APPENDIX M

Essential Fish Habitat Assessment

Federal Energy Regulatory Commission
Office of Energy Projects
Washington, DC 20426

Alaska LNG Project

Essential Fish Habitat Assessment

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ACRONYMS AND ABBREVIATIONS

µPa	microPascal
AAC	Alaska Administrative Code
ADF&G	Alaska Department of Fish and Game
ADEC	Alaska Department of Environmental Conservation
AGDC	Alaska Gasline Development Corporation
AK	Alaska
APDES	Alaska Pollutant Discharge Elimination System
AWC	*Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes*
BMP	best management practice
BP	British Petroleum
CFR	Code of Federal Regulations
Coast Guard	United States Coast Guard
COE	United States Army Corps of Engineers
dB	decibel
dB re 1 µPa	decibels relative to 1 microPascal
DMMP	Dredged Material Management Program
DMT	directional micro-tunneling
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	environmental impact statement
EPA	United States Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FMP	Fishery Management Plan
FP	material site code
FR	*Federal Register*
GOA	Gulf of Alaska
GTP	Gas Treatment Plant
HAPC	Habitat Area of Particular Concern
LNG	liquefied natural gas
MLV	mainline valve
MOF	material offloading facility
MP	milepost
MS	material site
NMFS	National Marine Fisheries Service
No.	Number
NOAA	National Oceanic and Atmospheric Administration
NPFMC	North Pacific Fishery Management Council
PBTL	Prudhoe Bay Unit Gas Transmission Line
PBU	Prudhoe Bay Unit
PLF	Product Loading Facility
Procedures	Project Wetland and Waterbody Construction and Mitigation Procedures
Project	Alaska LNG Project
PT	Point
PTMP	Point Thomson Unit Gas Transmission Line (PTTL) milepost
PTTL	Point Thomson Unit Gas Transmission Line
re	relative to
SPCC	Spill Prevention, Control, and Countermeasures
SWPPP	Stormwater Pollution Prevention Plan

UIC	underground injection control
VGP	General Permit for Discharges Incidental to the Normal Operation of Vessels
VSM	vertical support member

1.0 INTRODUCTION

Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act of 1972, as amended, requires federal agencies to consult on all actions or proposed actions authorized, funded, or undertaken by agencies, which could adversely affect Essential Fish Habitat (EFH). The Magnuson-Stevens Fishery Conservation and Management Act defines EFH as "those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity" (50 Code of Federal Regulations [CFR] 600). For the purposes of this definition, "waters" means aquatic areas and their associated physical, chemical, and biological properties; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means the habitat required to support a sustainable fishery and healthy ecosystem; and "spawning, feeding, and breeding" encompasses the complete life cycle of a species (50 CFR 600). The National Oceanic and Atmospheric Agency, National Marine Fisheries Service (NMFS) along with the Alaska Department of Fish and Game (ADF&G) and other agencies work together to identify and protect EFH for federally managed fish species. In Alaska, EFH is designated by Fisheries Management Councils in Fishery Management Plans (FMP) based on best available scientific information (NMFS, 2005). In addition, specific locations have been defined as Habitat Areas of Particular Concern (HAPC); these are areas "with extremely important ecological function and/or areas that are especially vulnerable to human-induced degradation" (NMFS, 2017).

Generally, the EFH consultation process includes the following steps.

1. Notification – The action agency should clearly state the process used for EFH consultations (e.g., incorporating EFH consultation into an environmental impact statement [EIS]).

2. EFH Assessment – The action agency should prepare an EFH Assessment that includes both identification of affected EFH and an assessment of impacts. Specifically, the EFH Assessment should include:

    a. a description of the proposed action;

    b. an analysis of the effects (including cumulative effects) of the proposed action on EFH, managed fish species, and major prey species;

    c. the federal agency's views regarding the effects of the action on EFH; and

    d. proposed mitigation, if applicable.

3. EFH Conservation Recommendations – After reviewing the EFH Assessment, NMFS should provide recommendations to the action agency regarding measures that can be taken by that agency to conserve EFH.

4. Agency Response – Within 30 days of receiving the recommendations, the action agency must respond to NMFS. The action agency may notify NMFS that a full response to the conservation recommendations would be provided by a specified completion date agreeable to all parties. The response must include a description of measures proposed by the agency to avoid, mitigate, or offset the activity's impact on EFH. For any conservation recommendation not adopted, the action agency must explain its reason to NMFS for not following the recommendation.

The Federal Energy Regulatory Commission (FERC) proposes to incorporate EFH consultation for the Alaska Liquefied Natural Gas (LNG) Project (Project) with the interagency coordination procedures required under the National Environmental Policy Act. For federal actions with the potential to affect EFH, the lead federal agency must prepare an EFH Assessment. The lead federal agency must submit its EFH Assessment to NMFS. In response, NMFS issues conservation recommendations within 30 days of the proposed action, or within existing review procedures. For the Project, we[1] have determined that EFH could be adversely affected, and are submitting this EFH Assessment to NMFS to begin consultation.

EFH has been designated in or near areas where Project activities would occur under the following FMPs:

- Arctic Management Area (Arctic FMP) (North Pacific Fishery Management Council [NPFMC], 2009);
- Groundfish of the Gulf of Alaska (GOA Groundfish FMP) (NPFMC, 2016); and
- Salmon Fisheries in the Exclusive Economic Zone (EEZ) off the Coast of Alaska (Salmon FMP) (NPFMC et al., 2012).

EFH designated under the Alaska Scallop FMP, the Bering Sea and Aleutian Island Groundfish FMP, and the Bering Sea/Aleutian Island King and Tanner Crab FMP are crossed by Project vessel routes but would not be affected by transiting vessels. Therefore, EFH designated under these FMPs is not discussed further.

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[1] The pronouns “we,” “us,” and “our” refer to the environmental staff of FERC’s Office of Energy Projects.

2.0 PROJECT DESCRIPTION

2.1 PROPOSED PROJECT FACILITIES

A summary of Project-specific details has been included in this EFH Assessment; however, more specific information can be found in the Project EIS (FERC Docket No. CP17-178-000). The proposed Mainline Pipeline would start at the proposed Gas Treatment Facilities on the North Slope and generally follow the existing Trans Alaska Pipeline System crude oil pipeline and adjacent highways south to Livengood, Alaska. From Livengood, the Mainline Pipeline would diverge from the Trans Alaska Pipeline System and generally head south–southwest to Trapper Creek following the Parks Highway and Beluga Highway, and then turn south–southeast around Viapan Lake. Finally, the Mainline Pipeline would cross Cook Inlet from near Beluga Landing on the west side of Cook Inlet to near Suneva Lake on the east side of Cook Inlet on the Kenai Peninsula, ending at the proposed Liquefaction Facilities (see figure 2.1-1). Land requirements for the Project are described in section 2.1 of the EIS.

The key components of each facility are described below. These facilities would each have a nominal design life of 30 years. More detailed information on the proposed facilities can be found in section 2.0 of the EIS.

2.1.1 Gas Treatment Facilities

The Gas Treatment Facilities would be new facilities in the Prudhoe Bay Unit (PBU) near the Beaufort Sea coast. The Gas Treatment Facilities would be on state land within the North Slope Borough in an area designated for oil and natural gas development. Components of the Gas Treatment Facilities are summarized below.

- Gas Treatment Plant (GTP)
    - three gas treatment systems (trains) to remove liquids and impurities from the natural gas;
    - control building;
    - on-site ancillary facilities, including flares, metering, fuel gas and propane pipelines, fuel systems, and byproduct pipelines; and
    - utilities, including power generation facilities, water supply and treatment systems, sewage treatment, waste disposal (including two underground injection control Class 1 wells), and a communication tower.
    - operations center and camp
- West Dock Causeway
    - widening of the West Dock Causeway and expansion of the West Dock (to be called West Dock 4) to accommodate delivery of pre-fabricated modular components of the GTP from marine vessels;
    - staging area; and
    - temporary, annually installed barge bridge and turning basin.

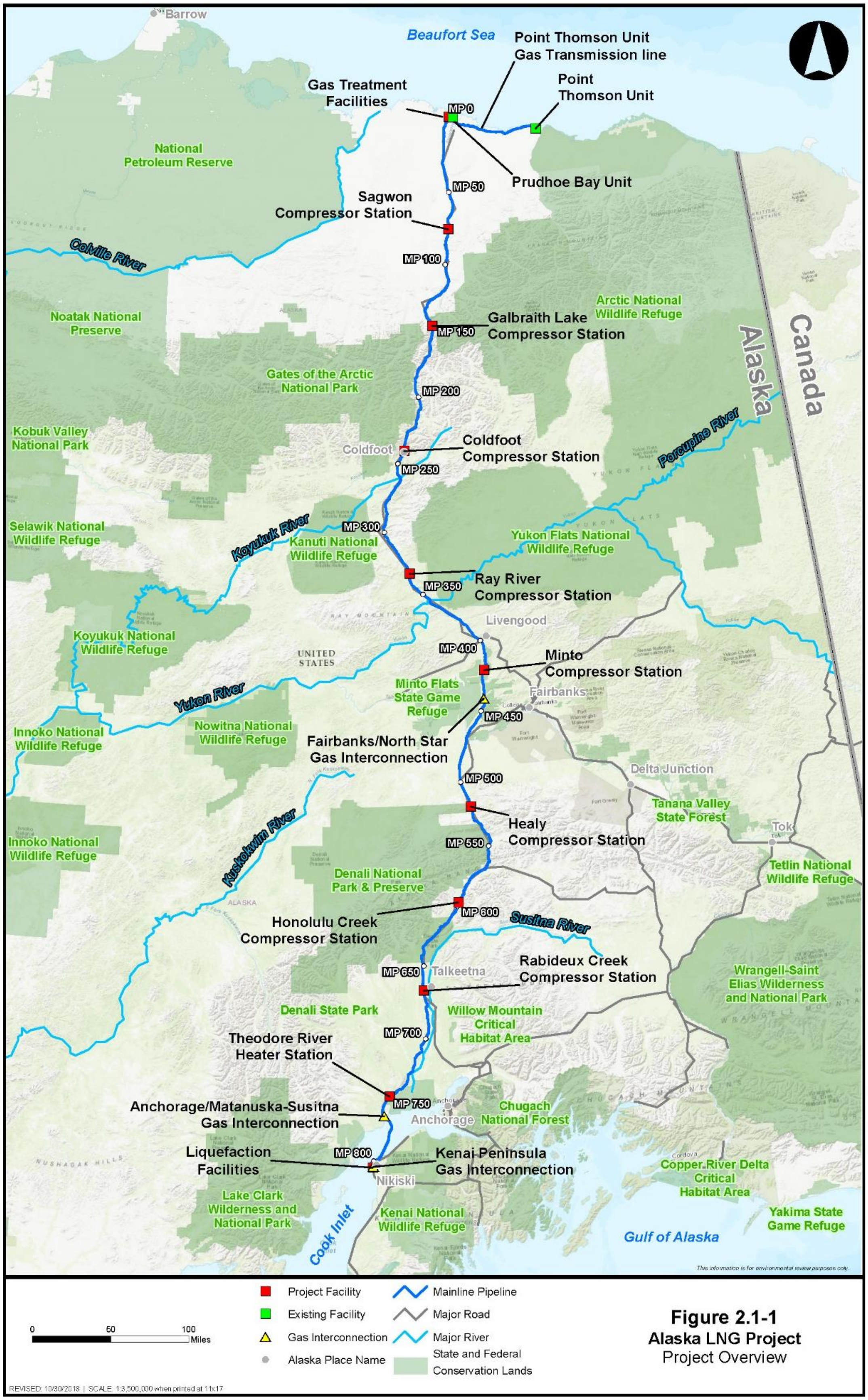

Figure 2.1-1
Alaska LNG Project
Project Overview

- Water reservoir
  - new freshwater reservoir constructed to supply water to the GTP, including pump facilities and a transfer pipeline between the reservoir and the GTP.
- Gravel mine
  - new gravel mine to supply granular fill for roads, pads, West Dock Causeway widening and expansion, staging areas, existing roads and pads, and augmentation and maintenance of pads and roads during operation.
- Prudhoe Bay Unit Gas Transmission Line (PBTL)
  - 1-mile-long, 60-inch-diameter pipeline to transport natural gas from the existing PBU Central Gas Facility to the GTP; and
  - new meter station.
- Point Thomson Unit Gas Transmission Line (PTTL)
  - 62.5-mile-long, 32-inch-diameter pipeline to transport natural gas from the Point Thomson Unit to the GTP; and
  - aboveground facilities, including a meter station, pig[2] launchers/receivers, and three Mainline valves.
- Access roads and staging area
  - four permanent gravel access roads to connect the GTP with other Gas Treatment Facilities;
  - temporary ice roads and ice pads used during construction;
  - 52 ice roads and ice pads for temporary access along the PTTL; and
  - module staging area.
- Pioneer camp
  - temporary construction camp to house workers as well as materials to commence construction.
- Associated transfer pipelines
  - 1.8-mile-long fuel gas pipeline from the PBU Central Gas Facility to the GTP and GTP operations camp;
  - 0.6-mile-long propane pipeline from the PBU Central Gas Facility to the GTP;
  - 1.1-mile-long Putuligayuk River pipeline from the Putuligayuk River to the reservoir; and
  - 5-mile-long supply water pipeline from the reservoir to the GTP and GTP operations camp.

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[2] A pipeline “pig” is a device to clean or inspect the pipeline. A pig launcher/receiver is an aboveground facility where pigs are inserted or retrieved from the pipeline.

2.1.2 Mainline Facilities

The Mainline Facilities includes a Mainline Pipeline originating in the North Slope Borough and terminating at the Liquefaction Facilities in the Kenai Peninsula Borough. Aboveground facilities and additional work areas are also included as summarized below.

- Mainline Pipeline
  - about 806.6 miles of 42-inch-diameter pipeline from the GTP on the North Slope to the Liquefaction Facilities in Nikiski, Alaska. The Mainline Pipeline would include a 27.3-mile-long offshore crossing of Cook Inlet.
- Aboveground Facilities
  - eight natural-gas-driven compressor stations, a heater station, two meter stations, Mainline valves, pig launching/receiving stations, and cathodic protection facilities;
  - permanent material offloading facility (MOF) near Beluga, referred to as the Mainline MOF; and
  - three gas interconnection sites with an isolation valve.
- Additional Work Areas
  - additional temporary workspaces, access roads, helipads and airstrips, construction camps, contractor yards, pipe storage yards, railway yards and spurs, disposal sites, and material yards.

2.1.3 Liquefaction Facilities

The Liquefaction Facilities would include new facilities constructed on the eastern shore of Cook Inlet in the Nikiski area of the Kenai Peninsula. The Liquefaction Facilities would consist of an LNG Plant, Marine Facilities, and additional work areas.

- LNG Plant
  - three natural gas liquefaction processing units, called trains, capable of liquefying up to 20 million metric tons per year of LNG;
  - one meter station;
  - two 63.4 million-gallon LNG storage tanks;
  - two flare systems, including a wet/dry ground flare at the LNG Plant and a low-pressure flare near the Marine Terminal;
  - power plant systems, including the electric power supply, cathodic protection system, diesel fuel system, fuel gas system, nitrogen system, and waste heat recovery system;
  - water supply systems, including a freshwater treatment system and a firewater system; and
  - associated infrastructure, including a condensate storage facility, catalysts and chemicals, lighting, communications facilities, and a consolidated building complex.

- Marine Facilities
    - product loading facility (PLF) that would include two product loading and ship berthing areas; and
    - marine terminal building.
- Additional Work Areas
    - temporary MOF, referred to as the Marine Terminal MOF;
    - existing dock facilities at Arctic Slope Regional Corporation's Nikiski Fabrication Facility and Rig Tenders Marine Terminal facilities as a "Pioneer MOF";
    - dredged material disposal areas; and
    - haul road, construction camp, material sites, and additional temporary work spaces.

