 FT SPAN WITH SPILL THROUGH ABUTMENTS AND SUBSTRUCTURE OF PRECAST CONCRETE PADS OR PILES.

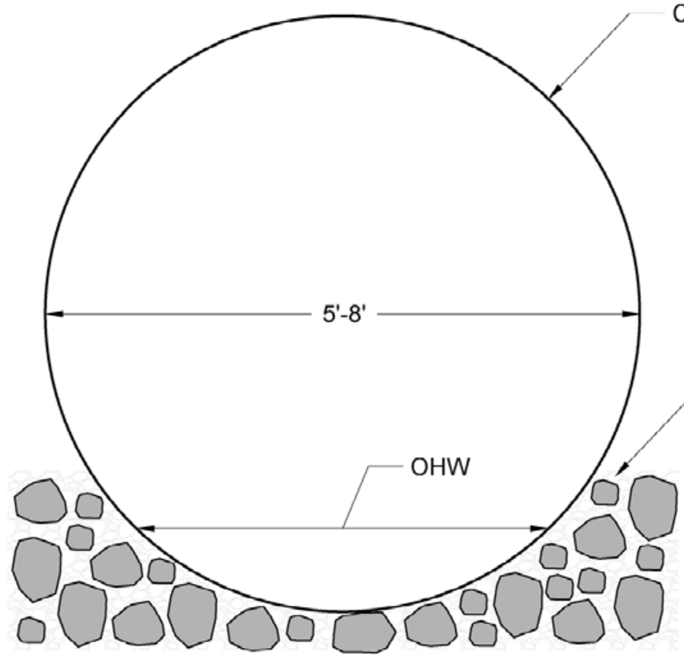
PEBBLE PROJECT

APPLICANT: PEBBLE LIMITED PARTNERSHIP

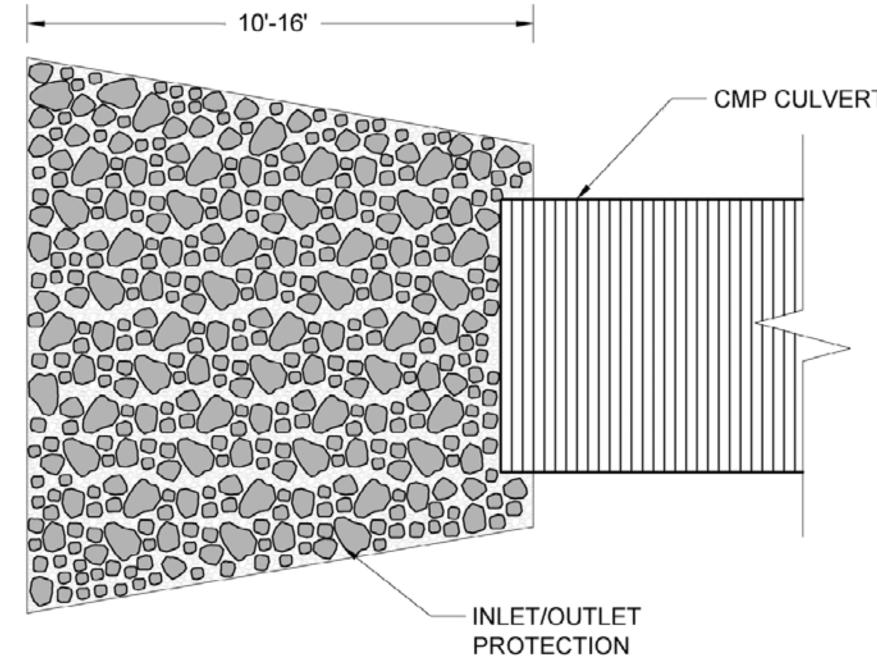
LAT., LONG. OF MINE: 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: MINERAL DEVELOPMENT
WATERWAY: UPPER TALARIK CREEK	FILE NO: POA-2017-271

DRAWING TITLE:
UPPER TALARIK CREEK BRIDGE PLAN, PROFILE, AND TYPICAL SECTION

DATE: JUNE 2020	FIGURE NO. A-15



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 5' - 8'.

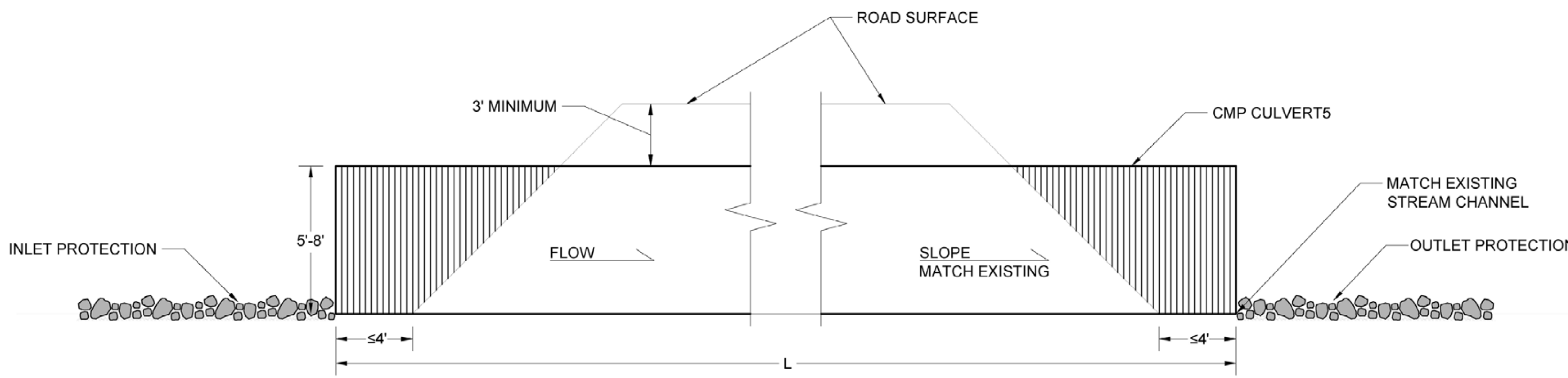
STREAM IMPACT AREA EQUALS STREAM WIDTH TIMES CULVERT LENGTH PLUS THE AREA ASSOCIATED WITH INLET/OUTLET PROTECTION.

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.

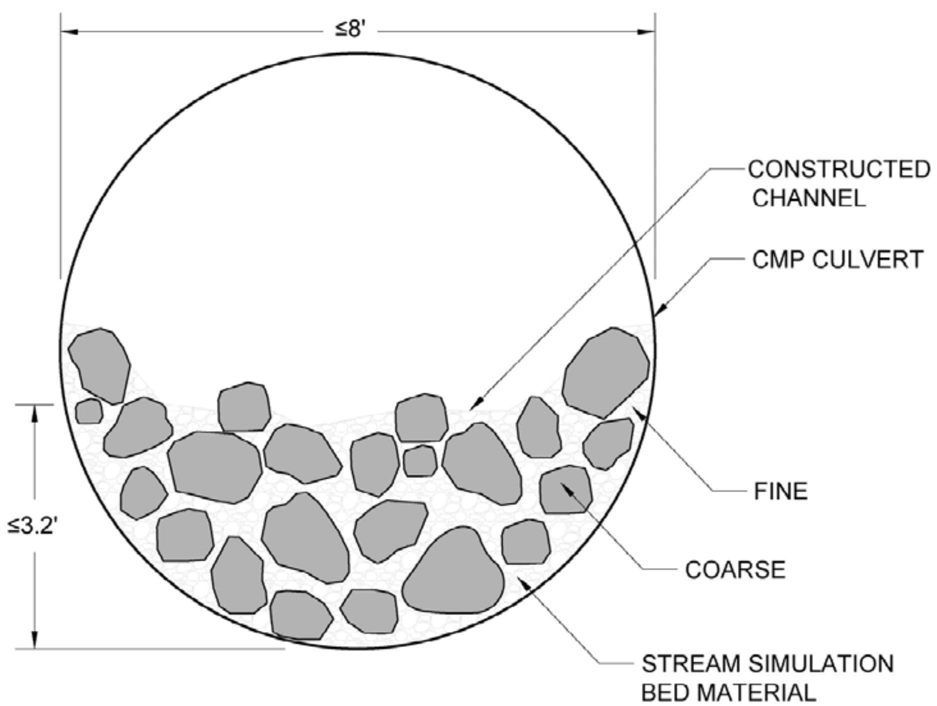
INLET/OUTLET PROTECTION SHALL BE CONSTRUCTED PER ALASKA DOT HIGHWAY DRAINAGE MANUAL.

FINAL DESIGN OF FISH PASSAGE CULVERTS WILL BE IN ACCORDANCE WITH USFWS GUIDELINES – CULVERT DESIGN GUIDELINES FOR ECOLOGICAL FUNCTION, USFWS ALASKA FISH PASSGE PROGRAM REVISION 5 (FEB 5, 2020).

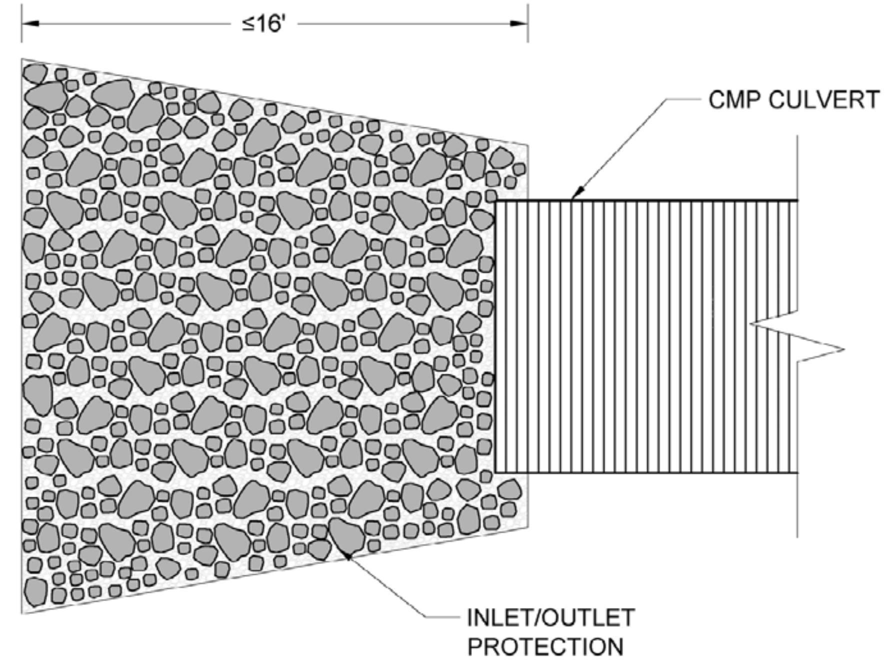


TYPICAL PROFILE
NTS

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: JUNE 2020 / FIGURE NO. A-16



TYPICAL SECTION
NTS

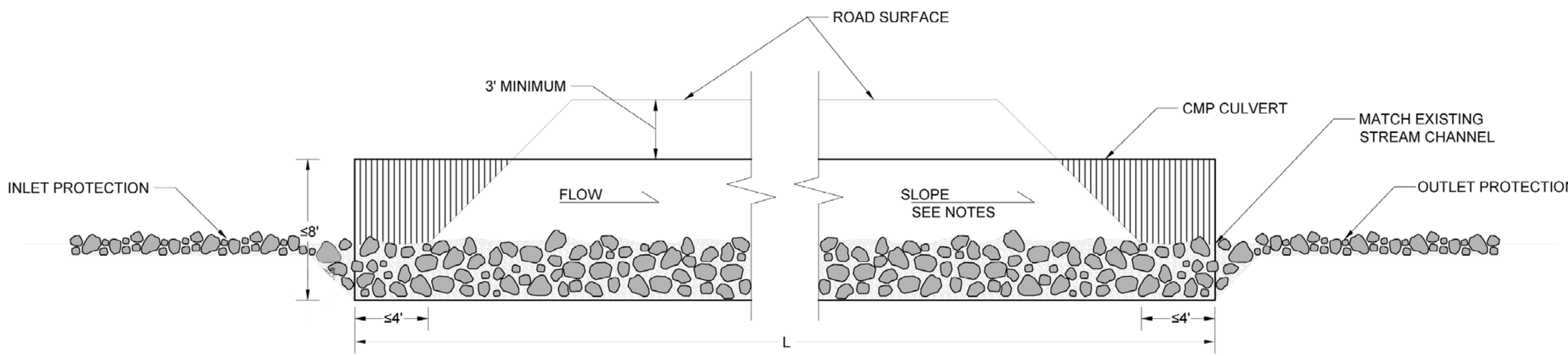


TYPICAL INLET/OUTLET PROTECTION
NTS

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.