2.2 CONSTRUCTION SCHEDULE

Project construction and commissioning would take about 8 years to complete with two phases of construction. The first phase (6 years) would involve installation of the LNG Plant, Marine Terminal, Mainline Facilities, GTP trains, PBTL, and PTTL to a point that would allow transport and export of the first production of LNG. The second phase (2 years) would include completion of the remaining Project facilities (additional trains and compressor stations) required for full production. Section 2.3 of the EIS discusses the proposed construction schedule, and details for activities by year are provided in section 2.3.1 of the EIS. Summarized below are the key components of the construction schedule for each facility; additional information is provided in section 2.3 of the EIS. The Alaska Gasline Development Corporation (AGDC) states that the facilities would each have a nominal design life of 30 years.

2.2.1 Gas Treatment Facilities

GTP infrastructure development and site preparation work would begin in Year 1 and continue into the middle of Year 4 of construction. Materials for these activities would be delivered to the GTP during the two pre-construction sealifts (Years 2 and 3). Infrastructure would include camps, granular material, and GTP site access. Site preparation activities would include installing sheet piling, installing initial building components, widening the road, and constructing the GTP pad, the service pipeline, and the water reservoir. The gravel mine and water reservoir would be developed simultaneously; the material excavated from these sites would be used for GTP construction. The water reservoir and gravel mine site would be accessed via temporary ice roads constructed in the winter of Year 1.

GTP facility modules and gas treatment trains would be delivered to the site during the four construction sealifts (Years 4 to 7). GTP train construction would commence in Year 4, and conclude with commissioning and start-up of the final GTP train in mid-Year 8.

Pre-work at the West Dock Causeway would be performed a year before the first season of deliveries to prepare the seafloor and install breasting dolphins for the barge bridge support. Six sealifts (two pre-construction and four construction) would occur annually during the ice-free period between Years 2 and 7. Before each sealift, the offshore area would be leveled and the temporary barge bridge would be placed between Dock Heads 2 and 3.

PBTL construction would take place over two winter construction seasons (Years 3 and 4). Tie-ins and cleanup would be completed before the end of the second winter season. Hydrostatic testing, dehydration, tie-ins, and restoration activities associated with the PBTL would occur the following summer.

Construction of the PTTL would occur over the course of one winter construction season (Year 3). AGDC proposes to construct the PTTL using two pipeline spreads that would operate simultaneously. Tie-ins and cleanup would be completed before the end of the winter season. Hydrostatic testing, dehydration, tie-ins, and restoration activities associated with the PTTL would occur the following summer.

2.2.2 Mainline Facilities

The construction schedule for the Mainline Pipeline (and additional work areas) would span up to 57 months for any one spread (Years 1 to 5). This includes 30 months of site preparation activities and 15 to 27 months for pipelay. Construction at any single point would typically last between about 6 and 12 weeks, but could be longer depending on the rate of progress, weather, terrain, and other factors.

The Mainline Pipeline pipelay would be staggered with the two southern spreads (Spreads 3 and 4) starting first. The two northern spreads (Spreads 1 and 2) would begin following the start of construction in the southern spreads, with overlap in the construction schedules. Overall, AGDC estimates it would lay about 54 percent of the pipe in the summer and 46 percent in the winter.

The aboveground facilities would be constructed over a 3-year period (Years 3 to 5). Each would require about 1 year for construction. Each meter station would be constructed in about 1 year, with workers housed at the closest Mainline Pipeline camp. Dedicated crews installing mainline valves (MLVs), launchers and receivers, cathodic protection systems, and gas interconnections would require about 3 months to complete work at each site.

2.2.3 Liquefaction Facilities

Construction of the Liquefaction Facilities would begin after necessary property rights, permits, and authorizations are received. Construction would commence with site preparation activities (e.g., clearing, grubbing) and infrastructure development. These activities would require a 5-year period (Years 3 to 7) to complete and would include the Marine Terminal MOF construction, trestle/PLF substructure installation, and site cut and fill work.

AGDC proposes to construct many of the major facilities for the LNG Plant off site and have each delivered by vessel over a 3-year period. Other major facilities would be built on site. On-site facilities, including the LNG storage tanks, would be erected over the course of 3 to 4 years. The commissioning of the tanks and processing units would occur as natural gas is delivered to the site.

3.0 ESSENTIAL FISH HABITAT IN THE PROJECT AREA

3.1 ESSENTIAL FISH HABITAT TYPES AND SPECIES

The Project has components along the Arctic coast, through the interior, and in Cook Inlet. Aspects of the Project have the potential to affect EFH in marine and freshwater waterbodies. Table 3.1-1 lists the FMPs and associated EFH species and identifies where overlap occurs with the Project. The potential for adverse effects on marine EFH along vessel routes is low due to the short time periods that ships would be present in EFH. Vessel traffic in transit in marine waters is not expected to have impacts on EFH so these species and Project impacts on these areas are not discussed further.

3.1.1 Arctic Fishery Management Plan

The Arctic FMP includes all marine waters in the U.S. EEZ of the Chukchi and Beaufort Seas from 3 miles offshore of the coast of Alaska or its baseline to 200 miles offshore, north of Bering Strait (from Cape Prince of Wales to Cape Dezhneva) and westward to the 1990 U.S./Russia maritime boundary line and eastward to the U.S./Canada maritime boundary. The Arctic FMP includes descriptions of EFH for three species: arctic cod, saffron cod, and snow (or opilio) crab (*Chionoecetes opilio*); however, only arctic cod are likely to overlap with Project components (see table 3.1-1). Saffron cod and snow crab will not be discussed further in this EFH Assessment due to the lack of occurrence in the Project area. Figure 3.1.1-1 shows the locations of EFH in the Arctic FMP for these species.

3.1.1.1 Life History and Distribution

Arctic cod are widely distributed in Arctic waters in the Bering Sea and throughout the Alaskan and Canadian Arctic. They make extensive use of nearshore areas for feeding in summer, especially as juveniles, and tend to be associated with low water temperatures (Craig et al., 1982; Mueter et al., 2016). In the summer, they tend to orient toward the transition zone between brackish and marine water where good habitat is abundant (Moulton and Tarbox, 1987). In the winter, arctic cod tend to aggregate offshore (Craig et al., 1982).

Arctic cod spawn in the winter under ice, making the early life stages difficult to study (Graham and Hop, 1995). Following spawning, eggs are generally buoyant and float just beneath the surface. Upon hatching, larvae stay near the surface, eventually increasing their depth range to 10 to 20 yards by their first summer (Graham and Hop, 1995).

Juvenile and adult arctic cod use a wide range of habitats and their distribution and numbers may vary widely among years (Craig et al., 1982, 1984). They tend to be generalists that feed primarily on zooplankton as juveniles, and expand their diet to consume larger prey items as they mature (Mueter et al., 2016).

TABLE 3.1-1

Essential Fish Habitat

EFH FMP/ Waterbody	Species	Life Stage	Project Component	Effects Analysis
Arctic FMP				
Beaufort Sea	Arctic cod (*Boreogadus saida*)	Late juvenile, adults	Gas Treatment Facilities, vessel routes	Potential to affect
	Saffron cod (*Eleginus gracilis*)	Late juvenile, adults	Vessel routes	Unlikely to affect
GOA Groundfish FMP				
GOA	Alaska plaice (*Pleuronectes quadrituberculatus*)	Eggs, larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Arrowtooth flounder (*Atheresthes stomias*)	Larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Atka mackerel (*Pleurogrammus monopterygius)*	Larvae, adults	Vessel routes	Unlikely to affect
	Dover sole (*Microstomus pacificus*)	Eggs, larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Dusky rockfish (*Sebastes variabilis*)	Larvae, adults	Vessel routes	Unlikely to affect
	Flathead sole (*Hippoglossoides elassodon)*	Eggs, larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Northern rockfish (*Sebastes polyspinis*)	Adults	Vessel routes	Unlikely to affect
	Northern rock sole (*Lepidopsetta polyxystra*)	Larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Pacific cod (*Gadus macrocephalus*)	Eggs, larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Pacific Ocean perch (*Sebastes alutus*)	Larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Rex sole *(Glyptocephalus zachirus)*	Eggs, larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Rougheye and blackspotted rockfish (*Sebastes aleutianus* and *Sebastes melanostictus)*	Adults	Vessel routes	Unlikely to affect
	Sablefish (*Anoplopoma fimbria*)	Eggs, larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Sculpins	Juveniles, adults	Vessel routes	Unlikely to affect
	Shortraker rockfish (*Sebastes borealis*)	Adults	Vessel routes	Unlikely to affect
	Skates	Adults	Vessel routes	Unlikely to affect
	Southern rock sole (*Lepidopsetta bilineata*)	Larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Squid	Late juvenile, adults	Vessel routes	Unlikely to affect
	Thornyhead rockfish (*Sebastolobus altivelis*)	Larvae, early juvenile, late juvenile, adults	Vessel routes	Unlikely to affect
	Walleye pollock (*Gadus chalcogrammus*)	Eggs, larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Yelloweye rockfish (*Sebastes ruberrimus*)	Larvae, early juvenile, late juvenile, adults	Vessel routes	Unlikely to affect
	Yellowfin sole (*Limanda aspera*)	Eggs, larvae, late juvenile, adults	Vessel routes	Unlikely to affect

TABLE 3.1-1

Essential Fish Habitat

EFH FMP/ Waterbody	Species	Life Stage	Project Component	Effects Analysis
Cook Inlet	Arrowtooth flounder	Larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Dusky rockfish	Larvae	Vessel routes	Unlikely to affect
	Flathead sole	Eggs, larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Forage fish complex	Not defined	Liquefaction Facilities, vessel routes	Potential to affect
	Northern rockfish	Larvae	Vessel routes	Unlikely to affect
	Pacific cod	Late juvenile, adults	Vessel routes	Unlikely to affect
	Pacific Ocean perch	Larvae	Vessel routes	Unlikely to affect
	Rex sole	Eggs, larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Rock sole (*Lepidopsetta* spp.)	Larvae, late juvenile, adults	Vessel routes	Unlikely to affect
	Sablefish	Late juvenile, adults	Vessel routes	Unlikely to affect
	Shortraker rockfish	Late juvenile, adults	Vessel routes	Unlikely to affect
	Skates	Adults	Vessel routes	Unlikely to affect
	Thornyhead rockfish	Larvae	Vessel routes	Unlikely to affect
	Walleye pollock	All	Vessel routes	Unlikely to affect
	Yelloweye rockfish	Larvae	Vessel routes	Unlikely to affect
Pacific Salmon FMP				
Freshwater Streams and Rivers	Chinook salmon (*Oncorhynchus tshawytscha*)	Eggs, larvae, fry, returning adults	Mainline Pipeline crossings	Potential to affect
	Chum salmon (*Oncorhynchus keta*)	Eggs, larvae, fry, returning adults	Mainline Pipeline crossings, PTTL	Potential to affect
	Coho salmon (*Oncorhynchus kisutch*)	Eggs, larvae, fry, returning adults	Mainline Pipeline crossings	Potential to affect
	Pink salmon (*Oncorhynchus gorbuscha*)	Eggs, larvae, fry, returning adults	Mainline Pipeline crossings, PTTL	Potential to affect
	Sockeye salmon (*Oncorhynchus nerka*)	Eggs, larvae, fry, returning adults	Mainline Pipeline crossings	Potential to affect
Beaufort Sea	Chum salmon	Juveniles, adults	Gas Treatment Facilities	Potential to affect
	Pink salmon	Juveniles, adults	Gas Treatment Facilities	Potential to affect
Cook Inlet	Chinook salmon	Juveniles, adults	Liquefaction Facilities, Mainline Pipeline crossing	Potential to affect
	Chum salmon	Juveniles, adults	Liquefaction Facilities, Mainline Pipeline crossing	Potential to affect
	Coho salmon	Juveniles, adults	Liquefaction Facilities, Mainline Pipeline crossing	Potential to affect
	Pink salmon	Juveniles, adults	Liquefaction Facilities, Mainline Pipeline crossing	Potential to affect
	Sockeye salmon	Juveniles, adults	Liquefaction Facilities, Mainline Pipeline crossing	Potential to affect

TABLE 3.1-1

Essential Fish Habitat

EFH FMP/ Waterbody	Species	Life Stage	Project Component	Effects Analysis
GOA	Chinook salmon	Adults	Vessel routes	Unlikely to affect
	Chum salmon	Adults	Vessel routes	Unlikely to affect
	Coho salmon	Adults	Vessel routes	Unlikely to affect
	Pink salmon	Adults	Vessel routes	Unlikely to affect
	Sockeye salmon	Adults	Vessel routes	Unlikely to affect

Sources: NPFMC, 2009, 2011, 2014, 2016; NPFMC et al., 2012

3.1.1.2 Essential Fish Habitat Distribution

EFH for arctic cod is described for late juveniles and adults (NPFMC, 2009). Insufficient information is available to determine EFH for eggs, larvae, and early juveniles. For both late juveniles and adults, EFH includes the general distribution areas for each life stage in pelagic (open sea) and epipelagic waters (waters with enough light for photosynthesis) from the nearshore to offshore areas along the entire shelf and upper slope of the Arctic coast. Both life stages are often associated with ice floes, which may occur in deeper waters. EFH for arctic cod in the Arctic FMP extends from the Alaska/Yukon border, west and south to Cape Prince of Wales in the Bering Strait.

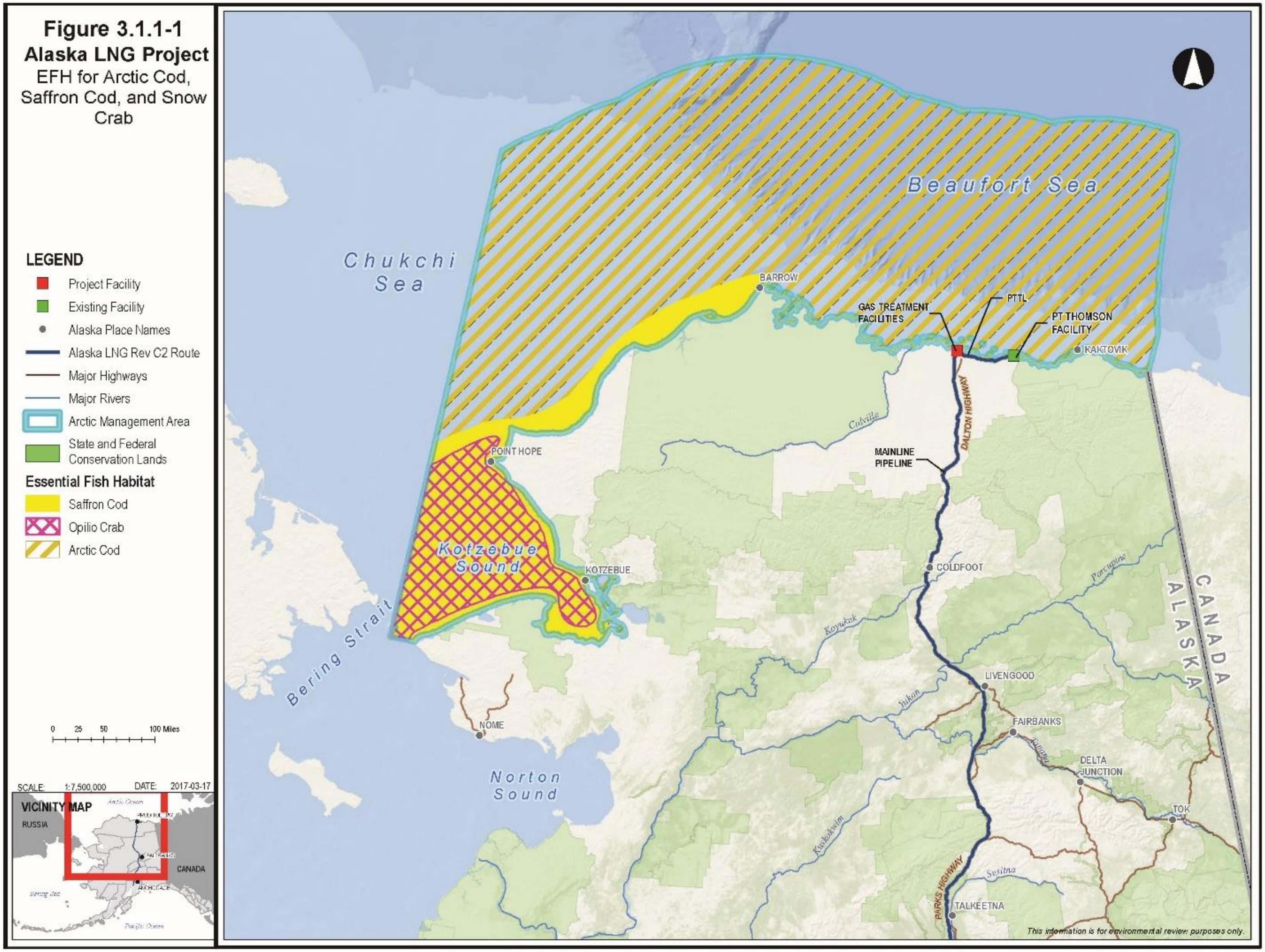
Project components that may overlap with the arctic cod EFH include the offshore components of the GTP, including West Dock Causeway and Dock Head 4, as well as vessel routes leading to and from the GTP.

3.1.2 Gulf of Alaska Groundfish Fishery Management Plan

Cook Inlet occurs within the purview of the GOA Groundfish FMP, which supports more than 24 species of groundfish and nine forage fish complexes. The GOA Groundfish FMP includes big skate (*Beringraja binoculata*), longnose skate (*Raja rhina*), octopus, sharks, and the shallow water flatfish complex. Spatial data does not exist for all the managed species in this area. Marine species expected to occur in the temporary Marine Terminal MOF area include forage fish species such as:

- capelin (*Mallotus villosus*);
- eulachon (*Thaleichtys pacificus*);
- longfin smelt (*Spirinchus thaleichthys*);
- Pacific herring (*Clupea pallasii*);
- Pacific sandfish (*Trichodon trichodon*);
- Pacific sand lance (*Ammodytes hexapterus*);
- Pacific staghorn sculpin (*Leptocottus armatus*);
- snake prickleback (*Lumpenus sagitta*);
- starry flounder (*Platichthys stellatus*); and
- walleye pollock (Moulton, 1997; Houghton et al., 2005a,b).

Figure 3.1.1-1
Alaska LNG Project
EFH for Arctic Cod, Saffron Cod, and Snow Crab



This information is for environmental review purposes only.

Walleye pollock, eulachon, capelin, and starry flounder are considered target species of the GOA Groundfish FMP (NPFMC, 2014) and are important prey species for Cook Inlet beluga whales (*Delphinapterus leucas*) in Upper Cook Inlet.

EFH is not defined for groundfish or forage fish species in Upper Cook Inlet near the Liquefaction Facilities or Mainline Pipeline crossing of Cook Inlet. However, juveniles for some groundfish and all life stages of some forage fish can be assumed to occur in this area. Walleye pollock juveniles were the most abundantly captured juvenile groundfish in Upper Cook Inlet surveys conducted by Moulton in 1997 and therefore are considered below. Of the forage fish complex, eulachon and capelin are some of the more abundant in coastal Alaska including within Upper Cook Inlet; they are described in the following section. GOA Groundfish EFH species are only affected as they occur in the vessel routes to and from the Marine Terminal (see table 3.1-1) and therefore are not described further.

Forage fishes are those species that are a critical food source for marine mammal, seabird, and fish species. The forage fish species category was established to allow for managing these species in a manner that prevents the development of a commercially directed fishery for forage fish (NPFMC, 2016). Insufficient information is available to determine EFH for eggs, larvae, early juveniles, late juveniles, or adults of the forage fish complex. The most frequently caught members of the forage fish complex for GOA Groundfish FMPs expected to potentially occur within the Cook Inlet Project areas include capelin and eulachon.

3.1.2.1 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 to 3 years) move inshore to spawn on coarse gravel and/or sand beaches. Eggs incubate in the substrate hatching 15 to 30 days later with larvae being subjected to the tides (Doyle et al., 2002). Capelin are high energy forage fish that play a key role in the overall marine food web. These fish are a common food source, especially during and after spawning events, used by numerous predators including sea birds, salmon, and marine mammals.

3.1.2.2 Eulachon

Eulachon generally spawn in the lower reaches of rivers or streams, broadcasting their eggs over stream bottoms where the eggs attach to sand, gravel, or woody debris. Eggs hatch in 3 to 6 weeks and the young are carried to the sea with the current where they feed mainly on copepod larvae and other plankton (ADF&G, 1994). Both juvenile and adult eulachon feed primarily on plankton. After 3 to 5 years at sea, they return to their spawning grounds. In south-central Alaska, eulachon typically gather in April in large schools at the mouths of spawning streams (ADF&G, 1994). Eulachon are a common prey species for Cook Inlet beluga whales.

3.1.3 Pacific Salmon Fishery Management Plan

Five species of Pacific salmon occur within and around the Project area: Chinook salmon, coho salmon, sockeye salmon, chum salmon, and pink salmon. The generalized life history of Pacific salmon in Alaska involves adult salmon spawning in freshwater; depositing fertilized eggs in a prepared redd (nest), usually in flowing water (although some species may also spawn on lake shores and in estuaries); and a period of incubation, followed by the emergence of fry from the redd. Once emerged, some species spend up to 2 years rearing in freshwater, while others migrate directly to the ocean where they feed and grow for up to 7 years before returning to their natal freshwater streams to spawn. Thus, all Pacific salmon have

EFH in both freshwater and marine environments. Table 4.7.1-2 in the EIS shows the seasonality of juvenile salmon presence in interior Alaska and the Susitna River, which illustrates the migratory periods of the five salmon species near the Project area.

The *Fishery Management Plan for Salmon Fisheries in the Exclusive Economic Zone off Alaska* (ADF&G, 2012) contains descriptions of EFH for the five Pacific salmon species in the marine environment. For the five salmon species, marine EFH includes the waters within the 200-mile EEZ around Alaska; all five salmon species are found in Cook Inlet, and chum and pink salmon are found in Prudhoe Bay. EFH for the freshwater phases of each species are listed in the *Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (AWC) (ADF&G, 1998) and its companion atlas. The catalog lists waterbodies where Pacific salmon species have been documented in field studies, but it is not a comprehensive list of fish-bearing waters; thus, additional field studies may be required to identify EFH for Pacific salmon in streams and rivers that are not listed in the catalog. Freshwater waterbodies with Pacific salmon EFH are discussed in section 4.1. Table 3.1.3-1 summarizes freshwater EFH affected by the Project (for additional detail, see appendix I of the EIS).

TABLE 3.1.3-1

Freshwater Essential Fish Habitat Waterbody Summary

	Mainline Pipeline	PTTL	Access Roads	Material Sites
Total Number of EFH Waterbodies Crossed or Affected	**70**	**3**	**28**	**12**
With pink salmon	20	3	16	6
With chum salmon	32	2	17	11
With coho salmon	58	0	16	2
With sockeye salmon	19	0	6	0
With Chinook salmon	41	0	6	5
Habitat				
With known overwintering habitat	36	3	10	0
With known EFH spawning habitat upstream of crossing	55	2	3	0
Season				
In-stream activity in winter	30	3	16	Unknown [a]
In-stream activity in summer	40	0	12	Unknown [a]
Crossing Method				
Aerial or DMT	5	3	N/A	N/A
Wet-ditch open-cut	24	0	N/A	N/A
Frozen-cut	11	0	N/A	N/A
Dry-ditch open-cut	30	0	N/A	N/A
Culvert	N/A	N/A	6	N/A
Bridge (structural) [b]	N/A	N/A	12	N/A
Ice bridge	N/A	N/A	8	N/A

N/A = not applicable; DMT = directional micro-tunneling

[a] Five of the material sites associated with the Sagavanirktok River would be developed in the winter; however, information is not available for the remaining seven sites.

[b] Three crossings could be either a bridge or culvert, depending on site conditions, and five crossings are at existing bridges.

3.1.3.1 Pink Salmon

Life History and Distribution

Pink salmon are widely distributed in coastal streams of North America from Oregon to the Bering Sea, with more sporadic distribution further north and along the Arctic coast. They have a fixed 2-year life span in which emergent fry migrate immediately to the marine environment with no freshwater residence time, and adults return to spawn about 18 months later. Because of their fixed life cycle, odd and even-year runs are reproductively isolated. In some river systems, one run (for example, the even-year run in Bristol Bay) is dominant and the run in the next year is negligible (McPhail, 2007).

Pink salmon eggs are generally deposited in gravel substrates in streams and occasionally in intertidal areas. The eggs hatch in winter, and fry emerge from the substrate in the spring. The fry generally migrate seaward within 15 days of emergence (although the duration of migration may last up to 2 months). The timing of the seaward smolt migration ranges from late February to mid-May; however, the peak of the migration tends to occur in mid-April (Groot and Margolis, 1991).

In the ocean, juvenile pink salmon feed on plankton and larval fish while occupying estuaries and shallow inshore waters. They grow rapidly in the ocean, and by the end of the first summer move out to open water (McPhail, 2007). As they mature, they feed increasingly on small fish, squid, euphausiids, and amphipods. Age-1 fish are found throughout the northern Pacific Ocean and Bering Sea, with populations from different coastal regions occupying distinct ocean nursery areas (Groot and Margolis, 1991). They remain in the ocean for about 18 months, returning to their natal streams the following year.

Adult pink salmon in the Cook Inlet area enter freshwater between early July and mid-August, while Arctic runs begin earlier in the summer (Craig and Haldorson, 1986; Groot and Margolis, 1991). Pink salmon migrations tend to be shorter than other salmon species (usually within 120 miles of the ocean); however, some exceptions occur and pink salmon runs of up to 420 miles have been observed (Groot and Margolis, 1991).

Pink salmon spawning occurs in both small and large streams over a uniform spawning bed characterized by clean gravel, moderate to fast current, and shallow water (Groot and Margolis, 1991). Males undergo a significant morphological change prior to spawning, which includes the development of a large hump and extended kype or lower jaw, which may be related to their aggressive defense of females and redds. Females dig a redd and lay between 1,200 and 1,900 eggs. The low fecundity of pink salmon females relative to other Pacific salmon may be related to their lower overall mortality rate throughout their short lifetimes (Groot and Margolis, 1991).

Essential Fish Habitat Description

EFH for pink salmon is described for all life stages in the freshwater and marine environments.

Freshwater

EFH for pink salmon eggs includes gravel substrates in those freshwaters identified in the AWC (ADF&G, 1998; Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017) (see figure 3.1.3-1). EFH for pink salmon larvae and juveniles in freshwater includes the general distribution area as identified in the AWC (Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017), and contiguous rearing areas within the boundaries of ordinary high water during the spring. EFH for adult spawning pink salmon includes the general distribution area as identified in the AWC (Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017), wherever spawning substrates consist of clean, medium-to-coarse gravel and at water depths between 6 and 20 inches. Spawning occurs from June through September.

Figure 3.1.3-1
Alaska LNG Project
EFH for Pink Salmon in the Gulf of Alaska and Bering Sea

This information is for environmental review purposes only.

LEGEND

- 🟥 Project Facility
- 🟩 Existing Facility
- ● Alaska Place Names
- Alaska LNG Rev C2 Route
- Anadromous Waters - Pink Salmon
- Major Highways
- Major Rivers

0 25 50 100 Miles

SCALE: 1:8,000,000 DATE: 2017-03-17

Marine

EFH for juvenile pink salmon includes estuarine areas in the general distribution area, as identified by the salinity transition zone (ecotone) and the mean higher tide line within nearshore waters. Pink salmon juveniles are generally present in this area from late April through June. Marine EFH for juvenile pink salmon includes all marine waters off the coast of Alaska from the mean higher tide line to the 200-mile limit of the U.S. EEZ. This includes Cook Inlet, the GOA, and the Arctic Ocean. Marine EFH for marine immature and maturing adult pink salmon includes all marine waters off the coast of Alaska from the mean higher tide line to the 200-mile limit of the U.S. EEZ, and to depths of up to 200 miles. This includes Cook Inlet, the GOA, and the Arctic Ocean. Some mature adult pink salmon spawn in intertidal areas.

3.1.3.2 Chum Salmon

Life History and Distribution

Chum salmon are widespread in Alaskan fresh waters, including in Arctic and Cook Inlet drainages. A substantial run occurs in the Susitna River in central Alaska, as well as in numerous short streams on the north side of Cook Inlet (Groot and Margolis, 1991). Most chum salmon spawn in close proximity to the ocean (within 60 miles); however, notable exceptions occur in the Yukon River, where some chum spawn more than 1,800 miles upstream from the river mouth (McPhail, 2007).

Like other salmonids, chum salmon tend to spawn in streams and rivers dominated by clean gravel substrates (Groot and Margolis, 1991; NPFMC et al., 2012), and are drawn to sites with upwelling water that is often warmer than the surrounding water (McPhail, 2007). Eggs incubate in the gravel over winter; fry hatch 2 to 3 months later and emerge from the gravel about 1 to 2.5 months after hatching (McPhail, 2007).

Like pink salmon, chum salmon fry do not overwinter in streams and migrate seaward shortly after emerging from the gravel (McPhail, 2007; NPFMC et al., 2012). The timing of outmigration ranges from February to June; however, the peak seaward migration tends to occur in April and May (NPFMC et al., 2012). Upon reaching the ocean, fry generally spend 3 to 4 weeks in estuaries, especially in tidal creeks, sloughs, and salt marshes, before moving into shallow, nearshore areas and, to deeper water by late fall of their first year (McPhail, 2007; NPFMC et al., 2012).

Immature and maturing adult chum salmon are found throughout the northern Pacific Ocean, especially in the GOA (McPhail, 2007). At sea, they feed primarily on invertebrates, but may also feed on small fish and squid.

Chum salmon reach maturity at variable ages ranging from 2 to 7 years, with the age of maturity coming later in northern populations than in southern populations (NPFMC et al., 2012). Most spawning tends to occur in the fall and early winter; however, chum exhibit a wide range of spawning timings and several river systems have two runs that are separated temporally. The Yukon River has summer and fall runs of chum, with the summer chum being more abundant but smaller in size (NPFMC et al., 2012).

Essential Fish Habitat Description

EFH for chum salmon is described for all life stages in the freshwater and marine environments.

Freshwater

EFH for chum salmon eggs includes gravel substrates in those waters identified in the AWC (ADF&G, 1998; Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017) (see figure 3.1.3-2). EFH for chum salmon larvae and juveniles in freshwater includes the general distribution area as identified in the AWC (Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017), and contiguous rearing areas within the boundaries of ordinary high water during the spring. EFH for adult spawning chum salmon includes the general distribution area as identified in the AWC (Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017), wherever spawning substrates consist of clean, medium-to-coarse gravel. Areas of water upwelling are preferred, and chum may use these upwellings in areas where finer substrates generally occur. Spawning occurs from June through January.

Marine

EFH for juvenile chum salmon includes estuarine areas in the general distribution area, as identified by the salinity transition zone (ecotone) and the mean higher tide line within nearshore waters. Chum salmon juveniles are generally present in this area from late April through June. Marine EFH for juvenile chum salmon includes all marine waters off the coast of Alaska from the mean higher tide line to the 200-mile limit of the U.S. EEZ, and to depths of up to 50 yards. This includes Cook Inlet, the GOA, and the Arctic Ocean. Marine EFH for marine immature and maturing adult chum salmon includes all marine waters off the coast of Alaska from the mean higher tide line to the 200-mile limit of the U.S. EEZ, and to depths of up to 200 yards. This includes Cook Inlet, the GOA, and the Arctic Ocean.

3.1.3.3 Coho Salmon

Life History and Distribution

Coho salmon are widely distributed throughout the North Pacific Ocean and its coastal tributaries; however, they are rarely captured in Arctic waters, and those that have been observed in the Arctic are thought to be stray individuals (Craig and Haldorson, 1986; Groot and Margolis, 1991). In Alaska, coho are captured all along the Alaskan coast from Norton Sound to the mouth of the Kuskokwim River (Groot and Margolis, 1991). They migrate far up the Yukon River, as well as up most streams and rivers in the Cook Inlet area.