FINAL DESIGN OF FISH PASSAGE CULVERTS WILL BE IN ACCORDANCE WITH USFWS GUIDELINES – CULVERT DESIGN GUIDELINES FOR ECOLOGICAL FUNCTION, USFWS ALASKA FISH PASSGE PROGRAM REVISION 5 (FEB 5, 2020).



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

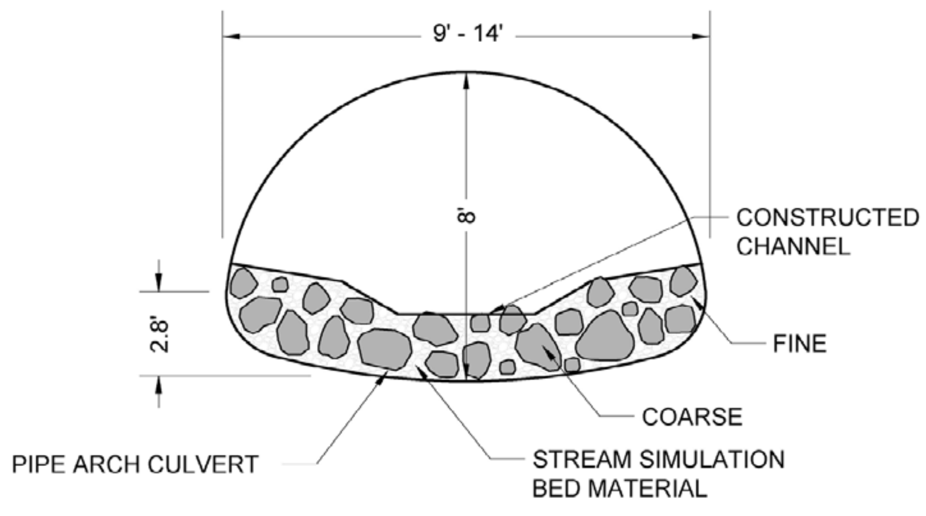
WATERWAY: VARIOUS

FILE NO. POA-2017-271

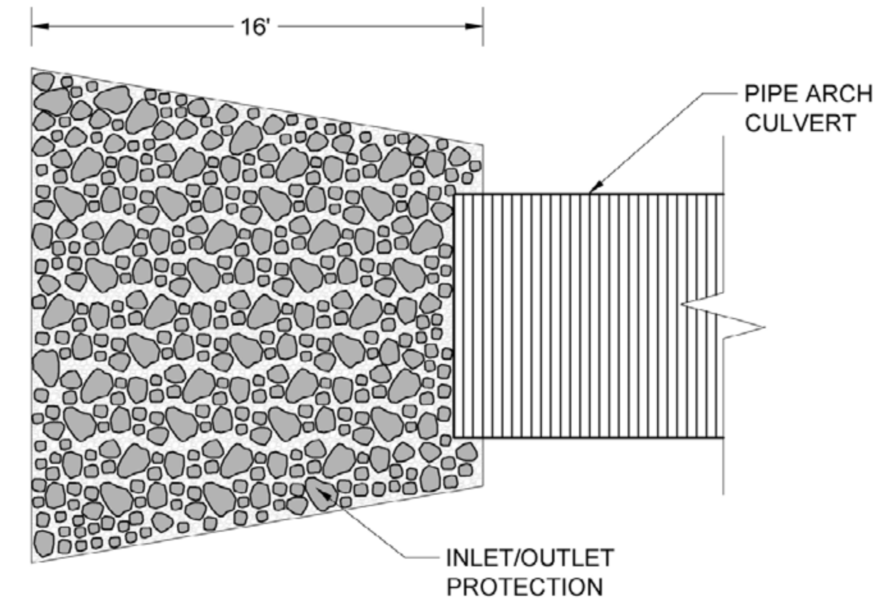
DRAWING TITLE: CULVERT DESIGN CATEGORY 4

DATE: JUNE 2020

FIGURE NO. A-17



TYPICAL SECTION
NTS

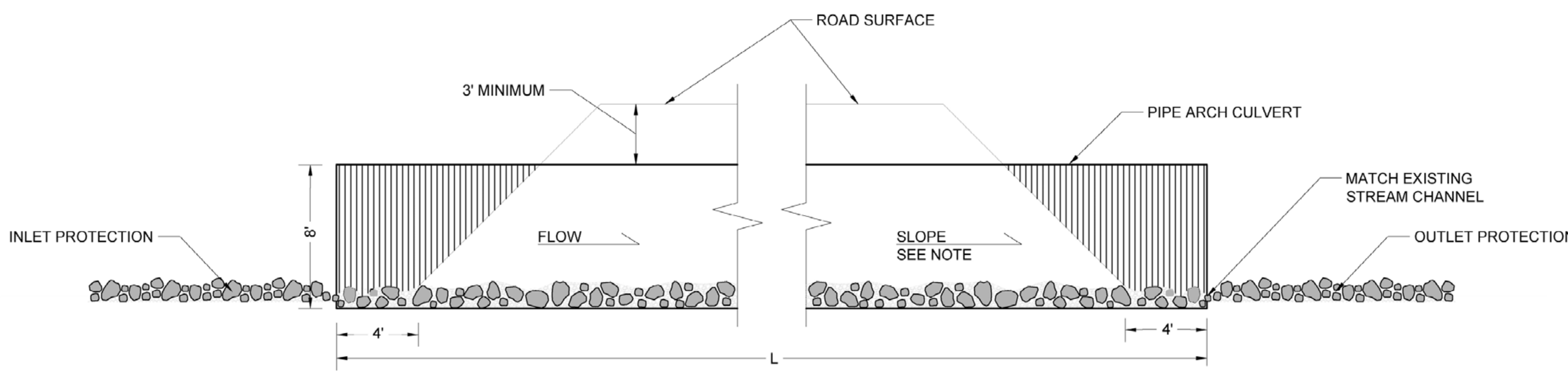


TYPICAL INLET/OUTLET PROTECTION
NTS

NOTES:

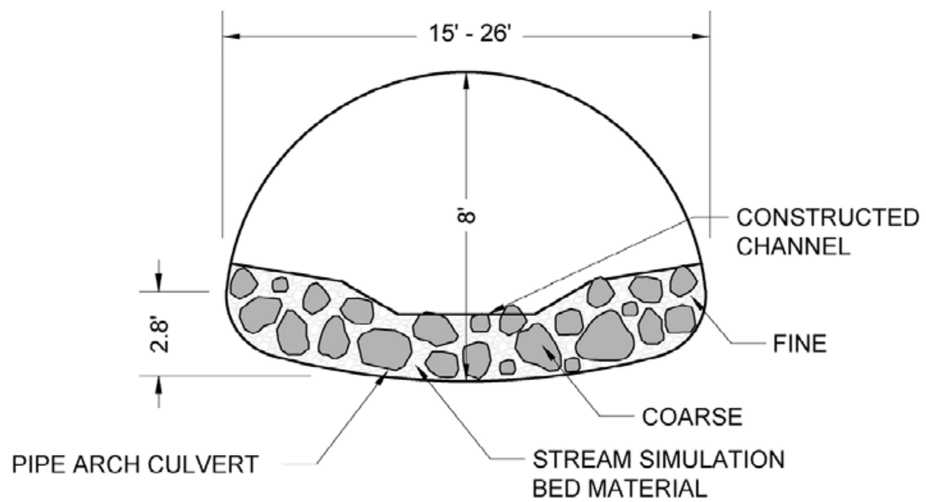
CATEGORY 6 CULVERTS SHALL BE INSTALLED IN MAPPED STREAMS WHERE FISH PASSAGE IS REQUIRED AND THAT HAVE A STREAM WIDTH GREATER THAN 6' UP TO 10' AT THE ORDINARY HIGH WATER (OHW) MARK.

FINAL DESIGN OF FISH PASSAGE CULVERTS WILL BE IN ACCORDANCE WITH USFWS GUIDELINES – CULVERT DESIGN GUIDELINES FOR ECOLOGICAL FUNCTION, USFWS ALASKA FISH PASSGE PROGRAM REVISION 5 (FEB 5, 2020).

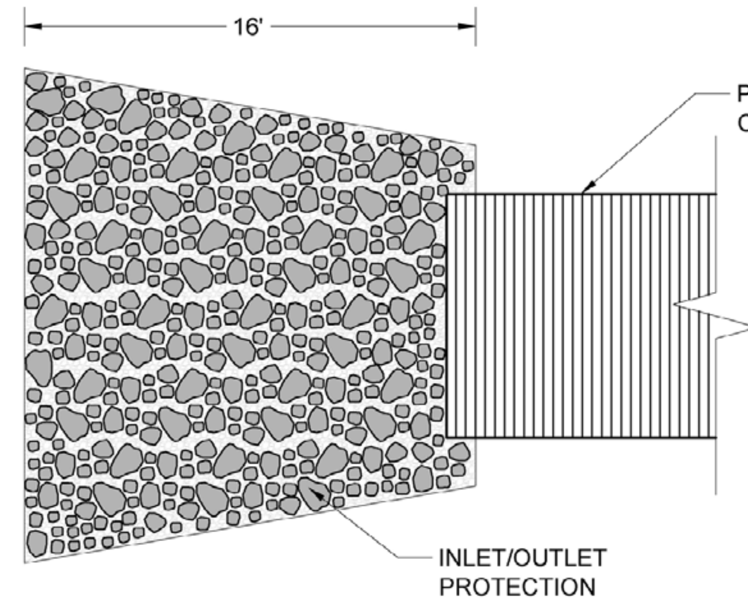


TYPICAL PROFILE
NTS

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: **JUNE 2020** / FIGURE NO. **A-18**



TYPICAL SECTION
NTS

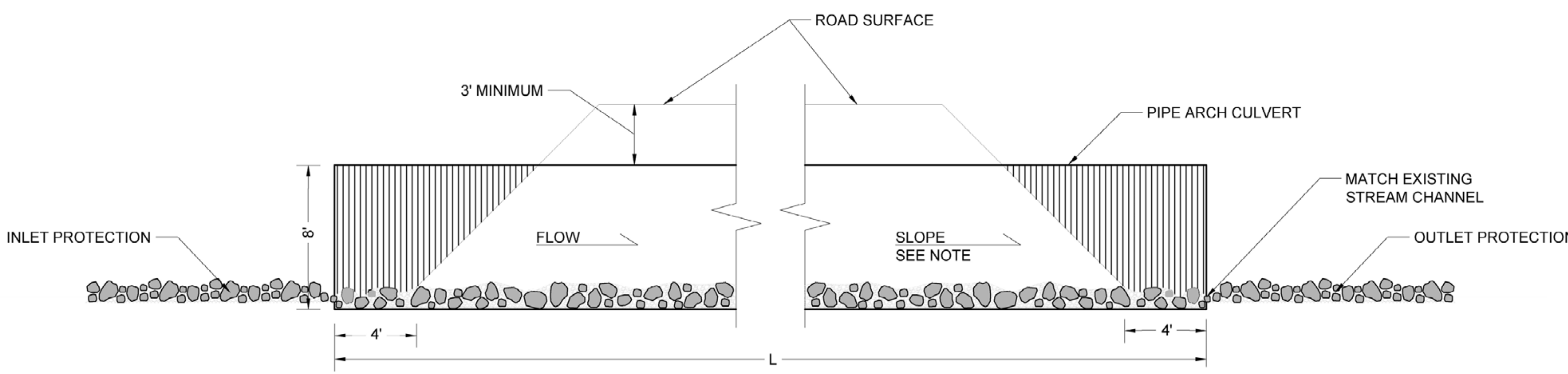


TYPICAL INLET/OUTLET PROTECTION
NTS

NOTES:

CATEGORY 7 CULVERTS SHALL BE INSTALLED IN MAPPED STREAMS WHERE FISH PASSAGE IS REQUIRED AND THAT HAVE A STREAM WIDTH GREATER 10' AT THE ORDINARY HIGH WATER (OHW) MARK.