Coho spawn in streams and rivers over gravel substrates and tend to prefer areas with interstitial flow such as pool tail-outs and upwelling sites (McPhail, 2007). Spawning generally occurs from September through February; eggs overwinter in the gravel and hatch between March and July (NPFMC et al., 2012). Females lay between 2,500 and 4,000 eggs among several nests.

Coho juveniles spend at least 1 year rearing in freshwater before migrating to the ocean, although some populations may spend up to 4 years rearing in freshwater where cold stream temperatures limit growth rates (NPFMC et al., 2012). In freshwater, coho juveniles are strongly associated with abundant structural habitat elements such as large woody debris and undercut banks (McPhail, 2007; NPFMC et al., 2012), and tend to aggregate in smaller tributaries, particularly in fall and winter (Bramblett et al., 2002).

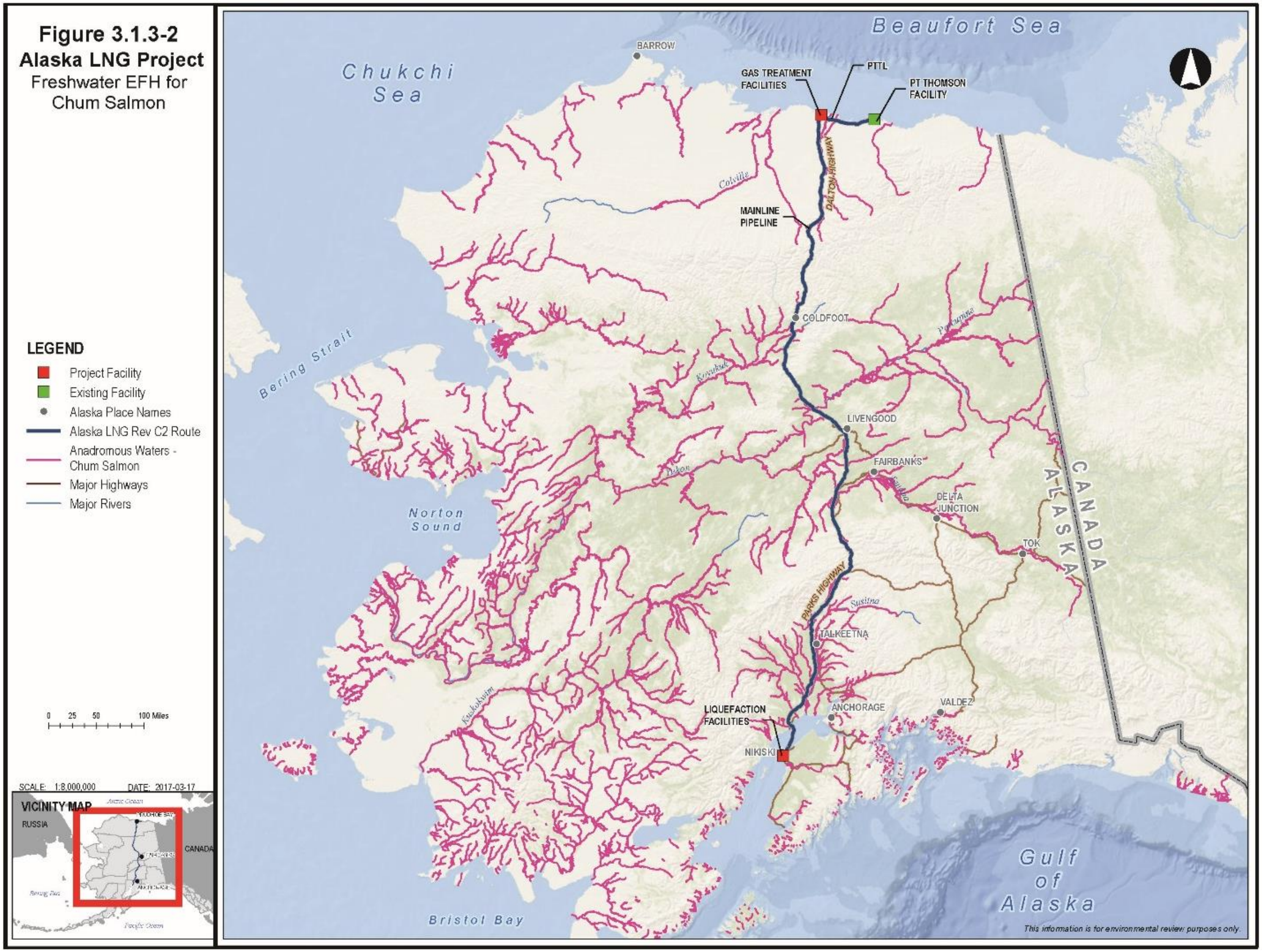


Figure 3.1.3-2
Alaska LNG Project
Freshwater EFH for Chum Salmon

LEGEND

- 🟥 Project Facility
- 🟩 Existing Facility
- ● Alaska Place Names
- Alaska LNG Rev C2 Route
- Anadromous Waters - Chum Salmon
- Major Highways
- Major Rivers

SCALE: 1:8,000,000 DATE: 2017-03-17

This information is for environmental review purposes only.

Juvenile migration to the ocean generally occurs in May and June. Once they reach the ocean, juvenile coho remain in estuaries through the summer and early fall using the abundance of invertebrates as a food source to facilitate rapid growth. Age-0 coho that emerge close to the ocean may use the estuaries during the summer, then return to small tributaries to rear during the winter (NPFMC et al., 2012).

Coho salmon generally spend about 18 months at sea before returning to spawn. In the ocean, their diet first consists of invertebrates, then shifts to fish as they get older. Some precocious male coho, known as jacks, return to freshwater to spawn after only 6 months (McPhail, 2007; NPFMC et al., 2012). Adult coho re-enter freshwater to spawn between early July and December. Many coho spawn a short distance from the ocean, but some may travel over 1,200 miles upstream in a migration that takes several weeks (NPFMC et al., 2012).

Essential Fish Habitat Description

EFH for coho salmon is described for all life stages in the freshwater and marine environments.

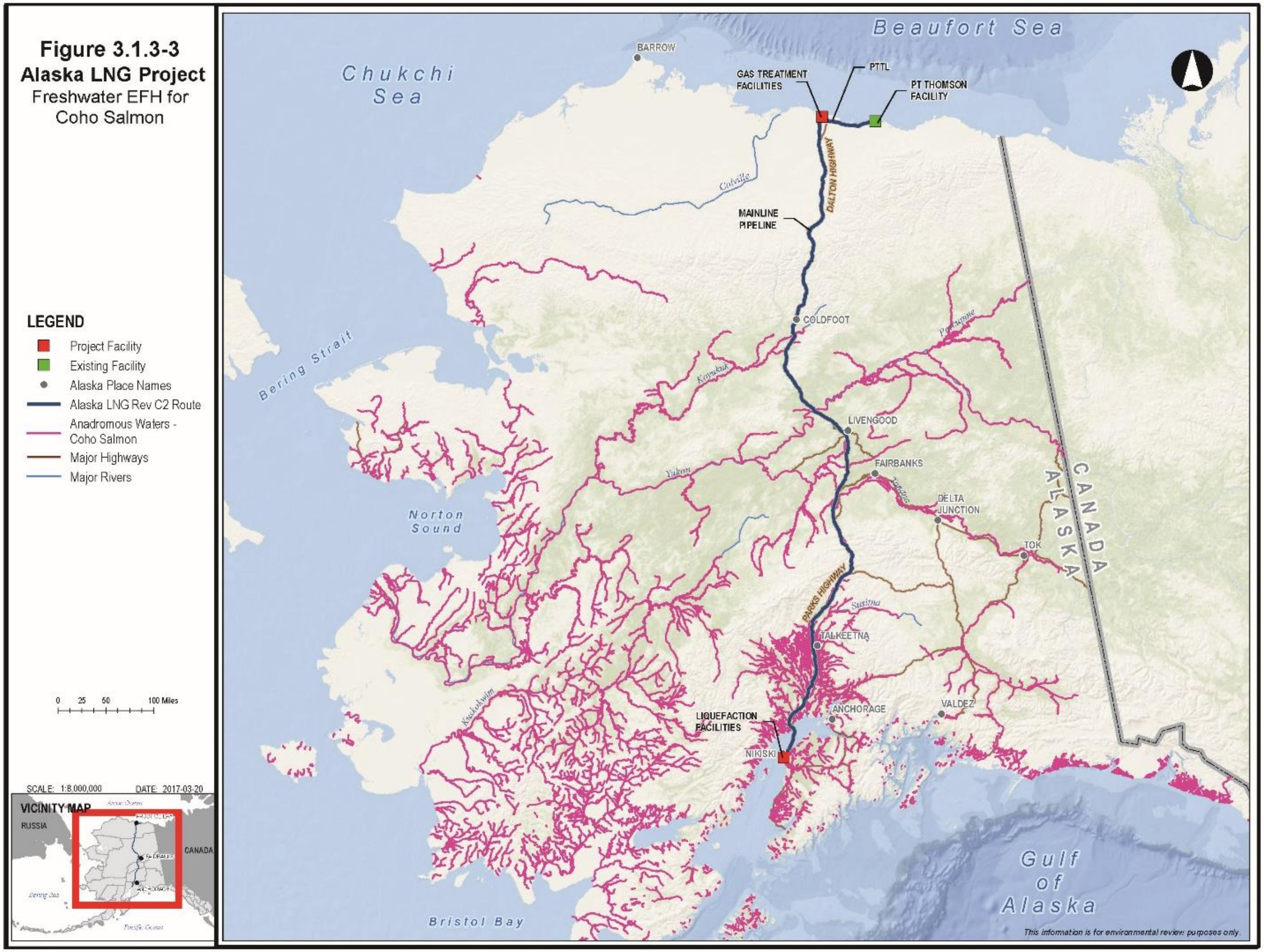
Freshwater

EFH for coho salmon eggs includes gravel substrates in those waters identified in the AWC, especially near pool tail-outs and areas of upwelling (ADF&G, 1998; Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017) (see figure 3.1.3-3). EFH for coho salmon larvae and juveniles in freshwater includes the general distribution area as identified in the AWC (Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017), and contiguous rearing areas within the boundaries of ordinary high water throughout the year. Fry generally migrate to a lake, slough, or estuary to rear for up to 2 years. EFH for adult spawning coho salmon includes the general distribution area as identified in the AWC (Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017), wherever spawning substrates consist of clean gravel. Spawning occurs from July through December.

Marine

EFH for juvenile coho salmon includes estuarine areas in the general distribution area, as identified by the salinity transition zone (ecotone) and the mean higher tide line in nearshore waters. Juvenile coho salmon require year-round rearing habitat in estuaries, as well as migration habitat from spring through fall to access the estuary from tributary streams. Marine EFH for juvenile coho salmon includes all marine waters off the coast of Alaska from the mean higher tide line to the 200-mile limit of the U.S. EEZ. This includes Cook Inlet and the GOA. Marine EFH for marine immature and maturing adult coho salmon includes all marine waters off the coast of Alaska from the mean higher tide line to the 200-mile limit of the U.S. EEZ, and to depths of up to 200 yards. This includes Cook Inlet, the GOA, and the Arctic Ocean.

Figure 3.1.3-3
Alaska LNG Project
Freshwater EFH for Coho Salmon



This information is for environmental review purposes only.

3.1.3.4 Sockeye Salmon

Life History and Distribution

Sockeye salmon occur throughout the North Pacific Ocean and surrounding tributaries. Most sockeye salmon populations have a period of lake rearing that ranges from 1 to 3 years, although some may use streams, side channels, or sloughs (McPhail, 2007; NPFMC et al., 2012). As a result of their lake-rearing requirements, distribution in streams and rivers is usually limited to systems associated with lakes. Some of the largest runs in Alaska occur in Bristol Bay (NPFMC et al., 2012). Sockeye salmon are indigenous to the Yukon River watershed, but they occur there in low numbers. Some sockeye have been reported in the Canadian Arctic, but they are thought to be strays (Groot and Margolis, 1991). Some populations of sockeye, known as kokanee, remain in freshwater for their entire life span (McPhail, 2007; NPFMC et al., 2012).

Sockeye salmon spawn in the fall in a variety of habitats generally associated with lakes, including tributary streams, river reaches between lakes, side channels, lake outlets, and lake shores (Groot and Margolis, 1991). Females choose nest sites often associated with upwelling and high interstitial flow, and lay between 2,000 and 4,000 eggs. Spawning occurs in late summer and fall, although there is considerable variation among populations in different regions. Eggs overwinter in the gravel with fry emerging between mid-April and early June (NPFMC et al., 2012).

Upon emergence, sockeye salmon fry migrate downstream to nursery areas (usually lakes). This migration happens mainly at night with fry sheltering under rocks and cover features during the day (McPhail, 2007; NPFMC et al., 2012). Once they reach the nursery lakes, sockeye fry disperse to feeding areas, taking advantage of zooplankton food sources in the limnetic zone (freshwater lakes or open water). Smoltification[3] generally occurs after 1 or more years of rearing, with smolts migrating to the ocean in spring or early summer (NPFMC et al., 2012).

Upon reaching the ocean, distribution of sockeye salmon juveniles varies depending on stock, with some using estuarine areas or the nearshore environment for the first several months. Most sockeye have typically moved offshore by the fall of their first marine year (NPFMC et al., 2012). In the ocean, juvenile sockeye rely on copepods and insects, as well as amphipods, euphausiids, and fish larvae for food.

Sockeye salmon spend between 1 and 4 years in the open ocean before returning to natal streams to spawn, generally moving in a counterclockwise direction around the GOA (McPhail, 2007). They re-enter freshwater between May and August, with more northern stocks generally entering freshwater earlier than southern stocks (NPFMC et al., 2012).

Essential Fish Habitat Description

EFH for sockeye salmon is described for all life stages in the freshwater and marine environments.

<u>Freshwater</u>

EFH for sockeye salmon eggs includes gravel substrates in those waters identified in the AWC (ADF&G, 1998; Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017) (see figure 3.1.3-4).

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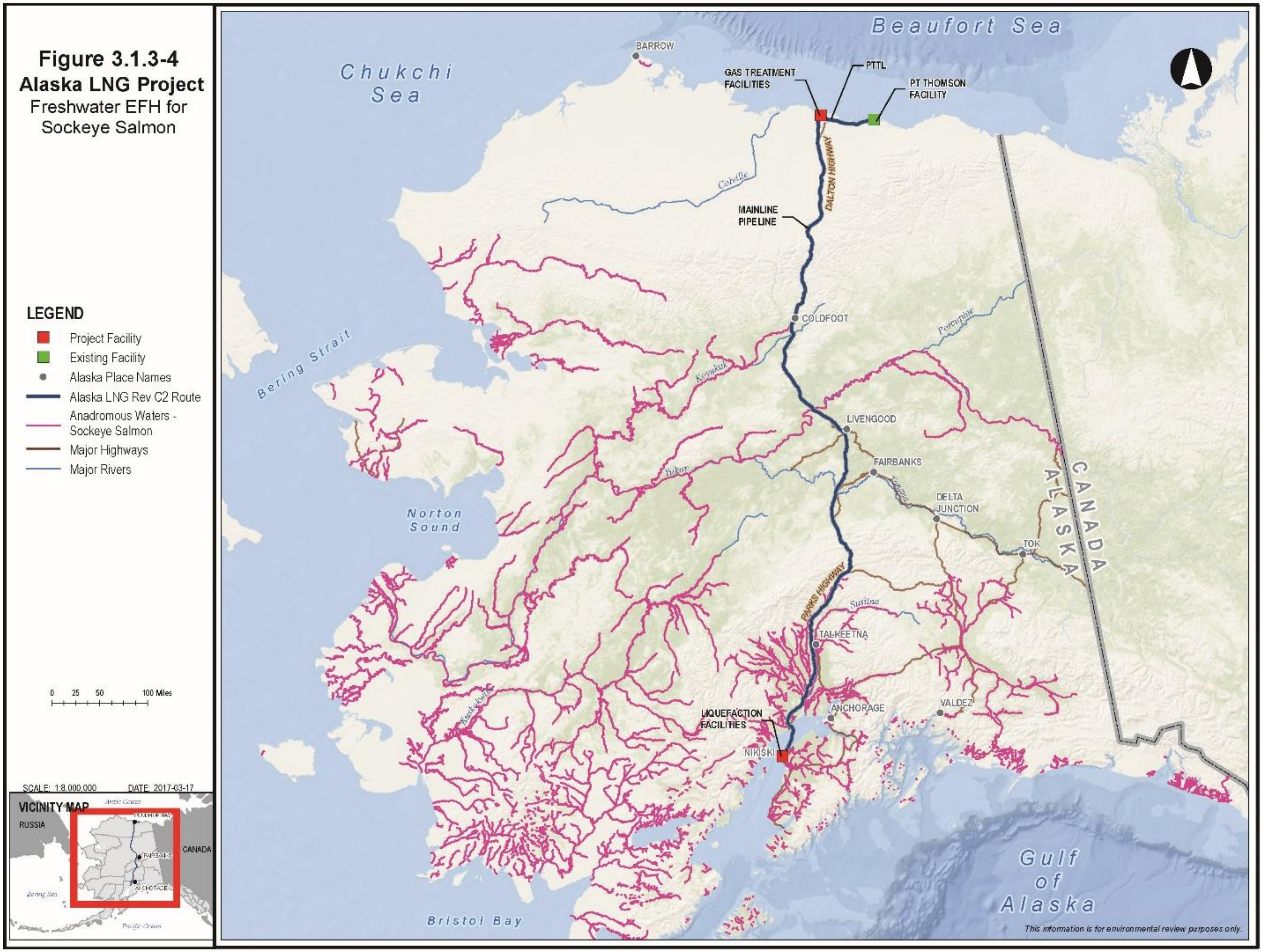
[3] The series of physiological changes where juvenile salmonid fish adapt from living in fresh water to living in seawater.

Figure 3.1.3-4
Alaska LNG Project
Freshwater EFH for Sockeye Salmon



EFH for sockeye salmon larvae and juveniles in freshwater includes the general distribution area as identified in the AWC (Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017), and contiguous rearing areas within the boundaries of ordinary high water throughout the year. Fry generally migrate downstream to a lake, or to estuarine or riverine rearing habitats for up to 2 years. Fry outmigration occurs between April and November, with smolts generally migrating to the ocean during spring and summer. EFH for adult spawning sockeye salmon includes the general distribution area as identified in the AWC (Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017), wherever spawning substrates consist of clean, medium-to-coarse gravel. Finer substrates may be used in areas of upwelling. Sockeye often spawn in lake substrates, as well as in streams from June through September.

Marine

EFH for juvenile sockeye salmon includes estuarine areas in the general distribution area, as identified by the salinity transition zone (ecotone) and the mean higher tide line in nearshore waters. Under-yearling, yearling, and older smolts occupy estuaries from March through early August. Marine EFH for juvenile sockeye salmon includes all marine waters off the coast of Alaska from the mean higher tide line to the 200-mile limit of the U.S. EEZ and to depths of 50 yards. This includes Cook Inlet, the GOA, and the Arctic Ocean. Marine juveniles occupy these habitats between mid-summer and December of their first oceanic year. Marine EFH for marine immature and maturing adult sockeye salmon includes all marine waters off the coast of Alaska from the mean higher tide line to the 200-mile limit of the U.S. EEZ, and to depths of up to 200 yards. This includes Cook Inlet and the GOA.

3.1.3.5 Chinook Salmon

Life History and Distribution

Chinook salmon are the largest and least abundant of the Pacific salmon in Alaska. Their natural range includes large portions of the Pacific Rim from California to Point Hope, Alaska. They have also been captured in the Canadian Arctic and there have been unconfirmed reports of Chinook occurring along the Alaskan Arctic coast (McPhail, 2007). Larger rivers tend to support the largest Chinook runs, with significant runs occurring in the Yukon River in Alaska. Chinook may spawn up to 1,920 miles upstream from the ocean, or they may use short tributaries (NPFMC et al., 2012).

Chinook salmon have two basic life history types: ocean-type Chinook migrate to sea in their first year, and stream-type Chinook spend up to 2 years in freshwater before migrating to the ocean (McPhail, 2007; NPFMC et al., 2012). Ocean residency times may be up to 6 years (McPhail, 2007; NPFMC et al., 2012). Chinook enter freshwater to spawn as early as April and as late as August, depending on latitude and local conditions (McPhail, 2007), and generally spawn in late summer and early fall.

Chinook females generally select coarser spawning gravel than other Pacific salmon, and require well-oxygenated interstitial flow to support their large eggs. The number of eggs laid varies widely and is dependent on geography and the size of the female (McPhail, 2007). Eggs overwinter in the substrate and fry emerge in the spring. Most ocean-type fish migrate 30 to 90 days after emergence, while stream-type fish spend up to 2 years rearing in freshwater streams, using a wide variety of habitats.

Estuarine residency varies among life history types, with ocean-type Chinook spending more time in estuaries than stream-type fish. Ocean-type fish in general are more oriented toward coastal areas, even as adults, and generally do not migrate as far as stream-type fish (McPhail, 2007; NPFMC et al., 2012).

As adults, Chinook generally remain at sea for 1 to 6 years. Chinook adults are more piscivorous (feeding on fish) than other Pacific salmon species (NPFMC et al., 2012). Ocean distribution is affected by both genetic and environmental factors, and is related to the cost-versus-benefit of accessing specific feeding grounds. Unlike most other Pacific salmon, Chinook do not congregate near the surface and are usually found at depths of 30 to 70 yards (NPFMC et al., 2012).

Essential Fish Habitat Description

EFH for Chinook salmon is described for all life stages in the freshwater and marine environments.

Freshwater

EFH for Chinook salmon eggs includes gravel substrates in those waters identified in the AWC (ADF&G, 1998; Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017) (see figure 3.1.3-5). EFH for Chinook salmon larvae and juveniles in freshwater includes the general distribution area identified in the AWC (Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017), and contiguous rearing areas within the boundaries of ordinary high water throughout the year. Juvenile outmigration from freshwater areas occurs in April, and fry may spend up to 1 year in major rivers and tributaries, including the Yukon River. EFH for adult spawning Chinook salmon includes the general distribution area as identified in the AWC (Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017), wherever spawning substrates consist of gravel. Spawning occurs from April through September.

Marine

EFH for juvenile Chinook salmon includes estuarine areas in the general distribution area, as identified by the salinity transition zone (ecotone) and the mean higher tide line in nearshore waters. Chinook salmon smolts may be present in these habitats from April through September. Marine EFH for juvenile Chinook salmon includes all marine waters off the coast of Alaska from the mean higher tide line to the 200-mile limit of the U.S. EEZ. This includes Cook Inlet, the GOA, and the Arctic Ocean. Fish are considered marine juveniles from April until January or February of their first oceanic year. Marine EFH for marine immature and maturing adult Chinook salmon includes all marine waters off the coast of Alaska from the mean higher tide line to the 200-mile limit of the U.S. EEZ. This includes Cook Inlet and the GOA.

3.2 ESSENTIAL FISH HABITATS OF PARTICULAR CONCERN

No HAPCs would overlap with Project components. Figure 3.2-1 shows the locations of HAPCs in the GOA. HAPCs are not discussed further in this EFH Assessment.

Figure 3.1.3-5
Alaska LNG Project
Freshwater EFH for Chinook Salmon

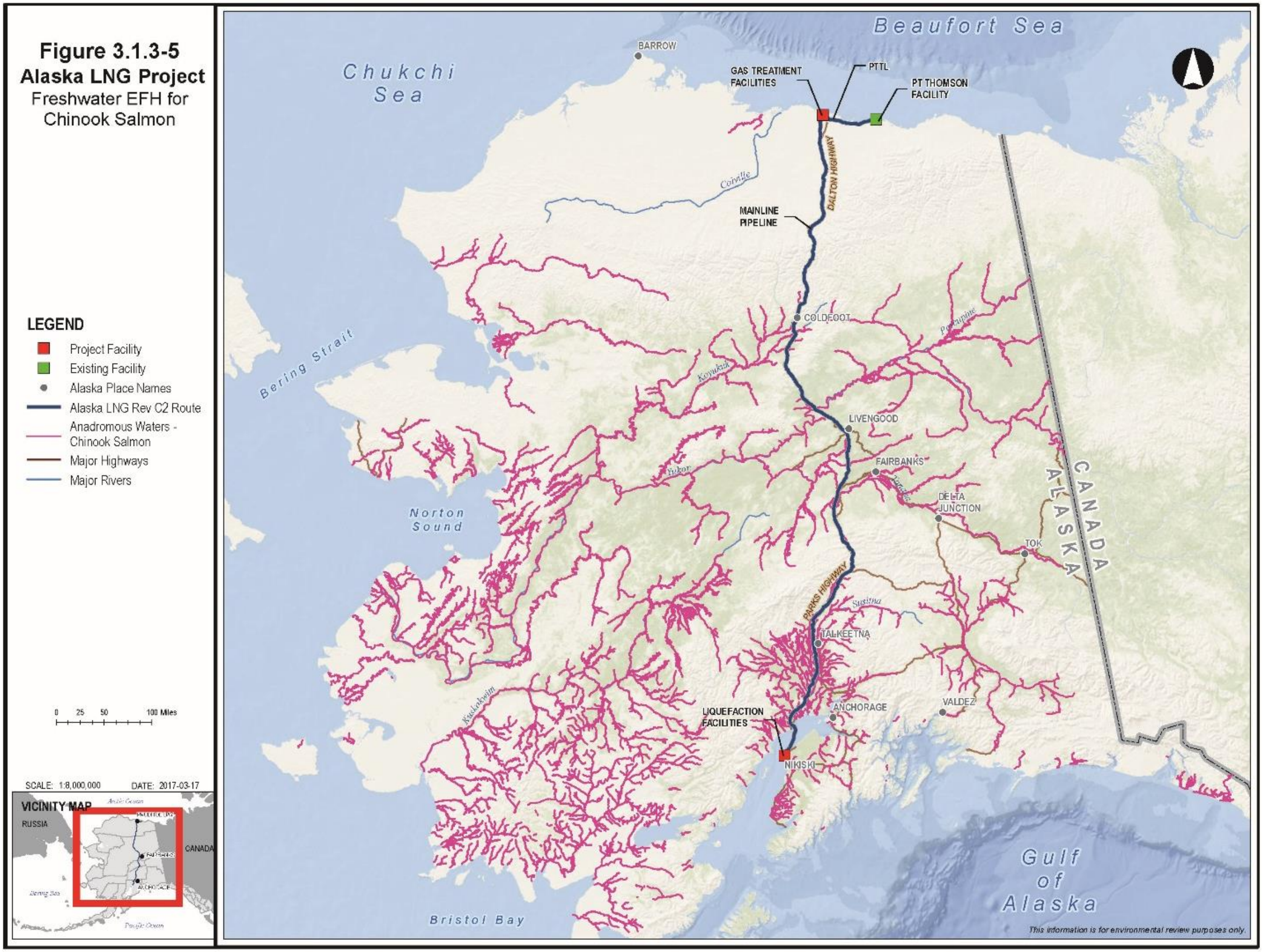


Figure 3.2-1
Alaska LNG Project
Habitats of Particular Concern in the Gulf of Alaska

This information is for environmental review purposes only.

LEGEND

- 🟥 Project Facility
- 🟩 Existing Facility
- Alaska LNG Rev C2 Route
- Major Highways
- ▭ Habitat Areas of Particular Concern

0 50 100 200 Miles

SCALE: 1:11,000,000 DATE: 2017-03-23

4.0 ANALYSIS OF POTENTIAL IMPACTS ON ESSENTIAL FISH HABITAT

4.1 FRESHWATER ESSENTIAL FISH HABITAT

The Mainline Pipeline would cross 70 freshwater streams and rivers with designated EFH for Pacific salmon; the PTTL would cross 3 freshwater rivers with EFH for Pacific salmon; and access roads would cross 28 freshwater streams and rivers with EFH (see tables 4.1-1 and 4.1-2). No freshwater EFH streams would be affected on the south side of Cook Inlet, at the Liquefaction Facilities, or at the GTP.

4.1.1 Construction

Construction of Mainline and PTTL pipeline crossings at EFH streams and rivers would be accomplished using several methods: aerial span, wet-ditch open-cut, frozen cut, directional micro-tunneling (DMT), and dry-ditch open-cut (flume or dam-and-pump to isolate flow) methods. Wet-ditch open-cut, frozen cut, and dry-ditch open-cut methods would be used at 65 Mainline crossings of EFH streams, 30 of which would be constructed during winter. Of the 30 crossings, 11 are expected to be frozen at the time of construction and would therefore not require flow diversions around the construction site. Ten of the remaining 19 stream crossings have known overwintering habitat (i.e., not frozen to the streambed) and winter construction is expected to have lethal impacts on EFH species at these crossings (see table 4.1-1).

Dry-ditch open-cut methods would be used at 30 of the Mainline Pipeline EFH crossings (11 in summer and 19 in winter). This method would use flow diversions to isolate the work site, maintaining flow between upstream and downstream areas. The Mainline Pipeline would be excavated into a trench in the isolated area, then covered before flow is returned to the waterbody. DMT would be used at five Mainline Pipeline crossings of EFH streams. This method uses directional drilling under the streambed to advance the pipeline without interrupting flow patterns or disrupting in-stream habitat.

AGDC would install the PTTL aerially over all waterbodies using a dual pile pier design that could be placed in the stream. The in-stream supports would require drilled pipe pile foundations to maintain the pipeline aboveground. The PBTL does not cross fish-bearing waters and would therefore have no impact on fish or fish habitat. Three rivers that would be crossed by aerial span for the PTTL have EFH (Shaviovik River East, Sagavanirktok River–Main Channel, and Sagavanirktok River–West Channel; see table 4.1-1). AGDC would install six vertical support members (VSM) in the Shaviovik River East and 38 VSMs in the Sagavanirktok River–Main Channel. AGDC would install the pipe on an existing aerial span bridge over the Sagavanirktok River–West Channel; therefore, no in-stream impacts would be expected at this crossing (see appendix I of the EIS). Installation of VSMs in active channels of two waterbodies with EFH could have local effects on the stream bed through erosion in the immediate vicinity of the piles. AGDC would place pilings about 150 feet apart. Overwintering fish or eggs and fry in the gravel at the two river crossings could be directly or indirectly killed or injured by in-stream construction of the pilings.