FINAL DESIGN OF FISH PASSAGE CULVERTS WILL BE IN ACCORDANCE WITH USFWS GUIDELINES – CULVERT DESIGN GUIDELINES FOR ECOLOGICAL FUNCTION, USFWS ALASKA FISH PASSGE PROGRAM REVISION 5 (FEB 5, 2020).

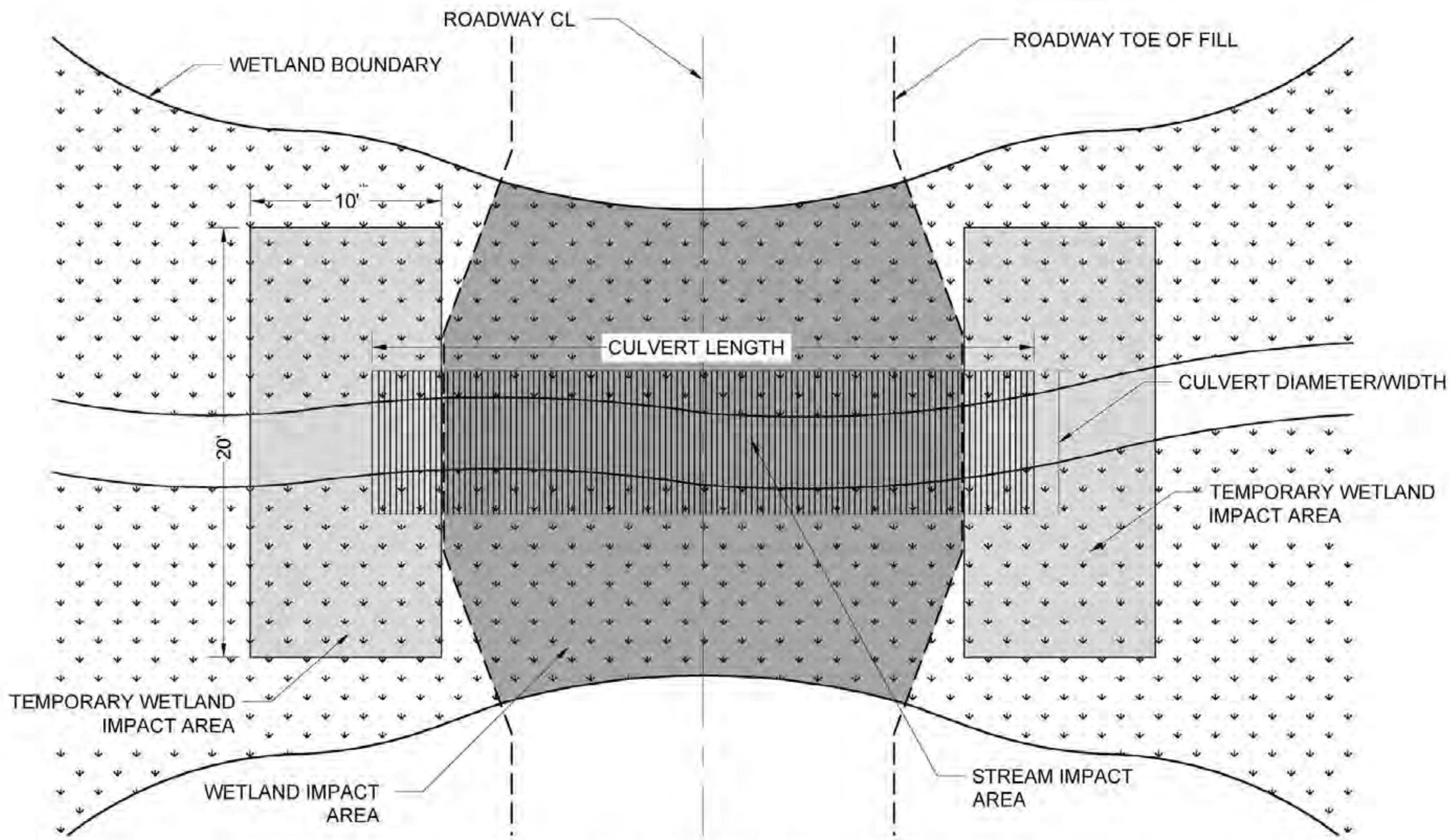


TYPICAL PROFILE
NTS

PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **CULVERT DESIGN CATEGORY 7**
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: **JUNE 2020** FIGURE NO. **A-19**

NOTES:

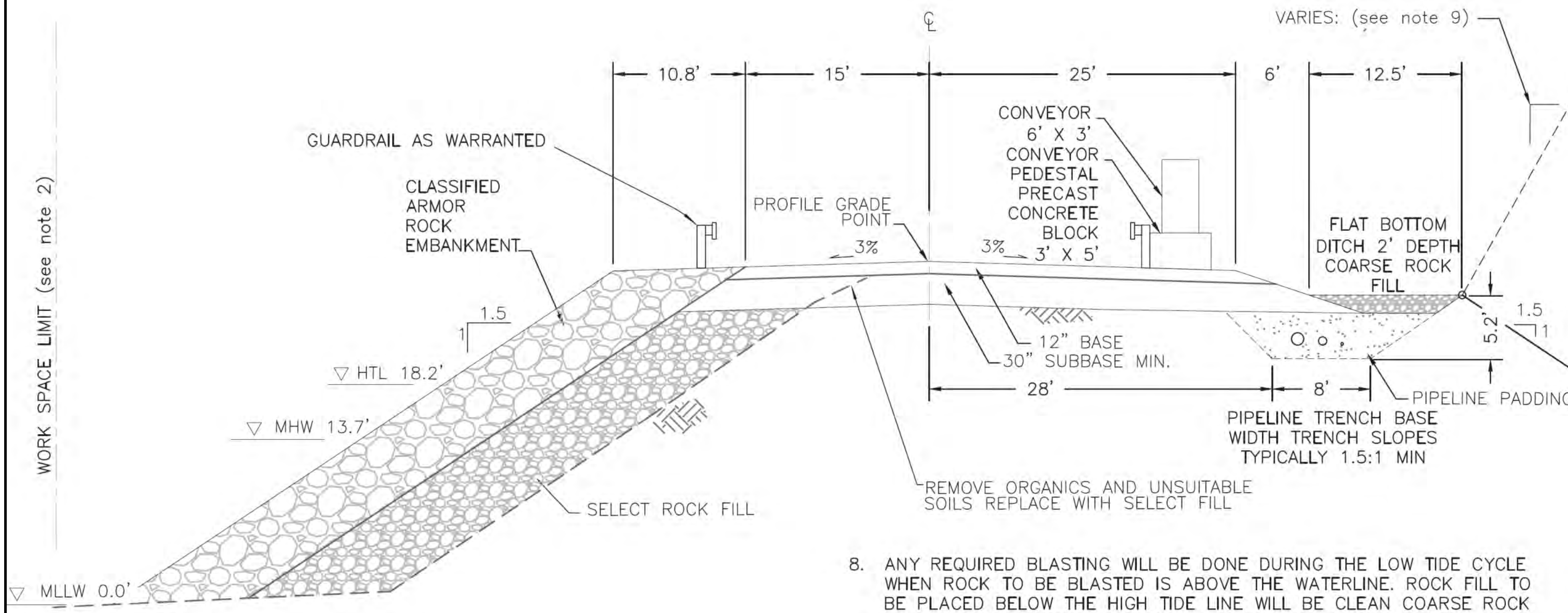
FINAL DESIGN OF FISH PASSAGE CULVERTS WILL BE IN ACCORDANCE WITH USFWS GUIDELINES – CULVERT DESIGN GUIDELINES FOR ECOLOGICAL FUNCTION, USFWS ALASKA FISH PASSGE PROGRAM REVISION 5 (FEB 5, 2020).



TYPICAL PLAN VIEW SCHEMATIC

NTS

PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **CULVERT DESIGN CATEGORY 2-7 PLAN SCHEMATIC**	
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**	DATE: **JUNE 2020**	FIGURE NO. **A-20**



NOTES:

1. TYPICAL SECTION APPLIES TO THE FOLLOWING INTERVALS:
   STA. 32+40 TO 82+26 (MP 0.61 TO MP 1.60)
2. WORK SPACE LIMIT 5 FT FROM TOE OF FILL OR TOP OF CUT.
3. BASE TO CONSIST OF 2 inch MINUS, DURABLE, WELL GRADED, CRUSHED ROCK WITH 6 TO 10% PASSING THE 200 SIEVE. 12" MIN DEPTH.
4. SUBBASE TO CONSIST OF CLEAN DURABLE COARSE ROCK OR GRAVEL. NON-FROST-SUSCEPTIBLE. 30" MIN DEPTH.
5. SELECT ROCK FILL MATERIAL; TO CONSIST OF DURABLE COARSE FREE DRAINING ROCK OR GRAVEL, AS APPROVED BY ENGINEER.
6. DEPTH OF EMBANKMENT STRUCTURAL FILL WILL VARY DEPENDING ON SOIL TYPE AND CONDITION. 3.5 FT TOTAL EMBANKMENT DEPTH WILL TYPICALLY BE THE MINIMUM.
7. EMBANKMENT FILL CONSISTING OF COARSE CLEAN ROCK TO BE INCORPORATED AS EROSION AND SEDIMENT CONTROL MEASURE.
8. ANY REQUIRED BLASTING WILL BE DONE DURING THE LOW TIDE CYCLE WHEN ROCK TO BE BLASTED IS ABOVE THE WATERLINE. ROCK FILL TO BE PLACED BELOW THE HIGH TIDE LINE WILL BE CLEAN COARSE ROCK OR RIP RAP AND WILL NOT INCLUDE SIGNIFICANT FINE MATERIAL.
9. BACKSLOPES WILL VARY DEPENDENT UPON SOIL OR ROCK TYPE AND CHARACTER.
   TYPICAL: 2:1 FOR GLACIAL MORAINE SOILS
   1.3:1 FOR COARSE ROCK OR GRAVEL
   0.25:1 TO 1:1 FOR ROCK
10. ARMOR ROCK TO BE PER SPEC FOR CLASS II ARMOR ROCK
11. ACCOMMODATE EXCESS EXCAVATION AND WASTE DISPOSAL BY FLATTENING AND/OR EXTENDING INSLOPE AT SELECT LOCATIONS AS APPROVED BY ENGINEER.
12. INSTALL GUARDRAIL ON LEFT SHOULDER 17 FT FROM CENTERLINE. ON RIGHT SIDE INSTALL GUARDRAIL AS WARRANTED.
13. NO REFUELING OF MOBILE EQUIPMENT WITHIN 200 FT OF WATER BODY.
14. SPOIL TO BE STORED OUT OF THE INTERTIDAL ZONE AND ADJACENT WETLANDS AND WITHIN THE CONSTRUCTION R.O.W.