TABLE 4.1-1

Freshwater Waterbodies with Known Essential Fish Habitat

Waterbody	Milepost	AWC Number	Crossing Method	Construction Season	EFH Present	Spawning Upstream of Crossing Location	Over-Wintering Habitat at Crossing Location	Potential In-stream Blasting
PTTL [a]								
Shaviovik River East	PTMP 25.5	330-00-10310	Aerial span	Winter	Pink (spawning)	Y	Y	N
Sagavanirktok River - Main Channel	PTMP 44.2	330-00-10360	Aerial span	Winter	Chum (present) Pink (spawning)	Y	Y	N
Sagavanirktok River - West Channel	PTMP 53.6	330-00-10361	Existing aerial span	Winter	Chum (present) Pink (present)	N	Y	N
Mainline Pipeline [b]								
Middle Fork Koyukuk River	211.1	334-40-11000-2125-3912	DMT	Summer	Chum (present) Chinook (present)	U	U	N
Minnie Creek	229.1	334-40-11000-2125-3912-4128	Frozen cut	Winter	Chinook (rearing)	Y	U	N
Marion Creek	236.5	334-40-11000-2125-3912-4112	Frozen cut	Winter [c]	Chinook (rearing) Chum (spawning)	Y	Y	Y
Slate Creek No. 1	241.0	334-40-11000-2125-3912-4100	Frozen cut	Winter	Chinook (present) Chum (present)	U	N	Y
South Fork Koyukuk River	260.7	334-40-11000-2125-3740	Dry-ditch open-cut	Winter [c]	Chinook (present) Chum (present) Coho (present)	Y	Y	Y
Jim River	272.5	334-40-11000-2125-3740-4080	Wet-ditch open-cut	Summer	Chinook (spawning) Chum (spawning) Coho (present)	Y	Y	Y
Unnamed Stream	272.6	None	Wet-ditch open-cut	Summer	Chum (present)	N	U	N
Douglas Creek	274.8	334-40-11000-2125-3740-4080-5062	Wet-ditch open-cut	Summer	Chinook (rearing) Chum (present)	Y	U	Y
Unnamed Tributary to Prospect Creek	280.6	None	Wet-ditch open-cut	Summer	Chum (present)	N	U	N
Prospect Creek	281.3	334-40-11000-2125-3740-4080-5030	Wet-ditch open-cut	Summer	Chinook (spawning, rearing) Chum (present)	Y	Y	Y
Yukon River	356.5	334-40-11000	DMT	Summer	Chinook (present) Coho (present) Chum (present) Pink (present) Sockeye (present)	Y	Y	N
Chatanika River	439.1	334-40-11000-2490-3151-4020	Dry-ditch open-cut	Winter [c]	Chinook (present) Coho (present) Chum (present)	Y	Y	Y

TABLE 4.1-1

Freshwater Waterbodies with Known Essential Fish Habitat

Waterbody	Milepost	AWC Number	Crossing Method	Construction Season	EFH Present	Spawning Upstream of Crossing Location	Over-Wintering Habitat at Crossing Location	Potential In-stream Blasting
Tanana River	473.0	334-40-11000-2490	DMT	Summer	Chinook (present) Coho (present) Chum (present)	Y	Y	N
Nenana River No. 1	476.0	334-40-11000-2490-3200	Dry-ditch open-cut	Winter [c]	Chinook (present) Coho (present) Chum (present)	Y	Y	Y
Nenana River No. 2	489.2	334-40-11000-2490-3200	Dry-ditch open-cut	Winter [c]	Chinook (present) Coho (present) Chum (present)	Y	Y	Y
Bear Creek	504.7	334-40-11000-2490-3200-4220-5005-6016	Frozen cut	Winter [c]	Coho (spawning) Chum (spawning)	Y	Y	Y
June Creek	504.9	334-40-11000-2490-3200-4220-5005	Frozen cut	Winter [c]	Coho (spawning) Chum (spawning)	Y	Y	N
Panguingue Creek	521.0	334-40-11000-2490-3200-4075	Dry-ditch open-cut	Summer	Coho (rearing, spawning)	Y	Y	Y
Middle Fork Chulitna River	586.3	247-41-10200-2381	Wet-ditch open-cut	Summer	Chinook (spawning, rearing) Chum (spawning) Coho (spawning) Pink (present) Sockeye (present)	Y	Y	Y
East Fork Chulitna River	589.8	247-41-10200-2381-3260	Wet-ditch open-cut	Summer	Chinook (spawning) Coho (present) Sockeye (present)	Y	Y	Y
Hardage Creek	593.8	247-41-10200-2381-3260-4020	Dry-ditch open-cut	Summer	Chinook (rearing)	N	U	Y
Honolulu Creek	598.5	247-41-10200-2381-3240	Dry-ditch open-cut	Summer	Chinook (spawning)	Y	Y	Y
Little Honolulu Creek	601.8	None	Dry-ditch open-cut	Summer	Chinook (spawning)	N	Y	Y
Pass Creek No. 2	612.4	None	Dry-ditch open-cut	Summer	Chinook (present) Sockeye (present) Coho (present) Chum (present) Pink (present)	N	U	Y
Little Coal Creek	614.6	247-41-10200-2381-3234	Dry-ditch open-cut	Summer	Chinook (present) Coho (present) Chum (present)	N	U	Y
Unnamed Tributary to Chulitna River	616.6	247-41-10200-2381-3232-4020	Dry-ditch open-cut	Summer	Coho (rearing)	Y	N	Y

TABLE 4.1-1

Freshwater Waterbodies with Known Essential Fish Habitat

Waterbody	Milepost	AWC Number	Crossing Method	Construction Season	EFH Present	Spawning Upstream of Crossing Location	Over-Wintering Habitat at Crossing Location	Potential In-stream Blasting
Horseshoe Creek	618.1	247-41-10200-2381-3220	Dry-ditch open-cut	Summer	Chinook (present) Sockeye (present) Coho (present) Chum (present) Pink (present)	Y	Y	Y
Byers Creek	634.2	247-41-10200-2381-3180	Wet-ditch open-cut	Summer	Chinook (spawning) Sockeye (present) Coho (spawning) Chum (spawning)	Y	Y	Y
Unnamed tributary to Chulitna River	638.0	247-41-10200-2381-3150	Dry-ditch open-cut	Summer	Coho (rearing) Pink (present)	Y	U	Y
Troublesome Creek	640.8	247-41-10200-2381-3130	Wet-ditch open-cut	Summer	Chinook (spawning) Coho (spawning) Chum (spawning) Pink (spawning)	Y	Y	Y
Chulitna River	641.8	247-41-10200-2381	DMT	Summer	Chinook (present) Sockeye (present) Coho (present) Chum (spawning) Pink (present)	Y	Y	N
Unnamed tributary to Chulitna River	650.8	247-41-10200-2381-3073	Wet-ditch open-cut	Summer	Coho (spawning) Pink (spawning)	Y	Y	Y
Unnamed tributary to Chulitna River	653.1	247-41-10200-2381-3060	Wet-ditch open-cut	Summer	Coho (present, rearing)	U	N	Y
Unnamed tributary to Chulitna River	655.2	247-41-10200-2381-3051	Wet-ditch open-cut	Summer	Coho (present)	U	U	Y
Unnamed tributary to Chulitna River	658.3	247-41-10200-2381-3007	Wet-ditch open-cut	Summer	Coho (present)	U	U	Y
Unnamed tributary to Chulitna River	659.0	247-41-10200-2381-3007-4029	Wet-ditch open-cut	Summer	Coho (present)	U	U	Y
Unnamed tributary to Chulitna River	660.1	247-41-10200-2381-3007-4017	Wet-ditch open-cut	Summer	Coho (present)	U	U	Y
Unnamed tributary to Chulitna River	661.3	247-41-10200-2361	Wet-ditch open-cut	Summer	Coho (spawning, rearing)	Y	Y	Y
Trapper Creek	663.7	247-41-10200-2341	Wet-ditch open-cut	Summer	Chinook (rearing) Coho (spawning, rearing)	Y	Y	Y
Unnamed tributary to Rabideux Creek	666.5	247-41-10200-2291-3049	Dry-ditch open-cut	Winter [c]	Coho (spawning, rearing)	Y	Y	Y

TABLE 4.1-1

Freshwater Waterbodies with Known Essential Fish Habitat

Waterbody	Milepost	AWC Number	Crossing Method	Construction Season	EFH Present	Spawning Upstream of Crossing Location	Over-Wintering Habitat at Crossing Location	Potential In-stream Blasting
Sawmill Creek	670.0	247-41-10200-2291-3041	Dry-ditch open-cut	Winter [d]	Chum (present) Coho (spawning, rearing)	Y	Y	Y
Unnamed tributary to Sawmill Creek	670.1	247-41-10200-2291-3041-4002	Frozen cut	Winter	Coho (present)	U	U	Y
Queer Creek	673.4	247-41-10200-2291-3011	Dry-ditch open-cut	Winter	Chinook (rearing) Chum (present) Coho (rearing)	Y	U	Y
Unnamed tributary of Queer Creek	678.5	247-41-10200-2291-3011	Frozen cut	Winter	Coho (rearing)	Y	U	Y
Deshka River	704.7	247-41-10200-2081	DMT	Summer	Chinook (present, rearing) Sockeye (present, rearing) Coho (spawning, rearing) Chum (spawning) Pink (present)	Y	Y	N
Unnamed tributary of Deshka River	705.6	247-41-10200-2081-3041	Frozen cut	Winter	Chinook (present) Chum (present) Coho (rearing) Pink (present) Sockeye (present)	Y	U	Y
Unnamed tributary of Deshka River	706.3	247-41-10200-2081-3035-4008	Frozen-cut	Winter	Coho (rearing)	Y	U	Y
Unnamed tributary of Deshka River	707.7	247-41-10200-2081-3035	Dry-ditch open-cut	Winter	Chinook (rearing) Coho (rearing)	Y	U	Y
Fish Creek No. 2	720.4	247-41-10200-2053-3020-4015	Dry-ditch open-cut	Winter	Chinook (present, rearing) Sockeye (present) Coho (rearing)	Y	U	Y
Yentna River	720.9	247-41-10200-2053	Dry-ditch open-cut	Winter [c]	Chinook (present, rearing) Sockeye (present, rearing) Coho (spawning, rearing) Chum (spawning) Pink (present)	Y	Y	Y
Unnamed stream	722.9	247-41-10200-2051	Dry-ditch open-cut	Winter	Coho (rearing)	Y	U	Y
Unnamed tributary to Anderson Creek	724.9	247-41-10200-2043-3018	Dry-ditch open-cut	Winter	Coho (rearing)	Y	U	N
Anderson Creek	725.7	247-41-10200-2043	Dry-ditch open-cut	Winter	Coho (present) Pink (present)	U	U	Y

TABLE 4.1-1

Freshwater Waterbodies with Known Essential Fish Habitat

Waterbody	Milepost	AWC Number	Crossing Method	Construction Season	EFH Present	Spawning Upstream of Crossing Location	Over-Wintering Habitat at Crossing Location	Potential In-stream Blasting
Alexander Creek	727.8	247-41-10200-2015	Dry-ditch open-cut	Winter	Chinook (present) Sockeye (present) Coho (rearing) Chum (present) Pink (present)	Y	U	Y
Unnamed tributary to Alexander Creek	728.8	247-41-10200-2015-3021	Dry-ditch open-cut	Winter	Coho (rearing)	Y	U	N
Pierce Creek	730.8	247-41-10200-2015-3019	Frozen-cut	Winter	Coho (rearing)	Y	U	Y
Granite Creek (North Fork)	732.8	247-41-10200-2015-3017	Dry-ditch open-cut	Winter [c]	Coho (spawning, rearing) Sockeye (rearing)	Y	Y	N
Granite Creek (South Fork)	734.2	247-41-10200-2015-3017-4021	Dry-ditch open-cut	Winter [c]	Coho (spawning, rearing) Sockeye (rearing)	Y	Y	Y
Tributary to Ivan River	744.1	247-30-10010-2023	Frozen-cut	Winter	Chinook (rearing)	Y	U	Y
Lewis River Floodplain A	745.4	247-30-10070	Dry-ditch open-cut	Winter [c]	Chinook (spawning, rearing) Coho (rearing) Pink (present)	Y	Y	Y
Theodore River	748.5	247-30-10080	Wet-ditch open-cut	Summer	Chinook (spawning, rearing) Coho (rearing) Chum (present) Pink (present)	Y	Y	Y
Pretty Creek	750.1	247-30-10090-2010	Wet-ditch open-cut	Summer	Chinook (rearing) Sockeye (rearing) Coho (rearing) Pink (spawning)	Y	Y	Y
Unnamed stream	750.8	247-30-10090-2010-3015-4006	Wet-ditch open-cut	Summer	Coho (rearing)	Y	U	Y
Unnamed stream	751.4	247-30-10090-2010-3015-4010	Wet-ditch open-cut	Summer	Coho (rearing)	Y	U	Y
Unnamed stream	751.7	247-30-10090-2010-3015-4012	Wet-ditch open-cut	Summer	Coho (rearing)	Y	U	Y
Unnamed tributary to Pretty Creek	752.2	247-30-10090-2010-3015	Wet-ditch open-cut	Summer	Chinook (spawning, rearing) Coho (present) Pink (spawning) Sockeye (present)	Y	Y	Y
Unnamed tributary to Pretty Creek	752.6	247-30-10090-2010-3015-4015	Wet-ditch open-cut	Summer	Chinook (present) Coho (present) Pink (spawning) Sockeye (present)	Y	Y	Y

TABLE 4.1-1

Freshwater Waterbodies with Known Essential Fish Habitat

Waterbody	Milepost	AWC Number	Crossing Method	Construction Season	EFH Present	Spawning Upstream of Crossing Location	Over-Wintering Habitat at Crossing Location	Potential In-stream Blasting
Olson Creek	754.1	247-30-10090-2020	Dry-ditch open-cut	Summer	Chinook (spawning, rearing) Coho (spawning, rearing)	Y	Y	Y
Beluga River	757.2	247-30-10090	Dry-ditch open-cut	Winter	Chinook (present, rearing) Sockeye (present, rearing) Coho (present, rearing) Pink (present)	Y	U	Y
Threemile Creek	763.9	247-20-10002	Dry-ditch open-cut	Summer	Chinook (present, rearing) Chum (present) Sockeye (present) Coho (spawning, rearing) Pink (spawning)	Y	Y	Y

PTMP = PTTL milepost; DMT = directional micro-tunneling; Y = yes; N = no; U = unknown

[a] PTTL Rev D

[b] Mainline Rev C2

[c] AGDC has proposed to cross these waterbodies in winter, but due to the potential for overwintering habitat with EFH, these would be crossed in the summer.

TABLE 4.1-2

Access Roads with Known Essential Fish Habitat

Waterbody	Near Mainline Milepost	Access Road ID	Crossing Type	Construction Season	AWC Number	EFH Present	EFH Spawning Upstream of Crossing Location [a]	Overwintering Habitat at Crossing Location [a]
Sagavanirktok River - West Anabranch	17.7	MS-WS-I-18.13 (XING-01)	Ice bridge	Winter	330-00-10361	Chum (present) Pink (present)	N	U
Sagavanirktok River - West Anabranch	24.3	MS-WS-E-24.31 (XING-02)	Ice bridge	Winter	330-00-10361	Chum (present) Pink (present)	U	U
Sagavanirktok River - West Anabranch	33.7	ALT-MS-33.6 (XING-01)	Ice bridge	Winter	330-00-10360	Chum (present) Pink (present)	N	U
Sagavanirktok River - West Anabranch	34.2	ALT-MS-34.23 (XING-01)	Ice bridge	Winter	330-00-10360	Chum (present) Pink (present)	N	U
Sagavanirktok River - West Anabranch	35.6	MS-WS-E-35.66 (XING-01)	Ice bridge	Winter	330-00-10360	Chum (present) Pink (present)	N	U
Sagavanirktok River - West Anabranch	46.8	MS-N-46.71 (XING-01)	Ice bridge	Winter	330-00-10360	Chum (present) Pink (present)	N	U
Sagavanirktok River - West Anabranch	72.6	WS-N-72.63 (XING-01)	Bridge/ culvert	Summer	330-00-10360	Chum (present) Pink (present)	N	U
Sagavanirktok River - West Anabranch	76.1	MS-N-76.12 (XING-01)	Bridge/ culvert	Summer	330-00-10360	Chum (present) Pink (present)	N	U
Sagavanirktok River	86.6	MS-N-86.57 (XING-01)	Ice bridge	Winter	330-00-10360	Chum (present) Pink (present)	Y	Y
Prospect Creek	281.7	ALT-MS-281.61 (XING-01)	Bridge/ culvert	Summer	334-40-11000-2125-3740-4080-5030	Chinook (spawning, rearing)	Y	Y
Nenana River	473.8	AR-GA-MS-PSY-I-473.78 (XING-01)	Existing bridge	Winter	334-40-11000-2490-3200	Chinook (present) Chum (present) Coho (present)	N	U
Unnamed tributary to Nenana River	473.8	AR-GA-MS-PSY-I-473.78 (XING-02)	Existing bridge	Winter	334-40-11000-2490-3200	Chinook (present) Chum (present) Coho (present)	N	U
Hardage Creek	593.7	SF-N-593.83 (XING-01)	Bridge	Summer	247-41-10200-2381-3260-4020	Chinook (rearing)	Y	U
Honolulu Creek	598.2	SF-N-598.46 (XING-01)	Bridge	Summer	247-41-10200-2381-3240	Chinook (spawning)	Y	Y
Pond	616.2	AR-MLBV-N-616.31 (XING-01)	Culvert	Summer	247-41-10200-2381-3232-4020	Coho (rearing)	N	U

TABLE 4.1-2

Access Roads with Known Essential Fish Habitat

Waterbody	Near Mainline Milepost	Access Road ID	Crossing Type	Construction Season	AWC Number	EFH Present	EFH Spawning Upstream of Crossing Location [a]	Overwintering Habitat at Crossing Location [a]
Queer Creek	674.0	AR-TL-CS-MLBV-MS-HT-N-674.75 (XING-01)	Culvert	Winter	247-41-10200-2291-3011	Chinook (rearing) Chum (present) Coho (rearing)	N	U
Deshka River	704.7	SF-N-704.67 (XING-01)	Bridge	Winter	247-41-10200-2081	Chinook (present, rearing) Chum (spawning) Coho (spawning, rearing) Pink (present) Sockeye (present, rearing)	Y	Y
Fish Creek	720.4	SF-N-720.24 (XING-01)	Bridge	Winter	247-41-10200-2053-3020-4015	Chinook (present, rearing) Coho (rearing) Sockeye (present)	Y	U
Yentna River	720.9	SF-N-720.24 (XING-02)	Ice bridge	Winter	247-41-10200-2053	Chinook (present, rearing) Chum (spawning) Coho (spawning, rearing) Pink (present) Sockeye (present, rearing)	Y	Y
Unnamed tributary to Anderson Creek	725.6	SF-N-725 (XING-02)	Culvert	Winter	247-41-10200-2043-3018	Coho (present)	U	U
Anderson Creek	725.8	SF-N-725 (XING-01)	Bridge	Winter	247-41-10200-2043	Coho (present) Pink (present)	U	U
Alexander Creek	727.9	SF-N-727.8 (XING-01)	Bridge	Winter	247-41-10200-2015	Chinook (present) Chum (present) Coho (rearing) Pink (present) Sockeye (present)	Y	U
Lewis River	745.1	AR-CAMP-PSY-I-745.04 (XING-02)	Existing bridge	Summer	247-30-10070	Chinook (spawning, rearing) Coho (rearing)	Y	Y
Theodore River	746.5	AR-CAMP-PSY-I-745.04 (XING-04)	Existing bridge	Summer	247-30-10080	Chinook (spawning, rearing) Chum (present) Coho (rearing) Pink (present)	N	Y
Unnamed stream	749.2	AR-MLBV-CS-E-749.39 (XING-02)	Existing culvert	Summer	247-30-10080-2031	Chinook (rearing) Coho (rearing)	Y	U

TABLE 4.1-2

Access Roads with Known Essential Fish Habitat

Waterbody	Near Mainline Milepost	Access Road ID	Crossing Type	Construction Season	AWC Number	EFH Present	EFH Spawning Upstream of Crossing Location [a]	Overwintering Habitat at Crossing Location [a]
Pretty Creek	750.1	MS-E-750.95 (XING-01)	Culvert	Summer	247-30-10090-2010	Chinook (rearing) Coho (rearing) Pink (spawning) Sockeye (rearing)	Y	Y
Pretty Creek	750.1	AR-I-749.39 (XING-01)	Existing culvert	Summer	247-30-10090-2010	Chinook (rearing) Coho (rearing) Pink (spawning) Sockeye (rearing)	Y	Y
Olson Creek	753.7	AR-I-749.39 (XING-09)	Existing bridge	Summer	247-30-10090-2020	Chinook (spawning, rearing) Coho (spawning, rearing)	Y	Y

Y = yes, N = no, U = unknown

In addition to pipeline crossings, several construction activities associated with Project development could have negative effects on EFH. These include construction of access roads (gravel, bridge, and ice), equipment crossings of streams, quarrying and granular fill extraction for construction purposes, and water withdrawals. The specific effects on EFH that could result from construction activities include three main categories of effects:

- habitat loss or alteration of in-stream habitat through pipeline and access road construction and material extraction, erosion and sedimentation, and surface water use;
- water quality effects caused by spills or releases of hazardous substances (e.g., fuel, lubricants) and increased turbidity; and
- lethal and sub-lethal effects through direct impacts on spawning and overwintering habitats, and barotrauma from blasting.

The following sections describe these potential effects on EFH as they pertain to each of the Project components and describe the proposed avoidance, minimization, and avoidance measures that would be employed to reduce the potential effects on EFH.

4.1.1.1 Habitat Loss and Alteration

Habitat loss at stream and river crossings could affect freshwater EFH through alteration of substrate, fine sediment introduction and deposition, loss of cover, and temporary dewatering. All construction methods except most aerial and all DMT crossings have the potential to cause habitat alteration or loss due to streambed excavation for installing the pipeline (some aerial crossings have VSMs in-stream). Streambed excavation could result in a change in bed texture, including an increase in the proportion of fine sediments, or substrate compaction. Most salmonids require clean gravel or cobble substrates for spawning and overwintering of eggs. In addition, several species preferentially spawn in areas of upwelling where interstitial flow maintains oxygen delivery to eggs; thus, streambed excavation in spawning areas could cause a loss of spawning habitat that could persist over several seasons (or permanently) until natural conditions are restored.

Waterbody crossing construction at sites with occupied overwintering habitat would result in the mortality of incubating eggs and larvae at these locations, either through the direct destruction of incubating eggs and larvae at the crossing site, or through the introduction of sediment to downstream areas where eggs and larvae occur. This could result in impacts on EFH and EFH species that range from minor to major, depending on the extent of use of the affected habitat, and the distribution of overwintering habitat relative to the rest of the waterbody. The streambed disturbance for open-cut crossings would be limited to the width of the trench in the waterbody, which is dependent on a number of factors, including sediment type, flow, etc. (see section 2.2.2 of the EIS). This would represent a small percentage of the spawning habitat in any stream; therefore, impacts would be minor.

The wet-ditch open-cut crossing method would generate the greatest sediment and turbidity, but the elevated levels would be short term and occur over short distances downstream of the crossing. According to the Project Wetland and Waterbody Construction and Mitigation Procedures (Procedures), AGDC would complete all in-stream work for wet-ditch open-cut streams in less than 24 hours for minor streams (less than or equal to 10 feet across) and less than 48 hours for intermediate streams (greater than 10 feet but less than or equal to 100 feet across). Fish migration through the waterbody during construction would be restricted, but due to the short timeframe for in-stream work, the effect on migrating fish would be minor. The construction method for waterbody crossings that are frozen to the streambed or dry would be similar to that for upland pipeline installation. Construction impacts on fish would not be anticipated from winter construction in areas without overwintering habitat since fish would not be present due to the frozen condition; however, pipeline installation causing changes in streambank and streambed composition would affect fish habitat.

The use of dry-ditch open-cut methods presents fewer concerns with sediment entrainment in streams, but could create temporary barriers to fish migration in summer to winter, or dewatering of eggs and fry in winter when flows are diverted around construction areas. Dry-ditch open-cut methods include dam-and-pump or flume crossing methods to move water around the construction site. Dam-and-pump methods would be used in cases where sensitive fish species passage is not necessary or indicated through resource agency guidance. In addition to the dry-ditch methods, in braided systems with multiple nearby channels or in dynamic systems with frequent and common channel shifts, diversions could be constructed to move flow to a historic channel or to a newly created channel within the floodplain. In most cases, there would be potential for short-term impacts on fish in the immediate vicinity of the construction area. Fish passage could be impeded or inhibited during this timeframe, which, if during critical migration periods, could lead to delayed or eliminated access to spawning habitats. The magnitude of these impacts on EFH species is expected to be low if no overwintering fish or eggs are present. For overwintering habitats with proposed winter dry-ditch open-cut crossings and channel diversions, there could be significant impacts.

An aerial crossing would be used along the PTTL to cross the Sagavanirktok River–Main Channel, which contains EFH for pink and chum salmon, and the Shaviovik River East, which contains EFH for pink salmon. VSM installation would occur in active channels, which could have local effects on the streambed through erosion in the immediate vicinity of the piles. Overwintering fish, or eggs and fry in the gravel at the Sagavanirktok River–Main Channel and Shaviovik River crossings would be directly or indirectly killed or injured by in-stream construction of the pilings. The crossing of the Sagavanirktok River–West Channel would be placed on an existing aerial span bridge, so this crossing would not affect EFH.

Surface drainage and groundwater recharge patterns could be temporarily altered by clearing, grading, trenching, and soil stockpiling activities, potentially causing minor fluctuations in groundwater levels and/or increased turbidity, particularly in shallow surficial aquifers and areas with higher concentrations of fine sediments. In areas where groundwater (including suprapermafrost groundwater in the active layer) is near the surface and unfrozen, trench excavation could intersect the shallow water table and dewatering or other permanent water control methods could be required. Dewatering of trenches could result in temporary fluctuations in local groundwater levels, but trench water would be discharged into well-vegetated upland areas to allow infiltration or to nearby surface waters in accordance with Alaska Department of Environmental Conservation (ADEC) requirements. A change to surficial groundwater patterns could affect adult spawning site selection and increase larval mortality temporarily and locally if these areas were connected to surface waters; however, impacts would be minimized with implementation of the stream crossing time of year restrictions (see section 5.1) (Bradford, 2008).

Streambank vegetation and structure, such as logs, rocks, and undercut banks, provide important fish habitat. Construction through waterbodies (except with DMT) in forested areas would temporarily remove this habitat, which could displace fish to similar habitat upstream or downstream of the pipeline crossing. Vegetation removal adjacent to a stream could alter the temperature locally at the crossing location. The scale of change in temperature would be dependent on the stream width, stream flow, and vegetation cleared. In addition to potential temperature impacts on EFH species, the reduction of large woody debris in streams and on land could affect salmon habitat use following construction in areas where waterbodies are adjacent to forested areas (Mossop and Bradford, 2004). Large logs provide in-stream channel structures (i.e., pools and riffles), which are critical to salmon spawning and rearing. Removal of the debris in the stream along with those forests that provide large woody debris to the streams, and the length of time for revegetation of those forests (see section 4.5 of the EIS), could alter salmon use at those stream crossing locations. These locations would be relatively small compared to the available habitat within the stream reach.

If construction should block fish migrations (through waterbodies or flooded wetlands, especially during the spring freshet period), it could have a major local impact on that fishery, including the loss of a year class and spawning year of the species. Wet-ditch open-cut Mainline Pipeline waterbody crossings would be completed in 24 or 48 hours according to the Project Procedures, and construction in smaller streams using a dry-ditch open-cut method would be of limited duration (often only a couple of days) minimizing the amount of time fish passage would be restricted.

Table 4.1.1-1 lists wetlands that are adjacent to EFH where placement of a pipeline beneath the surface could cause modifications to hydrogeology by allowing subsurface water flow along the pipeline trench. Fifteen of these riverine wetlands are associated with EFH streams with known spawning salmon species. Fifty-seven proposed PTTL and Mainline Pipeline crossings have known EFH spawning habitat upstream (see table 4.1-1). Crossing locations in or upstream from spawning areas could dewater spawning gravels and kill eggs or larval fish, depending on the installation timing. The primary potential for impacts during pipeline installation at crossings using open-cut methods would be associated with spawning migrations and spawning habitat impacts.

Linear granular fill features (e.g., access roads and granular work pads within the construction right-of-way) that are left in place after construction could permanently modify natural drainage patterns within wetlands. Additional information on granular fill in wetlands is discussed in section 4.4 of the EIS. One wetland associated with the Unnamed Tributary to Chulitna River with EFH would have granular fill left in place after construction (see table 4.1.1-1). Coho salmon migration could be impeded at this location due to altered drainage at the crossing. Due to the potential permanent impact on migrating salmon by placing granular fill in this wetland, FERC has recommended that AGDC remove the granular fill from this wetland once construction is complete at the Unnamed Tributary to Chulitna River (see section 4.7.1.7 of the EIS).

Habitat loss is also associated with access road construction, particularly the installation of culverts and bridges over streams. Improperly installed culverts could create fish-passage barriers and limit access to upstream habitat. Bridge and culvert construction could also cause a loss of in-stream habitat (replacement of natural substrates with culverts), increased erosion and sediment delivery, and loss of riparian habitat. Some of these access roads would be used for multiple years of construction and could continue to be used for operational activities. The development of ice roads and ice pads across waterbodies for construction and operation could cause interference with fish passage during breakup. Ice roads and ice pads would melt slower than the surrounding ice in the waterbody, which could cause a blockage for fish in the spring, potentially affecting fish migration depending on the timing of the breakup. Ice blockages in-stream could also result in flooding of adjacent riparian areas, stranding fish when the blockage melts, and temporarily altering habitat.

TABLE 4.1.1-1

Riverine Wetlands at Waterbody Crossings with Essential Fish Habitat

Unique ID	Near Milepost	Wetland Crossing Method [a]	Granular Fill	Associated Waterbody Name	Essential Fish Habitat Species
PTTL					
99538	PTMP 25.5	Aerial/VSM [b]	No	Shaviovik River East	Pink (spawning)
99506	PTMP 44.2	Aerial/VSM [b]	No	Sagavanirktok River –Main Channel	Chum (present) Pink (spawning)
98742	PTMP 53.6	Aerial/VSM [b]	No	Sagavanirktok River –West Channel	Chum (present) Pink (present)
Mainline					
38687	229.1	Frozen-cut	No	Minnie Creek	Chinook (rearing)
38678	236.5	Frozen-cut	No	Marion Creek	Chinook (rearing Chum (spawning)
37668	241.0	Frozen-cut	No	Slate Creek No. 1	Chinook (present) Chum (present)
37647	260.7	Dry-ditch open-cut	No	South Fork Koyukuk River	Chinook (present) Chum (present) Coho (present)
37638	272.5	Wet-ditch open-cut	No	Jim River	Chinook (spawning) Chum (spawning) Coho (present)
37628	274.8	Wet-ditch open-cut	No	Douglas Creek	Chinook (rearing) Chum (present)
37620	281.3	Wet-ditch open-cut	No	Prospect Creek	Chinook (spawning, rearing) Chum (present)
36790	356.5	DMT	No	Yukon River	Chinook (present) Chum (present) Coho (present) Pink (present) Sockeye (present)
33719	439.1	Dry-ditch open-cut	No	Chatanika River	Chinook (present) Chum (present) Coho (present)
31766	473.0	DMT	No	Tanana River	Chinook (present) Chum (present) Coho (present)
29224	476.0	Dry-ditch open-cut	No	Nenana River No. 1	Chinook (present) Chum (present) Coho (present)
29212	489.2	Dry-ditch open-cut	No	Nenana River No. 2	Chinook (present) Chum (present) Coho (present)
26923	504.9	Frozen-cut	No	June Creek	Chum (spawning) Coho (spawning)
26398	521.0	Dry-ditch open-cut	No	Panguingue Creek	Coho (spawning, rearing)

TABLE 4.1.1-1

Riverine Wetlands at Waterbody Crossings with Essential Fish Habitat

Unique ID	Near Milepost	Wetland Crossing Method [a]	Granular Fill	Associated Waterbody Name	Essential Fish Habitat Species
25021	586.3	Wet-ditch open-cut	No	Middle Fork Chulitna River	Chinook (spawning, rearing) Coho (spawning) Chum (spawning) Pink (present) Sockeye (present)
25015	589.8	Wet-ditch open-cut	No	East Fork Chulitna River	Chinook (spawning) Coho (present) Sockeye (present)
24429	598.5	Dry-ditch open-cut	No	Honolulu Creek	Chinook (spawning)
24410	614.6	Dry-ditch open-cut	No	Little Coal Creek	Chinook (present) Chum (present) Coho (present)
24405	618.1	Dry-ditch open-cut	No	Horseshoe Creek	Chinook (present) Chum (present) Coho (present) Pink (present) Sockeye (present)
24183	634.2	Wet-ditch open-cut	No	Byers Creek	Chinook (spawning) Chum (spawning) Coho (spawning) Sockeye (present)
24177	640.8	Wet-ditch open-cut	No	Troublesome Creek	Chinook (spawning) Chum (spawning) Coho (spawning) Pink (spawning)
23689	655.2	Granular fill workspace	Yes	Unnamed tributary to Chulitna River	Coho (present)
23288	663.7	Wet-ditch open-cut	No	Trapper Creek	Chinook (rearing) Coho (spawning, rearing)
21173	704.7	DMT	No	Deshka River	Chinook (present, rearing) Chum (spawning) Coho (spawning, rearing) Pink (present) Sockeye (present, rearing)
19963	720.4	Dry-ditch open-cut	No	Fish Creek No. 2	Chinook (present, rearing) Coho (rearing) Sockeye (present)
19959	720.9	Dry-ditch open-cut	No	Yentna River	Chinook (present, rearing) Chum (spawning) Coho (spawning, rearing) Pink (present) Sockeye (present, rearing)
19956	725.7	Dry-ditch open-cut	No	Anderson Creek	Coho (present) Pink (present)

TABLE 4.1.1-1

Riverine Wetlands at Waterbody Crossings with Essential Fish Habitat

Unique ID	Near Milepost	Wetland Crossing Method [a]	Granular Fill	Associated Waterbody Name	Essential Fish Habitat Species
19465	727.8	Dry-ditch open-cut	No	Alexander Creek	Chinook (present) Chum (present) Coho (rearing) Pink (present) Sockeye (present)
19454	748.5	Wet-ditch open-cut	No	Theodore River	Chinook (spawning, rearing) Chum (present) Coho (rearing) Pink (present)
19202	754.1	Dry-ditch open-cut	No	Olson Creek	Chinook (spawning, rearing) Coho (spawning, rearing)

VSM = vertical support member in wetland feature

[a] Wetland would be crossed using same method as associated waterbody.