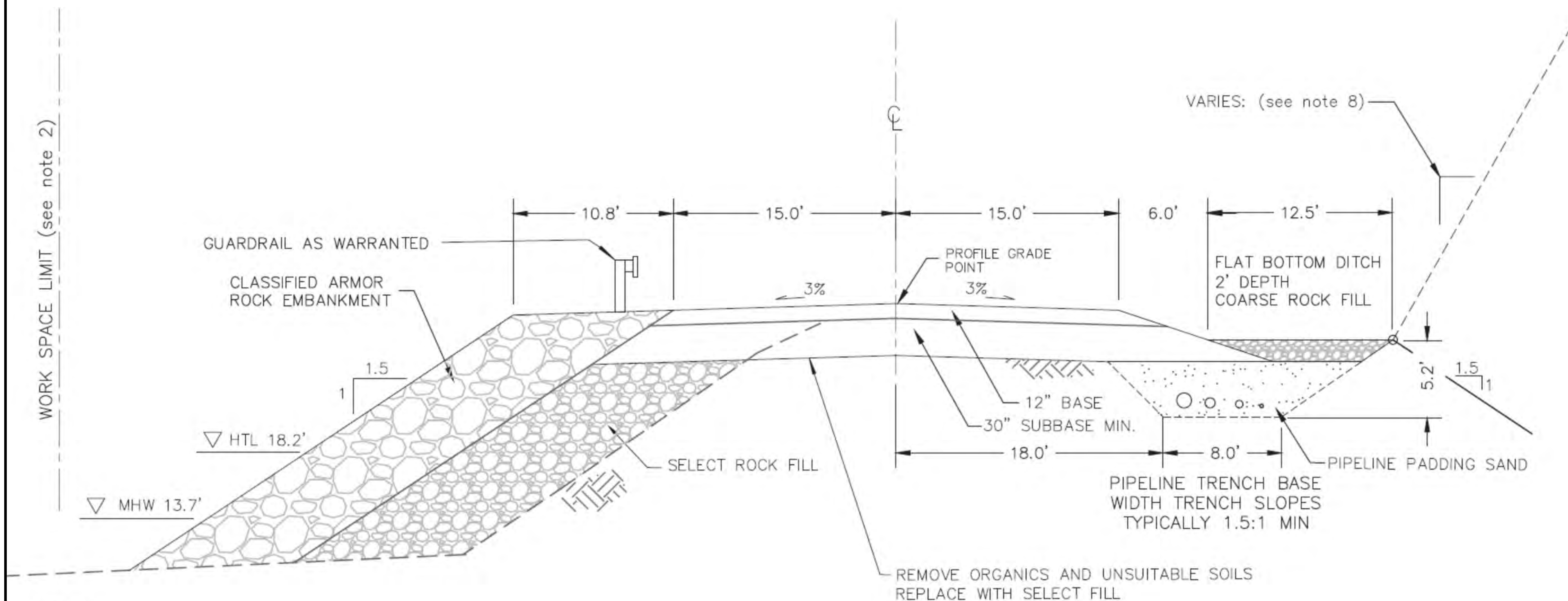
THE pebble PARTNERSHIP

FIGURE NO.
A - 21

MINE ACCESS ROAD TYPICAL SECTION IN INTERTIDAL ZONE AND WITH CONVEYOR

Essential Fish Habitat Assessment

File: PLPEFH_024.vsdx	Date: 5/28/2020
Revision: 02	Author: ORNRC



NOTES:

1. TYPICAL SECTION APPLIES TO THE FOLLOWING INTERVALS:
   STA. 108+43 TO 123+43 (MP 2.05 TO MP 2.34)
   STA. 133+90 TO 140+90 (MP 2.54 TO MP 2.67)
2. WORK SPACE LIMIT 5 FT FROM TOE OF FILL OR TOP OF CUT.
3. BASE TO CONSIST OF 2 inch MINUS, DURABLE, WELL GRADED, CRUSHED ROCK WITH 6 TO 10% PASSING THE 200 SIEVE. 12" MIN DEPTH.
4. SUBBASE TO CONSIST OF CLEAN DURABLE COARSE ROCK OR GRAVEL. NON-FROST-SUSCEPTIBLE. 30" MIN DEPTH.
5. SELECT ROCK FILL MATERIAL; TO CONSIST OF DURABLE COARSE FREE DRAINING ROCK OR GRAVEL, AS APPROVED BY ENGINEER.
6. DEPTH OF EMBANKMENT STRUCTURAL FILL WILL VARY DEPENDING ON SOIL TYPE AND CONDITION. 3.5 FT TOTAL EMBANKMENT DEPTH WILL TYPICALLY BE THE MINIMUM.
7. ANY REQUIRED BLASTING WILL BE DONE DURING THE LOW TIDE CYCLE WHEN ROCK TO BE BLASTED IS ABOVE THE WATERLINE. ROCK FILL TO BE PLACED BELOW THE HIGH TIDE LINE WILL BE CLEAN COARSE ROCK OR RIP RAP AND WILL NOT INCLUDE SIGNIFICANT FINE MATERIAL.
8. BACKSLOPES WILL VARY DEPENDENT UPON SOIL OR ROCK TYPE AND CHARACTER.
   TYPICAL: 2:1 FOR GLACIAL MORAINE SOILS
   1.3:1 FOR COARSE ROCK OR GRAVEL
   0.25:1 TO 1:1 FOR ROCK
9. ARMOR ROCK TO BE PER SPEC FOR CLASS II ARMOR ROCK
10. ACCOMMODATE EXCESS EXCAVATION AND WASTE DISPOSAL BY FLATTENING AND/OR EXTENDING INSLOPE AT SELECT LOCATIONS AS APPROVED BY ENGINEER.
11. INSTALL GUARDRAIL ON LEFT SHOULDER 17 FT FROM CENTERLLINE. ON RIGHT SIDE INSTALL GUARDRAIL AS WARRANTED.
12. NO REFUELING OF MOBILE EQUIPMENT WITHIN 200 FT OF WATER BODY.
13. SPOIL TO BE STORED OUT OF THE INTERTIDAL ZONE AND ADJACENT WETLANDS AND WITHIN THE CONSTRUCTION R.O.W.
14. EMBANKMENT FILL CONSISTING OF COARSE CLEAN ROCK TO BE INCORPORATED AS EROSION AND SEDIMENT CONTROL MEASURE.

THE pebble PARTNERSHIP

FIGURE NO.
A - 22

MINE ACCESS ROAD TYPICAL SECTION IN INTERTIDAL ZONE

Essential Fish Habitat Assessment

File: PLPEFH_041	Date: 6/10/2020
Revision: 02	Author: ORNRC

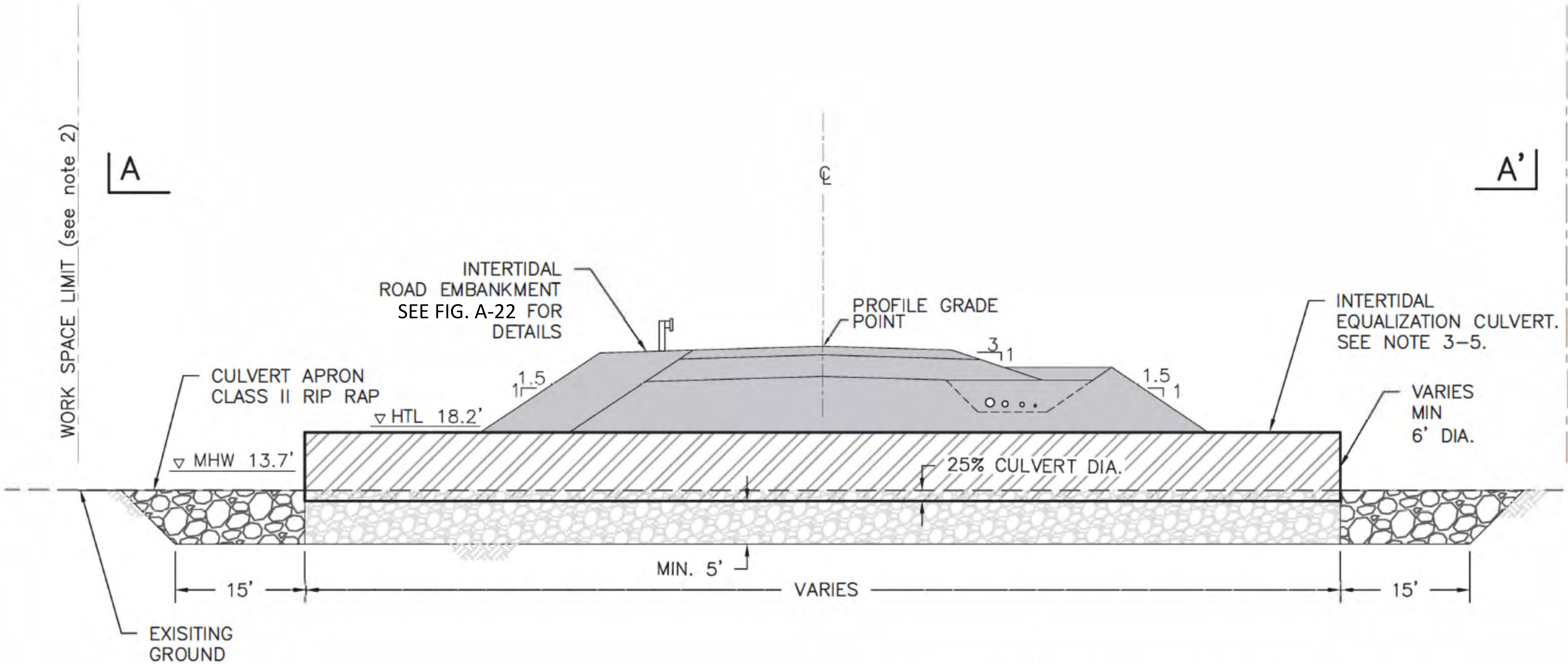


FIGURE NO.
A - 23

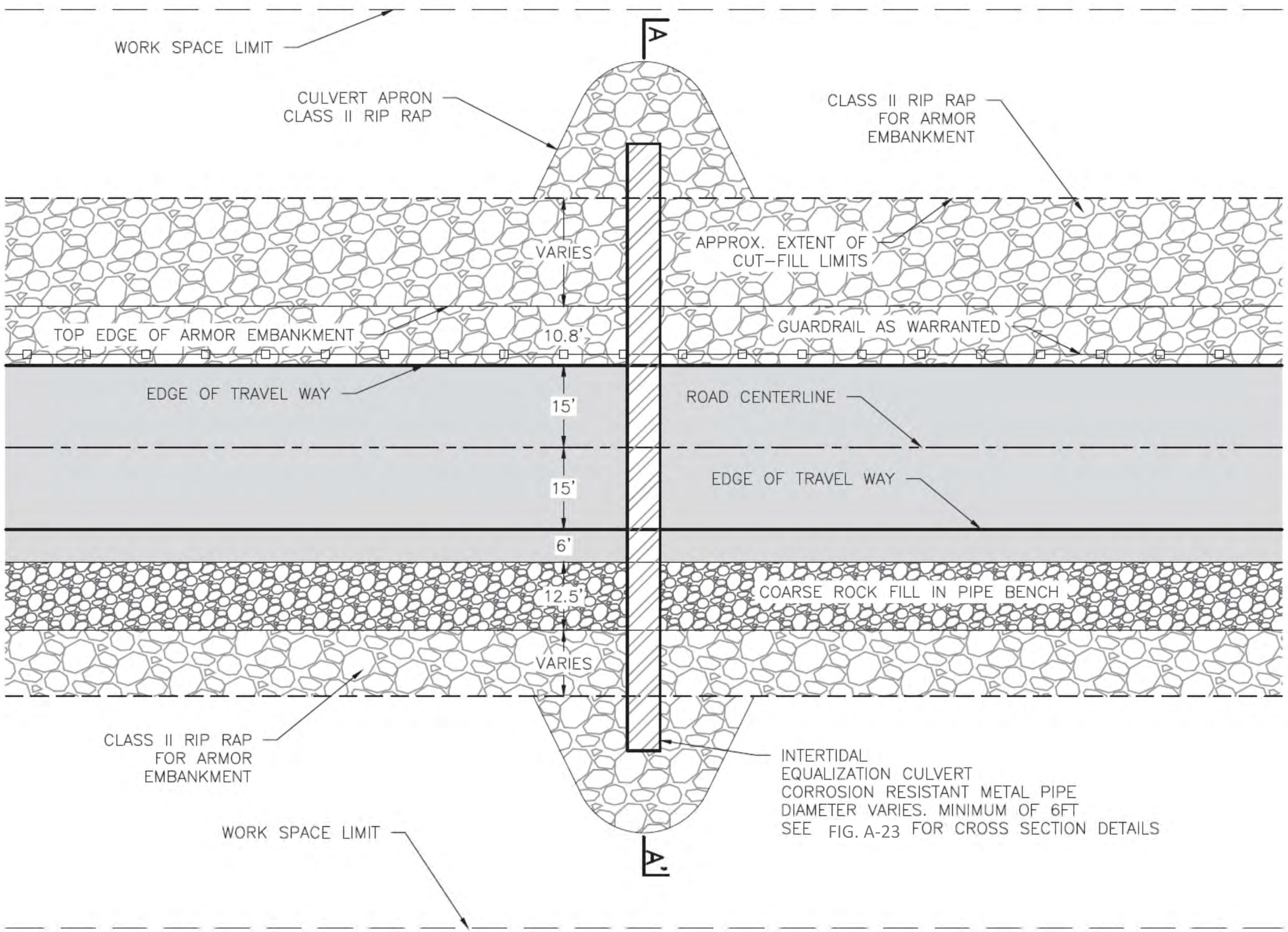
MINE ACCESS ROAD TYPICAL SECTION INTERTIDAL CULVERT

Essential Fish Habitat Assessment

NOTES:

1. INTERTIDAL CULVERT TO BE INSTALLED AT THE FOLLOWING LOCATIONS:
   - STA. 128+40 (MP 2.43)
   - STA. 129+80 (MP 2.45)
   - STA. 133+40 (MP 2.53)
   - STA. 043+66 (MP 0.83)
   - STA. 062+55 (MP 1.18)
2. WORK SPACE LIMIT 5 FT BEYOND EDGE OF CULVERT APRON.
3. BEDDING MATERIAL TO BE A MINIMUM DEPTH OF 5FT. FINAL DEPTH MAY VARY, DEPENDING ON GEOTECHNICAL INVESTIGATION.
4. EXCAVATION AND FILL TO BE DONE DURING LOW TIDE CYCLE WHEN WORK AREA IS ABOVE THE WATERLINE.
5. CULVERT TO BE CORRUGATED METAL PIPE AND WILL BE DESIGNED FOR SEAWATER ENVIRONMENT.
6. NO REFUELING OF MOBILE EQUIPMENT WITHIN 200 FT OF WATERBODY.
7. SPOIL TO BE STORED OUT OF THE STREAM CHANNEL AND ADJACENT WETLANDS AND WITHIN THE CONSTRUCTION R.O.W.
8. MAINTAIN TIDAL FLOW THROUGHOUT CROSSING CONSTRUCTION.
9. RESTORE DISTURBED AREAS OF LITTORAL ZONE TO APPROXIMATE PRE–CONSTRUCTION PROFILE AND SUBSTRATE.
10. SEE FIG. A-24 FOR PLAN VIEW ADDITIONAL DETAILS.

File: PLPEFH_042	Date: 6/10/2020
Revision: 02	Author: ORNRC



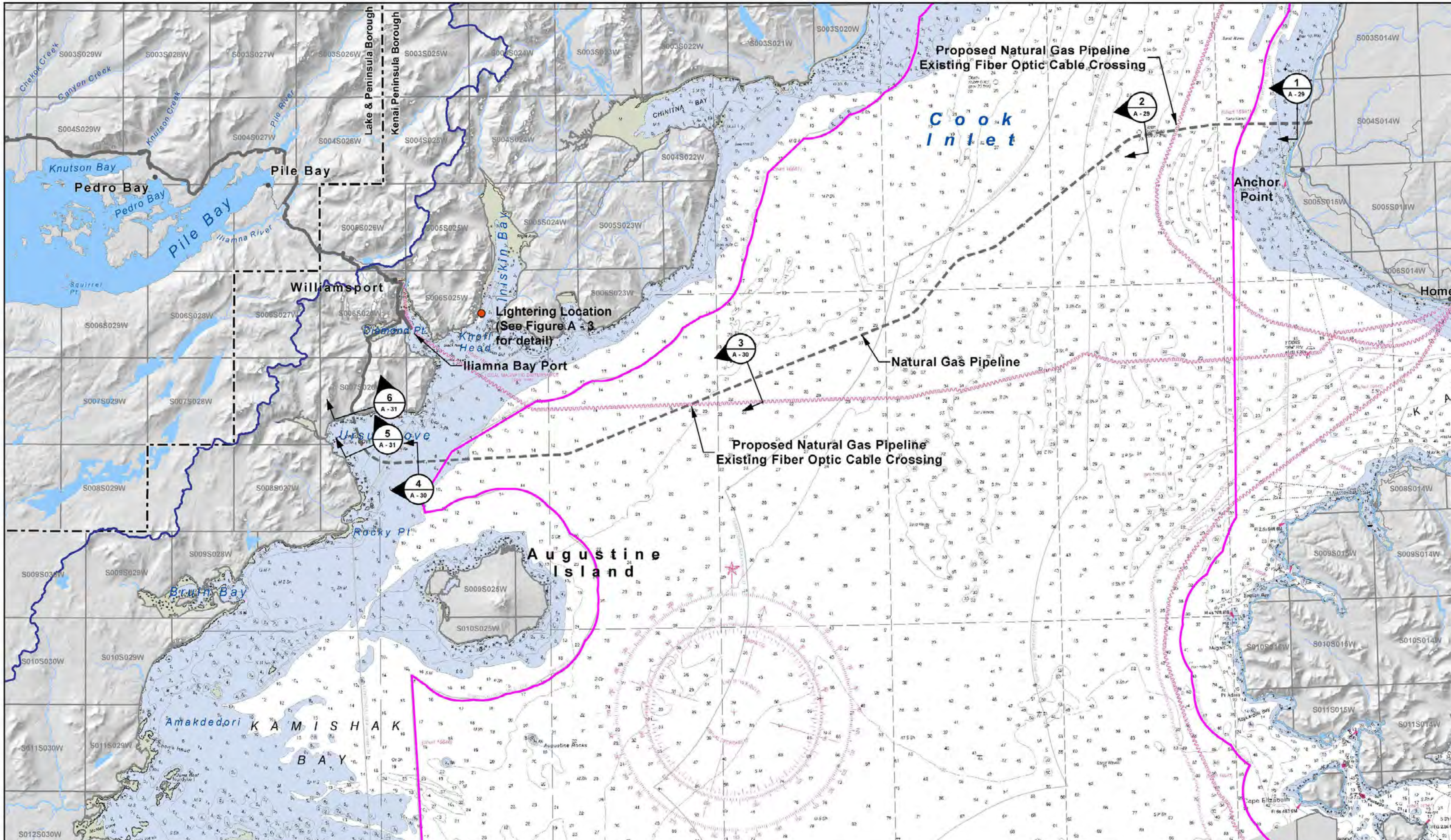
THE pebble PARTNERSHIP

FIGURE NO.
A - 24

MINE ACCESS ROAD PLAN VIEW
INTERTIDAL CULVERT

Essential Fish Habitat Assessment

File: PLPEFH_043	Date: 6/10/2020
Revision: 02	Author: ORNRC



Natural Gas Pipeline
Project Footprint
Lightering Location
Waterbody
Major Stream
Bristol Bay / Cook Inlet Watershed Divide
Existing Roads
Communities
Township
Borough Boundary
Existing Submarine Cable
Submerged Lands Act Boundary

0 3 6 9 Miles

1 inch = 6 miles

NAD 1983 StatePlane Alaska 5 FIPS 5005 Feet

PEBBLE PROJECT

APPLICANT: PEBBLE LIMITED PARTNERSHIP

LAT., LONG. OF MINE
59°53'51.29"N 155°18'2.83"W

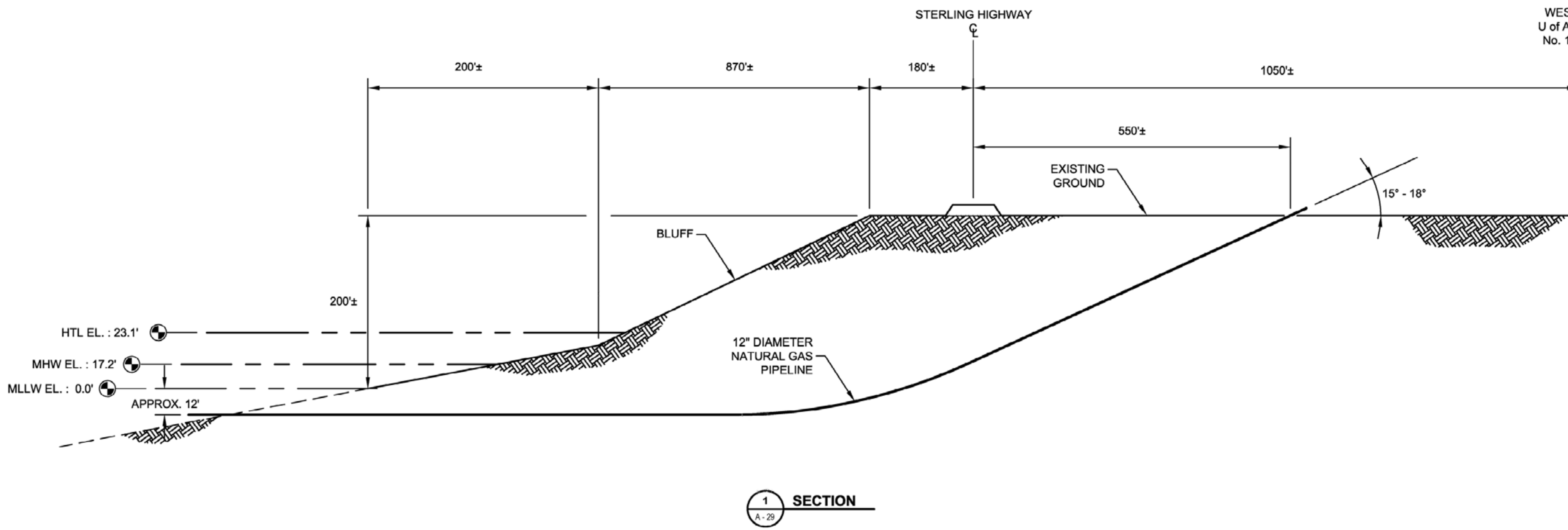
PROPOSED ACTIVITY:
MINERAL DEVELOPMENT

FILE NO.
POA-2017-271

DRAWING TITLE:
PLAN VIEW
NATURAL GAS PIPELINE
COOK INLET CROSSING

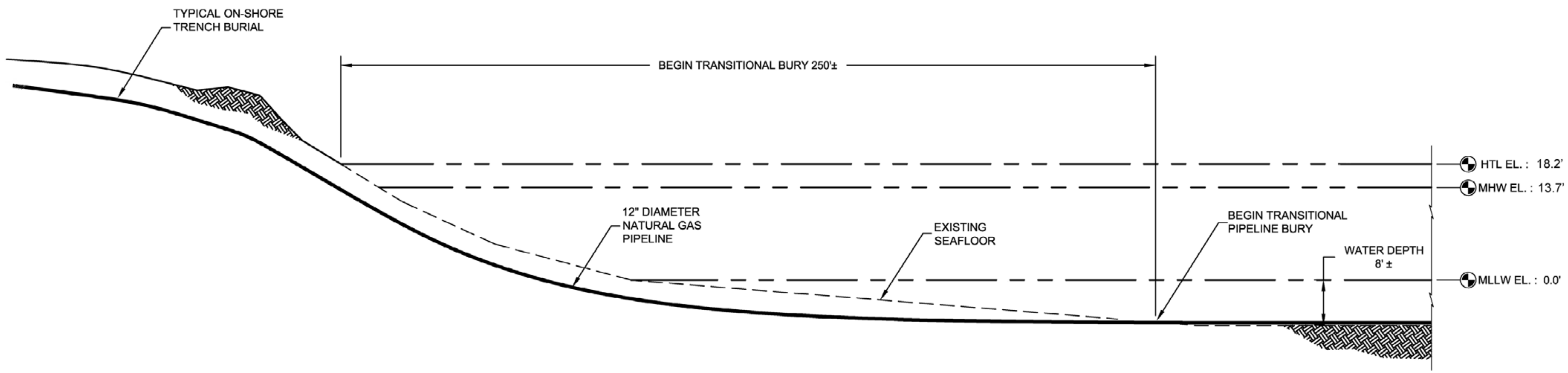
DATE:
JUNE 2020

FIGURE NO.
A - 25



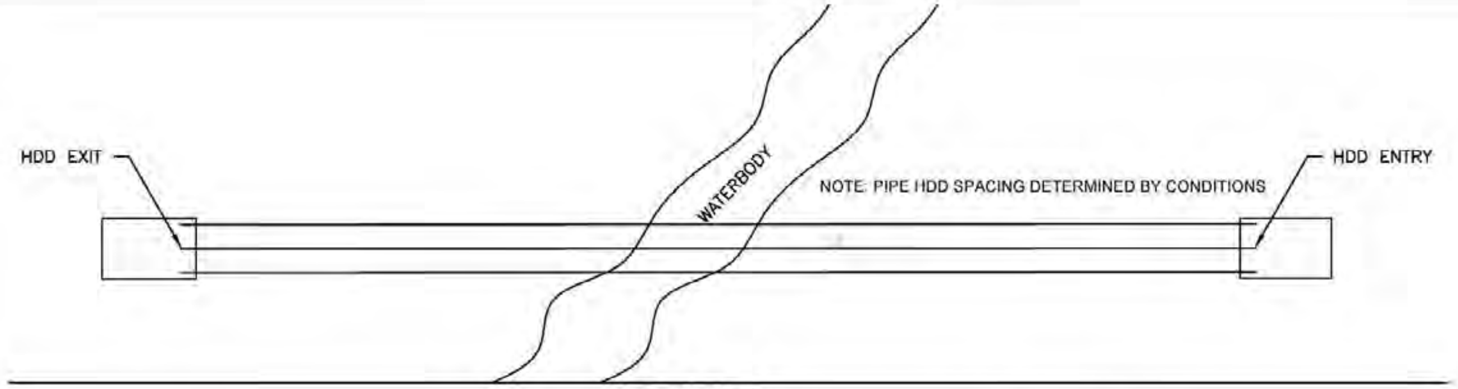
NOTE: TIDE ELEVATIONS BASED ON
SELDOVIA STATION ID 9455500

PEBBLE PROJECT		DRAWING TITLE:	
APPLICANT: PEBBLE LIMITED PARTNERSHIP		NATURAL GAS PIPELINE ANCHOR POINT BLUFF HHD TYPICAL SECTION	
LAT., LONG. OF MINE 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: MINERAL DEVELOPMENT		
WATERWAY: COOK INLET	FILE NO. POA-2017-271	DATE: JUNE 2020	FIGURE NO. A-26

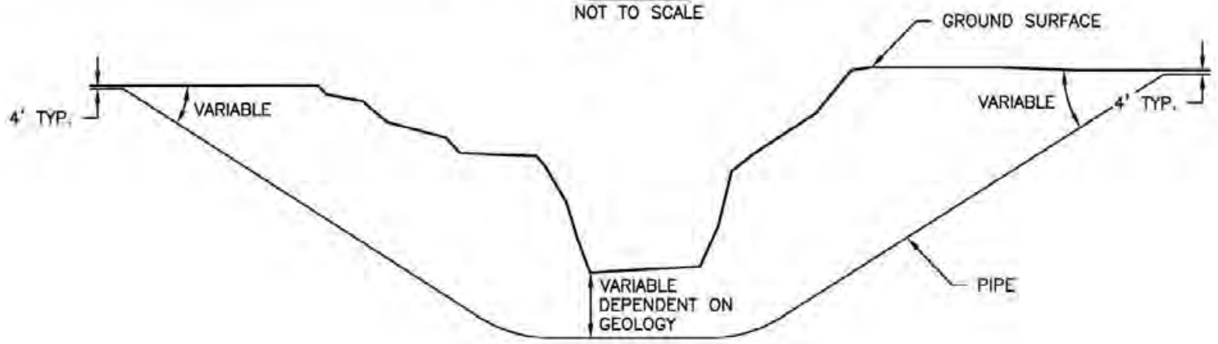


1 / A - 29 **SECTION**

PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **NATURAL GAS PIPELINE WEST COOK INLET SHORE TRANSITION PROFILE**	
LAT., LONG. OF MINE 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: **MINERAL DEVELOPMENT**		
WATERWAY: **COOK INLET**	FILE NO. **POA-2017-271**	DATE: **JUNE 2020**	FIGURE NO. **A-27**

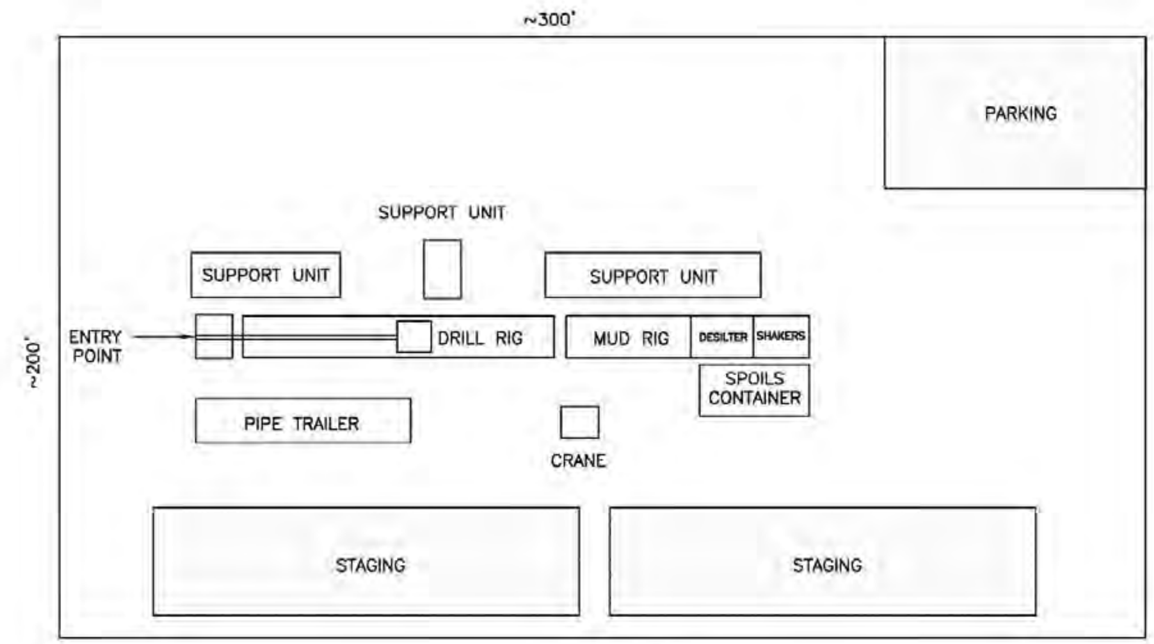


PLAN VIEW
NOT TO SCALE



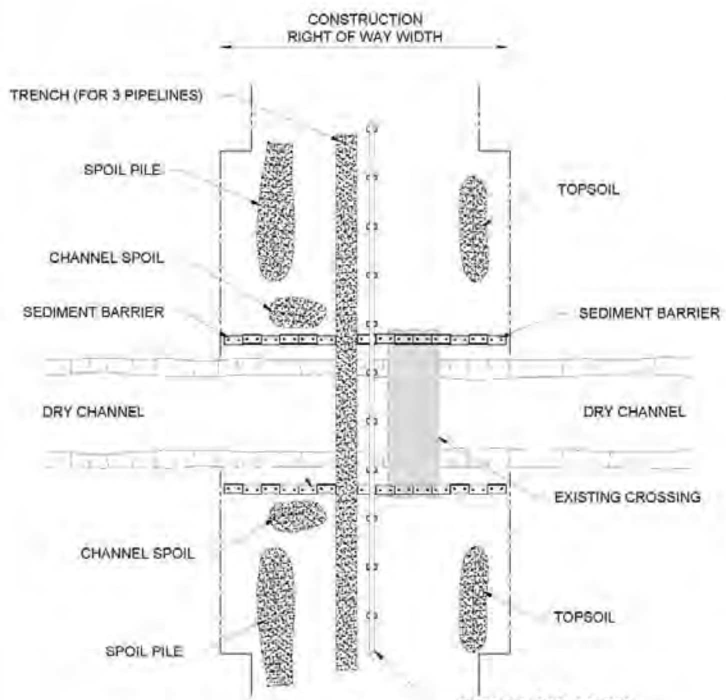
PROFILE VIEW
NOT TO SCALE

TYPICAL HDD PLAN & PROFILE



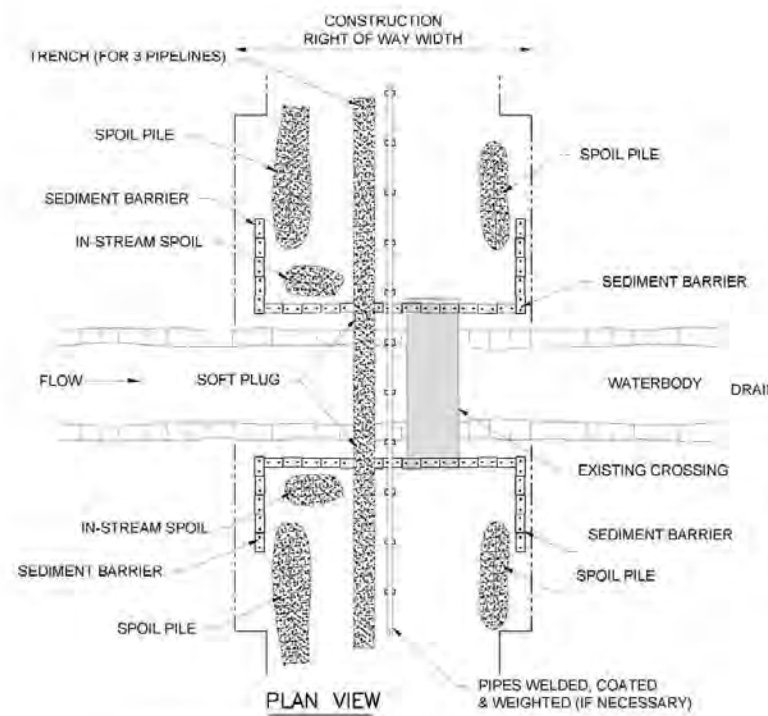
PLAN VIEW
NOT TO SCALE

TYPICAL HDD ENTRY/EXIT SITE
EQUIPMENT LAYOUT



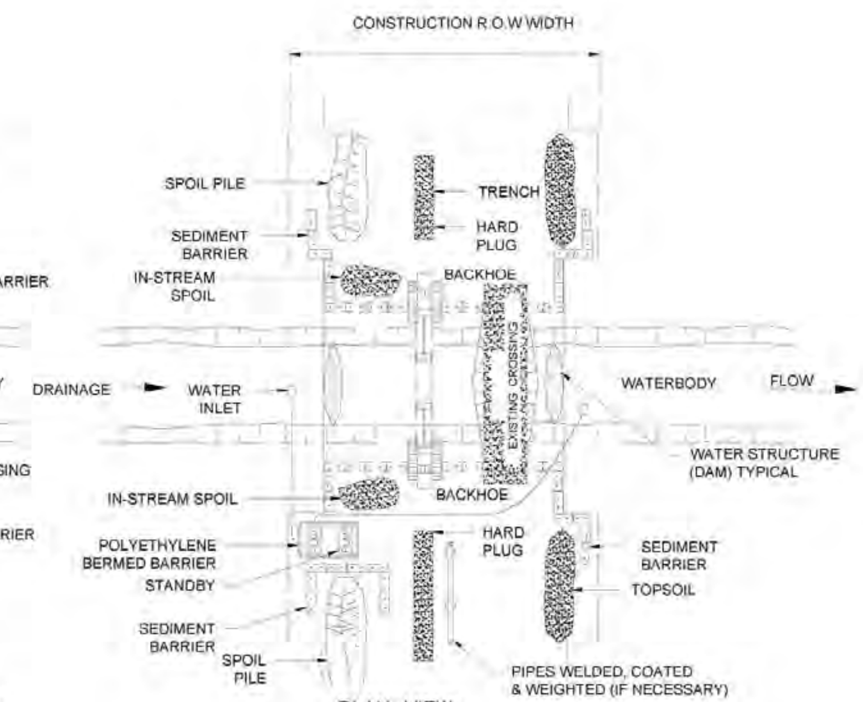
PLAN VIEW
NOT TO SCALE

TYPICAL NON-FLOWING WATERBODY
CROSSING OPEN-CUT



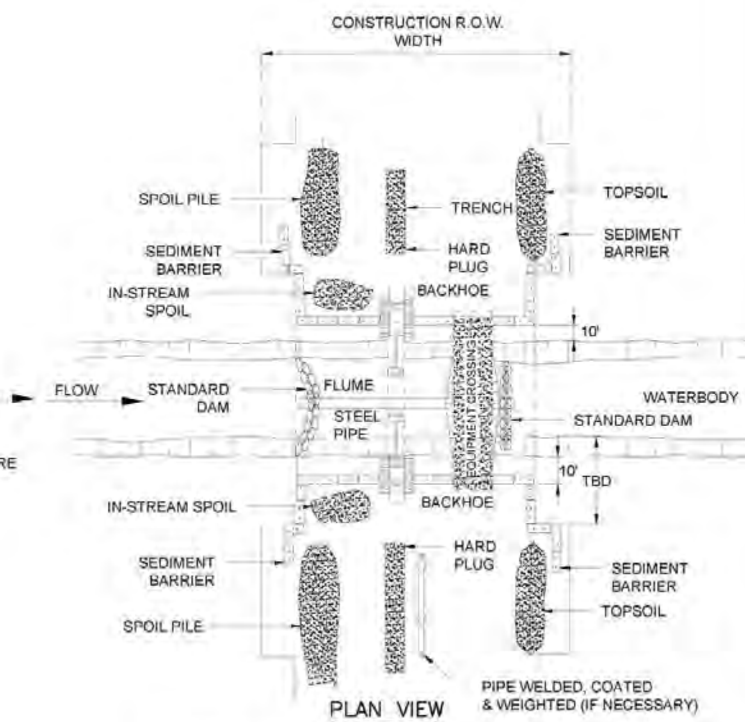
PLAN VIEW
NOT TO SCALE

TYPICAL FLOWING WATERBODY
CROSSING OPEN-CUT



PLAN VIEW
NOT TO SCALE

TYPICAL FLOWING WATERBODY
CROSSING OPEN-CUT DAM & PUMP



PLAN VIEW
NOT TO SCALE

TYPICAL FLOWING WATERBODY
CROSSING OPEN-CUT DRY FLUME

CROSSING MODE SELECTION CRITERIA AND PRECEDENCE

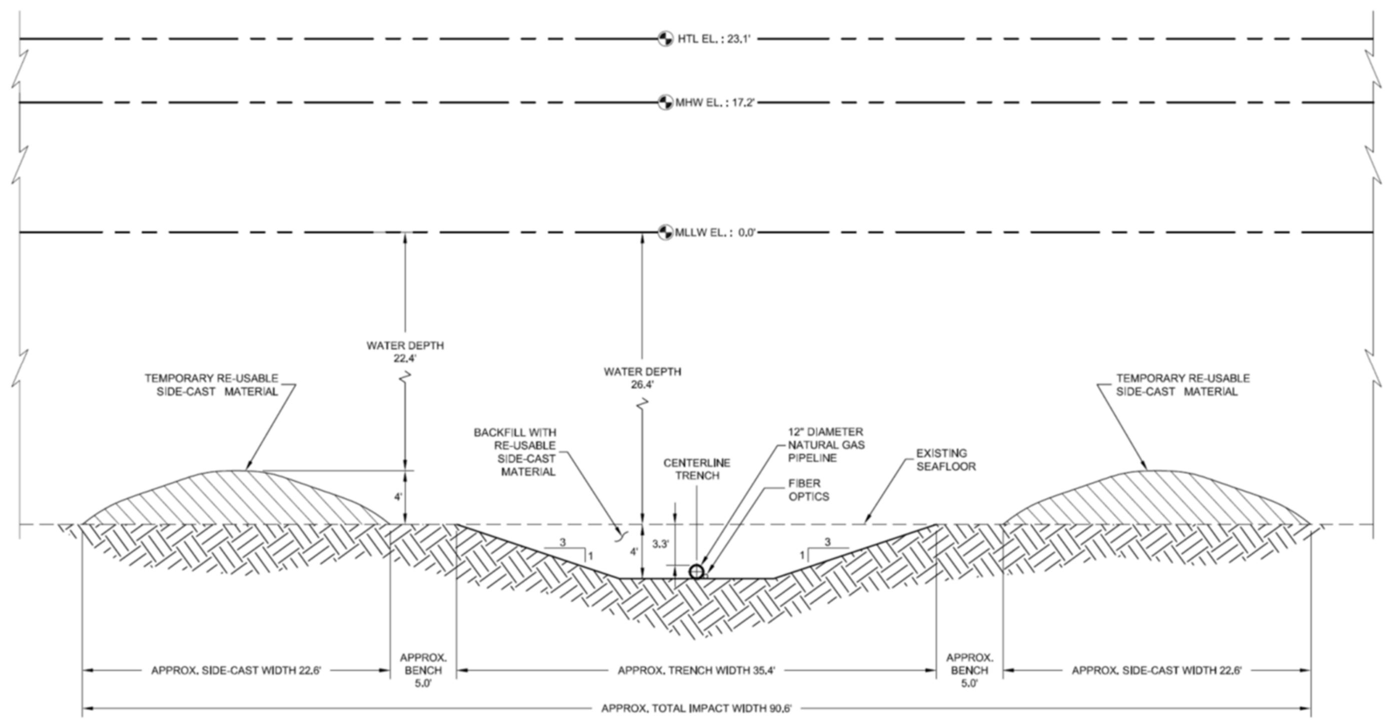
1) BEDROCK CROSSING OR ADF&G CONDITION - UTILIZE HDD, OTHERWISE OPEN CUT
2) NON-FLOWING WATERBODY - UTILIZE OPEN-CUT
3) FLOW VELOCITY AND STREAMBED MATERIAL SUPPORT OPEN-CUT - UTILIZE UNLESS DIRECTED OTHERWISE BY ADF&G
4) FLOW VOLUME SUITABLE FOR DAM & PUMP - UTILIZE OPEN-CUT DAM & PUMP
5) FLOW VOLUME TO LARGE FOR DAM & PUMP - UTILIZE OPEN-CUT DRY FLUME

NOTES:

1. SCHEDULE CROSSING DURING LOW FLOW PERIOD IF POSSIBLE.
2. COMPLETE ALL IN-STREAM ACTIVITIES WITHIN 24 HOURS IF FEASIBLE.
3. NO REFUELING OF MOBILE EQUIPMENT WITHIN 200 FEET OF WATERBODY.
4. CONSTRUCT SEDIMENT BARRIERS ALONG THE SIDES OF STOCKPILES AND ACROSS THE ENTIRE CONSTRUCTION R.O.W.
5. SPOIL TO BE STORED OUT OF THE STREAM CHANNEL AND ADJACENT WETLANDS AND WITHIN THE CONSTRUCTION R.O.W.
6. INSTALL SOFT PLUGS AT THE EDGE OF STREAM BANKS UNTIL JUST PRIOR TO PIPE INSTALLATION IF NEEDED.
7. MAINTAIN STREAM FLOW THROUGHOUT CROSSING CONSTRUCTION.
8. BACKFILL WITH NATIVE MATERIAL.
9. RESTORE WATERBODY CHANNEL TO APPROXIMATE PRE-CONSTRUCTION PROFILE AND SUBSTRATE.
10. RESTORE STREAM BANKS TO APPROXIMATE ORIGINAL CONDITION AND STABILIZE, AS REQUIRED.
11. ALL DIMENSIONS SHALL BE DETERMINED BY ACTUAL CONSTRUCTION CONDITIONS.

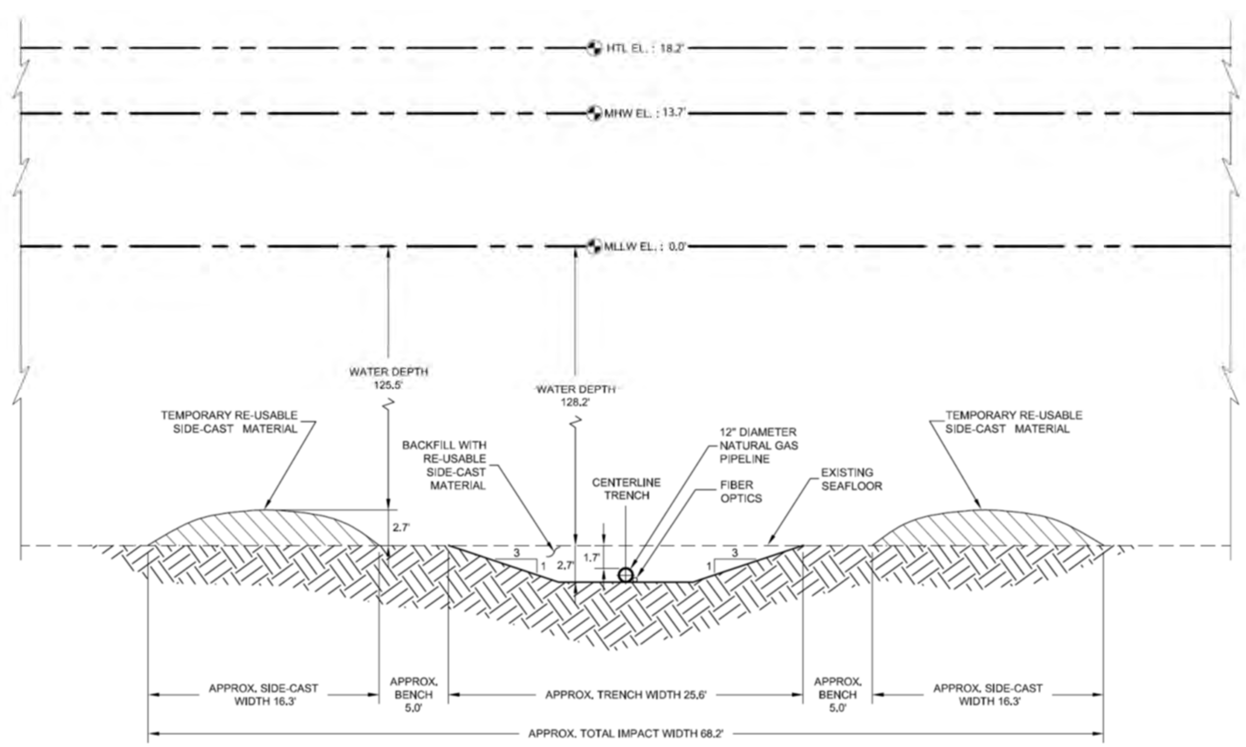
PEBBLE PROJECT APPLICANT: **PEBBLE LIMITED PARTNERSHIP**		DRAWING TITLE: **NATURAL GAS PIPELINE WATERBODY CROSSINGS TYPICALS**
LAT., LONG. OF MINE 59°53'51.29"N 155°18'2.83"W	PROPOSED ACTIVITY: MINERAL DEVELOPMENT	
WATERWAY: VARIOUS	FILE NO. POA-2017-271	DATE: JUNE 2020 — FIGURE NO. A-28

90.6 FT TOTAL IMPACT WIDTH



1 SECTION
A - 29

68.2 FT TOTAL IMPACT WIDTH



2 SECTION
A - 29

THE pebble PARTNERSHIP

FIGURE NO.
A - 29

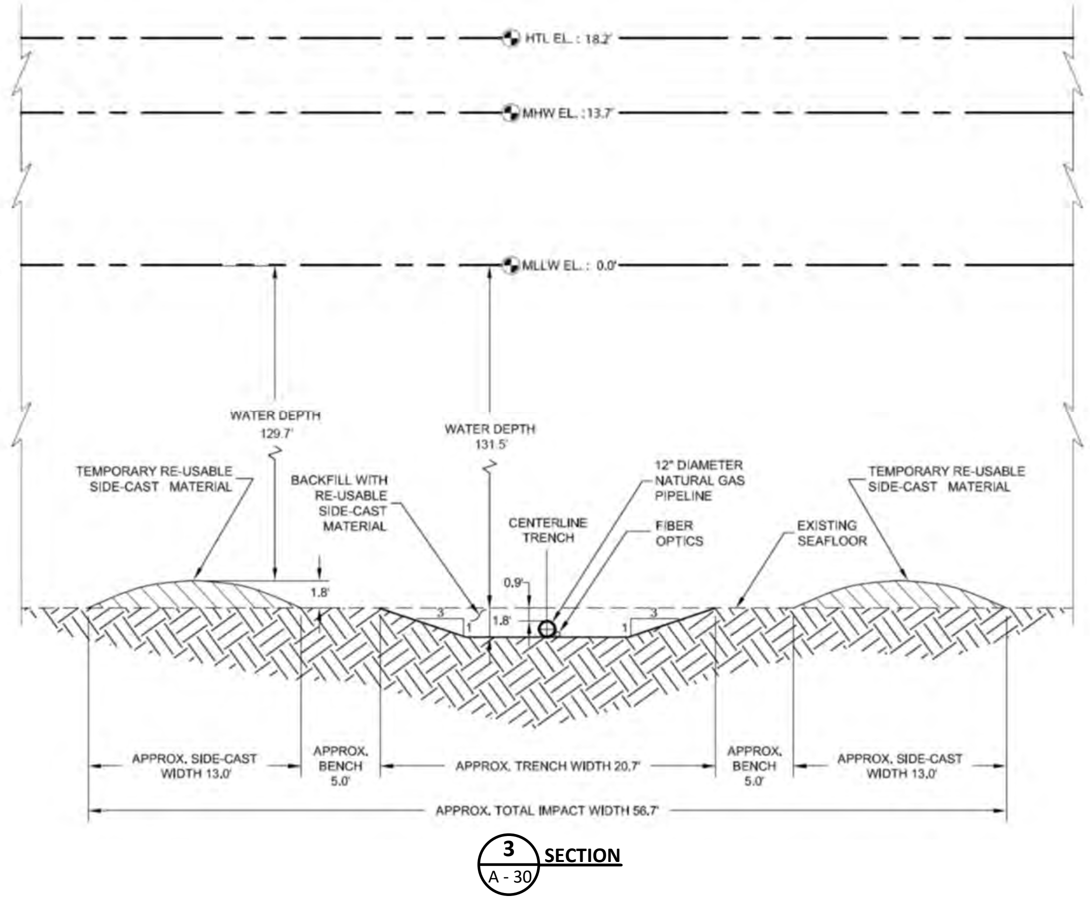
Natural Gas Pipeline and Fiber Optic Cable Seabed Typicals (90.6 ft, and 68.2 ft Impact Width)

(See Table 3-1 and Figure A-25)

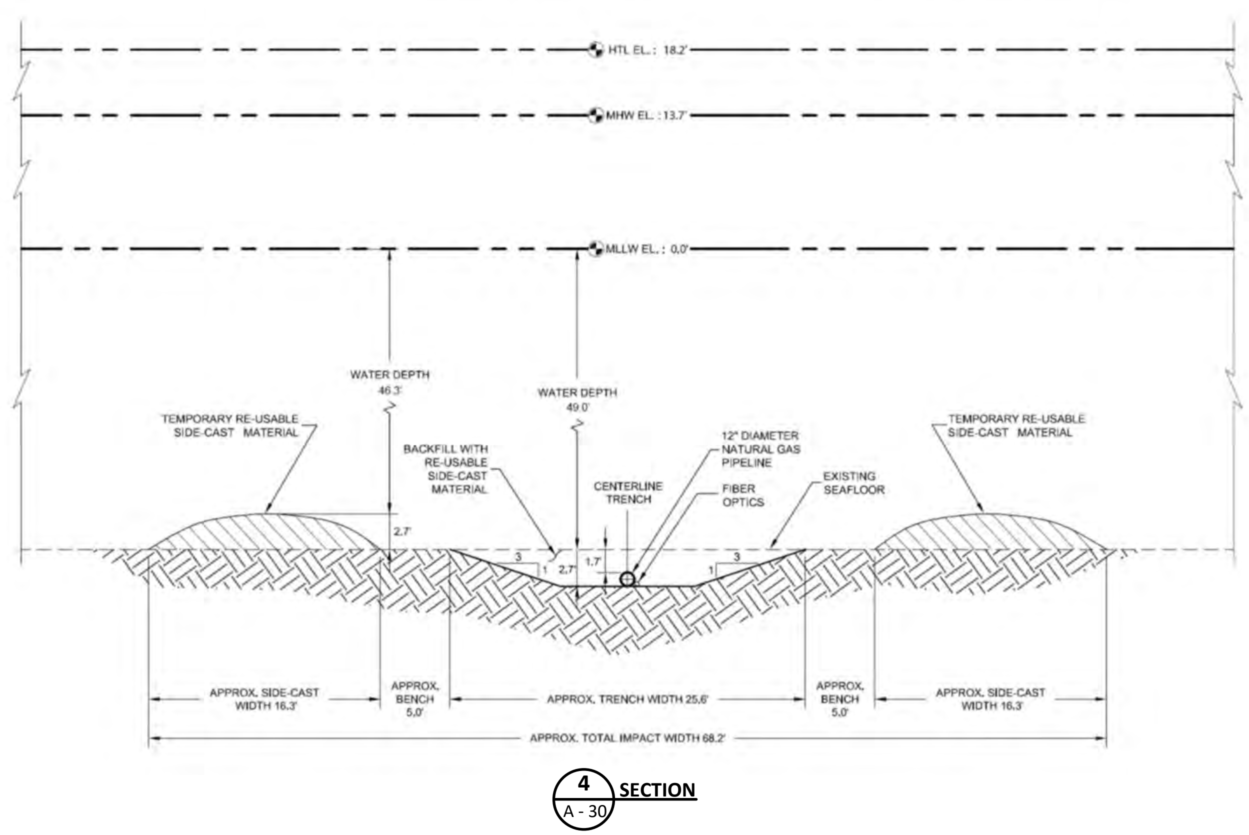
Essential Fish Habitat Assessment

File: PLPEFH_039	Date: 6/10/2020
Revision: 02	Author: ORNRC

56.7 FT TOTAL IMPACT WIDTH



68.2 FT TOTAL IMPACT WIDTH



THE pebble PARTNERSHIP

FIGURE NO.
A - 30

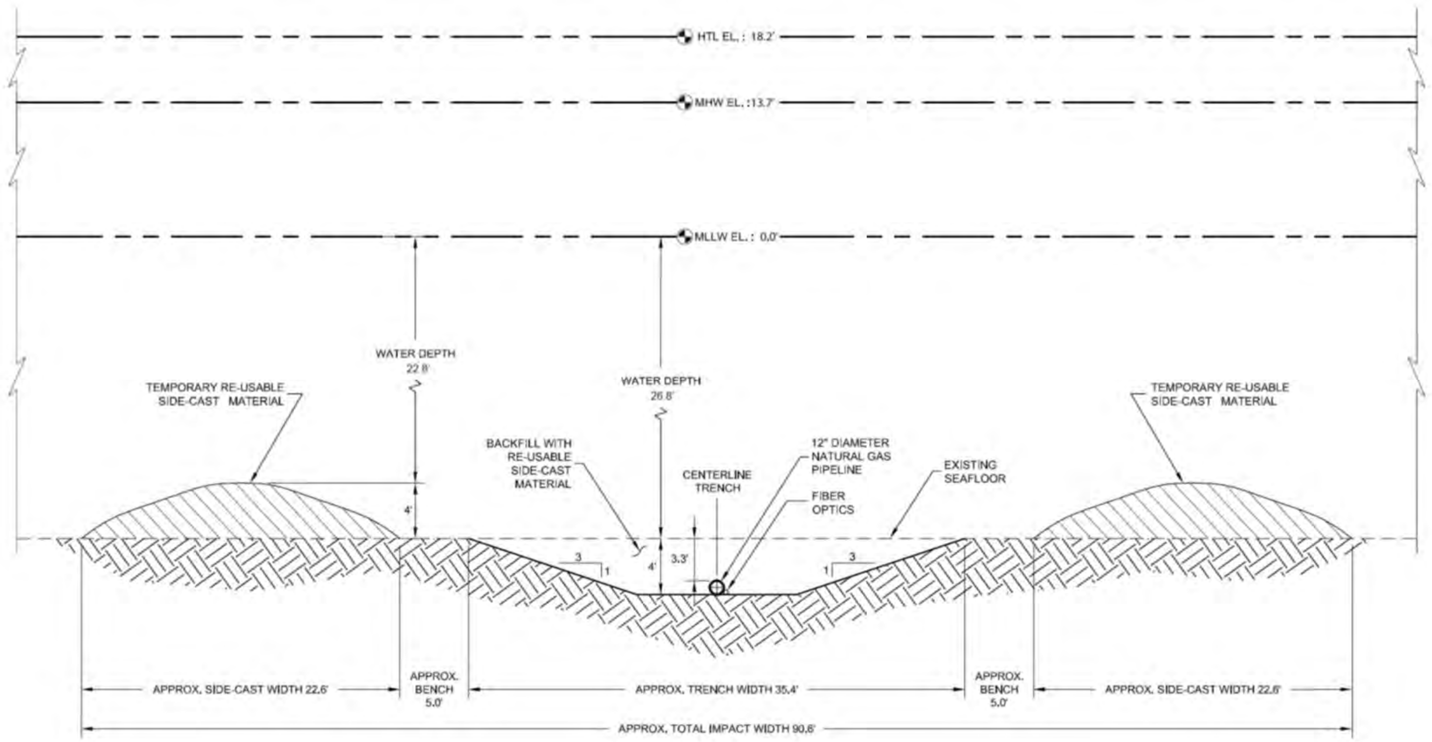
Natural Gas Pipeline and Fiber Optic Cable Seabed Typicals (56.7 ft, and 68.2 ft Impact Width)

(See Table 3-1 and Figure A-25)

Essential Fish Habitat Assessment

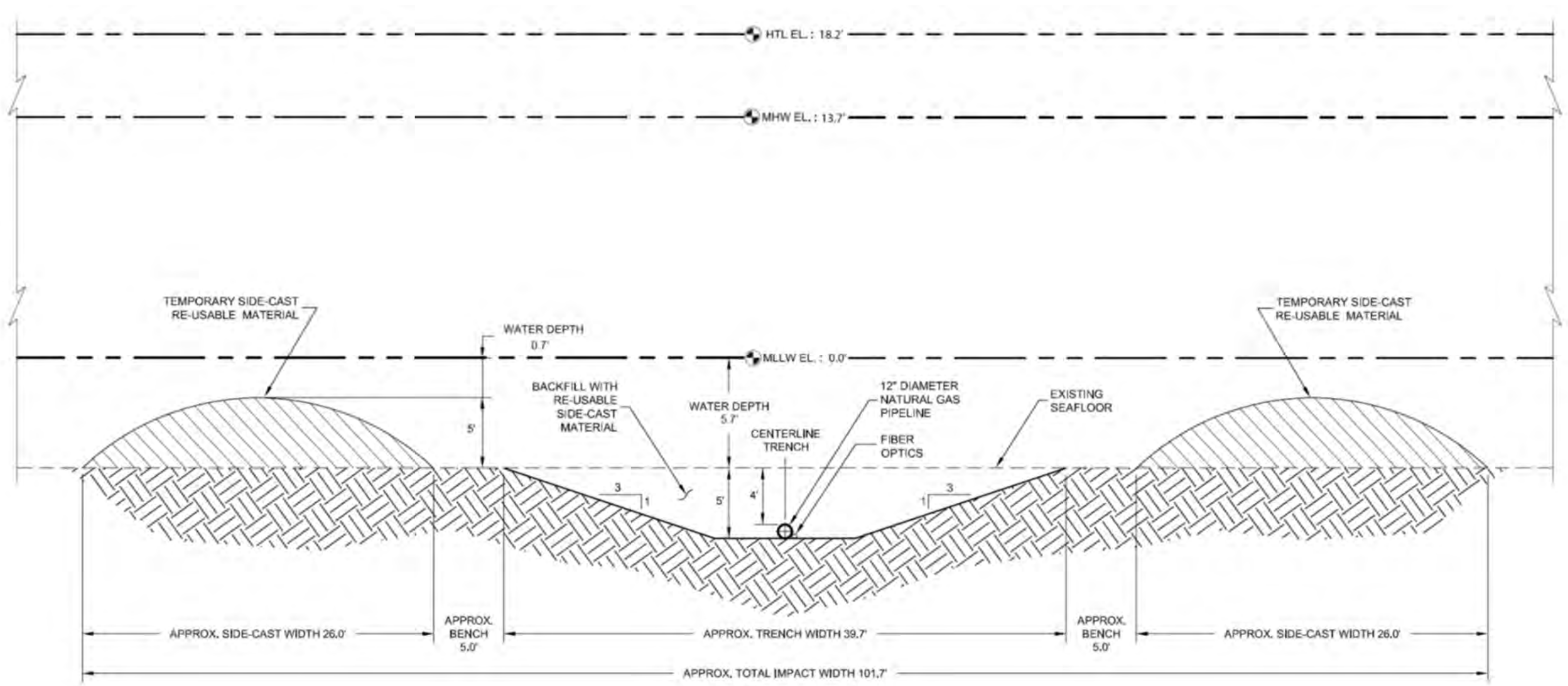
File: PLPEFH_037	Date: 6/10/2020
Revision: 02	Author: ORNRC

90.6 FT TOTAL IMPACT WIDTH



5
A - 31
SECTION

101.7 FT TOTAL IMPACT WIDTH



6
A - 31
SECTION

THE pebble PARTNERSHIP

FIGURE NO.
A - 31

Natural Gas Pipeline and Fiber Optic Cable Seabed Typicals (90.6 ft, and 101.7 ft Impact Width)

(See Table 3-1 and Figure A-25)

Essential Fish Habitat Assessment

File: PLPEFH_038	Date: 6/10/2020
Revision: 02	Author: ORNRC