[b] VSM would be within wetland feature.

Permanent loss of stream habitats would occur from development of material extraction sites (see section 4.3.2 of the EIS). A list of material sites within or adjacent to EFH are listed in table 4.1.1-2. Material sites constructed within floodplains could have a variety of effects on EFH. Material extraction sites studied in arctic and subarctic floodplains in Alaska have shown a variety of adverse and beneficial effects on fish and fish habitat (Ott et al., 2014). The effects are dependent on many factors, including the type and size of the river, the type of material extraction employed, the amount of material extracted, and the time of year that the material is extracted. Material site development could lead to destabilization of river channels, river channel diversion or migration, floodplain widening, and reduced water quality, which can all negatively affect fish habitats (Joyce et al., 1980). Ott et al. (2014) determined that active channel mining should be avoided when possible, particularly when important spawning or wintering habitats are nearby. Ott et al. (2014) also documented fish entrapment potential at sites where extraction sites left depressions in floodplains that were later flooded at high water and then became isolated waters as water levels dropped.

Ott et al. (2014) also identified configurations where mining methods (e.g., limitations on gravel removed specific to stream type and size) and location of gravel removal sites could enhance habitats and reduce the potential for stream altering processes to occur. Some benefits to local fish populations, including the creation of wintering habitats and productive feeding habitats, have been identified. Ott et al. (2014) summarizes fish use of several granular material sites, most constructed as pits that were subsequently connected to nearby drainages on Alaska's North Slope. While some sites took many years to be used by appreciable numbers of fish, most were used for overwintering. In that study, extraction sites provided overwintering habitat that is in limited supply in the Arctic. Several of the sites studied had been rehabilitated primarily to provide overwintering habitat for fish, but also had productive shallow water habitats incorporated in their design to foster both productivity and enhanced overwintering habitat.

TABLE 4.1.1-2

Material Sites Within or Adjacent to Essential Fish Habitat Waterbodies

Waterbody Name	Material Site [a]	Near Mainline Milepost	AWC Code	Essential Fish Habitat Species
Sagavanirktok River – West Anabranch [b]	MS-17.81	17.9	330-00-10361	Chum (present) Pink (present)
Sagavanirktok River – West Anabranch [b]	65-9-026-2	25.5	330-00-10361	Chum (present) Pink (present)
Sagavanirktok River – Main Channel [b]	65-9-040-2	47.0	330-00-10360	Chum (present) Pink (present)
Sagavanirktok River – Main Channel	65-9-072-2-1	75.8	330-00-10360	Chum (present) Pink (present)
Sagavanirktok River – Main Channel [b]	65-9-072-2-2	75.8	330-00-10360	Chum (present) Pink (present)
Sagavanirktok River [ab]	Alternate Site 34 Extra	86.6	330-00-10360	Chum (present) Pink (present)
Marion Creek	65-9-098-2	236.9	334-40-11000-2125-3912-4112	Chinook (rearing) Chum (spawning)
South Fork Koyukuk River	Alternate Site 43 Extra	261.4	334-40-11000-2125-3740	Chinook (present) Chum (present) Coho (present)
Prospect Creek	Site 4 Extra 1	282.2	334-40-11000-2125-3740-4080-5030	Chinook (spawning, rearing) Chum (present)
Prospect Creek	Site 4 Extra 2	282.2	334-40-11000-2125-3740-4080-5030	Chinook (spawning, rearing) Chum (present)
Prospect Creek	Site 4 Extra 3	282.2	334-40-11000-2125-3740-4080-5030	Chinook (spawning, rearing) Chum (present)
Unnamed tributary to Rabideux Creek	35-2-5007-1	666.2	247-41-10200-2291-3049	Coho (spawning, rearing)

Sources: Johnson and Klein, 2009; Johnson and Litchfield, 2015; Johnson and Blossom, 2017

[a] Blasting may occur at all material sites.

[b] Material site is within waterbody.

Water would be withdrawn from surface freshwater sources at the GTP for a water reservoir, construction camps, ice roads and ice pads, and other facilities; at the PTTL, PBTL, and Mainline Pipeline for hydrostatic testing; for DMT of portions of the Mainline Pipeline; for Mainline Pipeline construction and operation camps and ice roads and ice pads; and for the Liquefaction Facilities camp. Dust control water for construction activities would be withdrawn from wells, which, due to their depth and lack of contact with surface water, are not expected to impact EFH. A summary of water sources with EFH is included in table 4.1.1-3. The Project Water Use Plan includes additional details on water usage volumes. Not all of these waterbodies would be crossed by the Mainline Pipeline or PTTL, but would be used as a water source for pipeline construction, ice road and ice pad development, and other construction activities.

TABLE 4.1.1-3

Waterbodies with Known Essential Fish Habitat and Planned Water Withdrawals

Waterbody Name	Near Milepost	AWC Code	EFH Species
PTTL			
Lake #10-10	PTMP 28.4	330-00-10361	Chum (present) Pink (spawning)
Lake #24	PTMP 34.1	330-00-10361	Chum (present) Pink (spawning)
Lake #10-05	PTMP 42.7	330-00-10361	Chum (present) Pink (spawning)
Sagavanirktok River	PTMP 44.2	330-00-10360	Chum (present) Pink (spawning)
Unnamed Lake 12	PTMP 44.9	330-00-10361	Chum (present) Pink (spawning)
Lake #10-03	PTMP 45.8	330-00-10361	Chum (present) Pink (spawning)
Drill Site 4 Lake – North of East Dock Road	PTMP 54.8	334-40-11000-2125-3912	Chinook (present) Chum (present)
Drill Site L3 Lake	PTMP 54.8	334-40-11000-2125-3912-4128 (Minnie Creek)	Chinook (rearing)
Coleen Lake	PTMP 55.5	334-40-11000-2125-3912-4123 (Wiseman)	Chinook (rearing)
059-D Lake	PTMP 56.3	334-40-11000-2125-3912-4112	Chinook (rearing) Chum (spawning)
T 3 C Lake	PTMP 56.7	334-40-11000-2125-3912-4100	Chinook (present) Chum (present)
GTP L09 Lake	PTMP 56.8	334-40-11000-2125-3740-4080	Chinook (spawning) Chum (spawning) Coho (present)
Drill Site 18 Lake	PTMP 58.8	334-40-11000-2125-3740-4080	Chinook (spawning, rearing)
GTP-L02 Lake	PTMP 62.5	334-40-11000	Chinook (present) Chum (present) Coho (present) Pink (present) Sockeye (present)
Mainline Facilities [a]			
Sagavanirktok River	35.6	330-00-10360	Chum (present) Pink (spawning)
Sagavanirktok River	56.5	330-00-10361	Chum (present) Pink (spawning)
Sagavanirktok River	85.7	330-00-10361	Chum (present) Pink (spawning)
Sagavanirktok River	90.5	330-00-10361	Chum (present) Pink (spawning)
Sagavanirktok River	95.9	330-00-10361	Chum (present) Pink (spawning)
Sagavanirktok River	100.8	330-00-10361	Chum (present) Pink (spawning)
Middle Fork Koyukuk River	211.1	334-40-11000- 2125-3912	Chum (present) Chinook (present)

TABLE 4.1.1-3

Waterbodies with Known Essential Fish Habitat and Planned Water Withdrawals

Waterbody Name	Near Milepost	AWC Code	EFH Species
Middle Fork Koyukuk River and Minnie Creek	227.8	334-40-11000-2125-3912-4128 (Minnie Creek)	Chinook (rearing)
Middle Fork Koyukuk River and Wiseman Creek	230.4	334-40-11000-2125-3912-4123 (Wiseman)	Chinook (rearing)
Marion Creek	236.5	334-40-11000-2125-3912-4112	Chinook (rearing) Chum (spawning)
Slate Creek	241.0	334-40-11000-2125-3912-4100	Chinook (present) Chum (present)
Jim River	272.5	334-40-11000-2125-3740-4080	Chinook (spawning) Chum (spawning) Coho (present)
Prospect Creek	281.3	334-40-11000-2125-3740-4080-5030	Chinook (spawning, rearing)
Yukon River	356.5	334-40-11000	Chinook (present) Chum (present) Coho (present) Pink (present) Sockeye (present)
Chatanika River	439.1	334-40-11000-2490-3151-4020	Chinook (present) Chum (present) Coho (present)
Tanana River	473.0	334-40-11000-2490	Chinook (present) Chum (present) Coho (present)
Nenana River	489.2	334-40-11000-2490-3200	Chinook (present) Chum (present) Coho (present)
Bear Creek	504.7	334-40-11000-2490-3200-4220-5005-6016	Chum (spawning) Coho (spawning)
Panguingue Creek	521.0	334-40-11000-2490-3200-4075	Coho (spawning, rearing)
Middle Fork Chulitna River	586.3	247-41-10200-2381	Chinook (spawning, rearing) Chum (spawning) Coho (spawning) Pink (present) Sockeye (present)
Hardage Creek	593.7	247-41-10200-2381-3260-4020	Chinook (rearing)
Chulitna River	641.8	247-41-10200-2381	Chinook (present) Chum (spawning) Coho (present) Pink (present) Sockeye (present)
Susitna River	675.7	247-41-10200	Chinook (present) Chum (present) Coho (spawning) Pink (present) Sockeye (present)
Trapper Lake	689.8	247-41-10200-2081-3050-0050	Chinook (rearing) Coho (present, rearing)

TABLE 4.1.1-3

Waterbodies with Known Essential Fish Habitat and Planned Water Withdrawals

Waterbody Name	Near Milepost	AWC Code	EFH Species
Deshka River	704.7	247-41-10200-2081	Chinook (present, rearing) Chum (spawning) Coho (spawning, rearing) Pink (present) Sockeye (present, rearing)
Yentna River	9.0	247-41-10200-2053	Chinook (present, rearing) Chum (spawning) Coho (spawning, rearing) Pink (present) Sockeye (present, rearing)
Susitna River	725.1	247-41-10200	Chinook (present) Chum (present) Coho (spawning) Pink (present) Sockeye (present)
Lewis River	745.4	247-30-10070	Chinook (spawning, rearing) Coho (rearing) Pink (present)
Beluga River	757.2	247-30-1009	Chinook (present, rearing) Coho (present, rearing) Pink (present) Sockeye (present, rearing)
Tukallah Lakes	763.5	247-20-10002-0010	Chinook (present, rearing) Coho (spawning, rearing) Pink (present) Sockeye (spawning)

PTMP = PTTL milepost

[a] South of the Brooks Range, Mainline Facilities operation would require water sourced from nearby surface waters, trucked in and stored on site, or acquired from on-site groundwater wells. AGDC anticipates that 15,000 gallons would be required annually for these sites, which would be spread out over the year. AGDC has not indicated that any operational water use would be needed north of the Brooks Range for the Mainline Pipeline. If needed, however, that water would either be trucked in or sourced from nearby surface waters. The specific waterbodies and volumes needed are unknown at this time.

Water withdrawal activities could affect fish in multiple ways. Fish or fish eggs could be entrained or entrapped within the water pumping system itself or become impinged on the intake structure at the point of water withdrawal. Excessive withdrawal from any one site could also have impacts by reducing the available water downstream of the water withdrawal location. Water withdrawal during winter (such as for ice roads and ice pads) can lead to water levels that reduce habitat quality, including an inadequate volume for pools within the waterbody to resist freezing, exposure of embryo- and fry-stage salmon to freezing winter conditions, and inadequate volume to retain high enough dissolved oxygen concentration for fish survival. Water withdrawn from waterbodies for ice road and ice pad construction would be made up of ice chips, water, or both. Winter withdrawal could lead to reduced flows in streams and could affect spawning beds and fish eggs within the gravel, as well as impede fish passage to and between important overwintering habitats. Fish overwintering areas can exist as isolated pools or stream reaches that would be highly sensitive to water removal.

Summer season withdrawal could have similar effects on fish and fish habitat if the volume removed was too large. Reductions in water levels and flows could increase water temperatures beyond the thermal tolerances of some fish species, but could also increase productivity (in other words, warmer waters could grow more algae that smaller fish could feed on) for juveniles of others. Any withdrawal that led to discontinuous surface flows within a creek or lake outlet would trap fish.

During winter, water withdrawal effects could last for the entire winter construction season. Summer withdrawals would have less potential for long-term adverse effects on fish and fish habitat due to availability of flowing water and recharge, but excessive withdrawal could still lead to minor to moderate short-term impacts depending on the timing of the withdrawal. Small or juvenile fish could be impinged on intake structures due to their weaker swimming ability and size resulting in mortality of those individuals.

4.1.1.2 Water Quality

Water quality could be affected by construction of the pipeline and associated infrastructure through the introduction of sediment, fuel, lubricants, and other substances. Effects on EFH and EFH species include increased turbidity and suspended sediment and exposure to contaminants from spills and water discharges.

Sediment could be introduced to watercourses during in-stream construction of pipeline crossings and access road crossings, during equipment crossings, and from runoff from roads, additional temporary workspace, and other disturbed areas. Because data was unavailable to quantify impacts on turbidity and sedimentation from wet-ditch open-cut crossings, AGDC conducted a sediment transport study on 11 minor and intermediate waterbodies representative of waterbodies that would be affected by the Project. The study assumed that excavated spoil would be stored at least 10 feet from the water's edge, construction timeframes would be consistent with the Project Procedures (24 or 48 hours), and there would be a base threshold to maintain water quality standards for designated uses (see section 4.3.2.4 of the EIS).[4] According to the sediment transport model, the average sediment accumulation would range from 0.02 to 0.4 inch about 160 feet downstream of the trench excavation. Similarly, the maximum downstream distance exceeding water quality standards would be about 290 feet, which would last about 1 hour after excavation ceases.

All freshwater EFH is susceptible to increased sedimentation, but fish in watercourses with naturally high turbidity (e.g., glacial streams) may be more resilient to sediment introduction than sites with naturally clear water. High sediment inputs can alter habitat by increasing turbidity and suspended solids, settling into the substrate, and accumulating in slack water areas. Increased turbidity could cause habitat avoidance, increased stress, decreased feeding efficiency, and mortality among EFH species. Sediment that settles out of the water column could alter substrate composition, which could affect spawning success and habitat use.

Installing the Mainline Pipeline using the DMT method at the Middle Fork Koyukuk River (milepost [MP] 211.1), Yukon River (MP 356.5), Tanana River (MP 473.0), Chulitna River (MP 641.8), and Deshka River (MP 704.7) would avoid impacts on fisheries and fish habitat within and adjacent to waterbodies unless an inadvertent release of drilling fluid into the stream should occur. An inadvertent release of drilling fluid into a stream would affect water quality and could smother fish eggs and degrade spawning habitat. Depending on the magnitude of drilling fluid loss and whether drilling fluids escape into the water column, sedimentation of substrates downstream from the release site could occur. All but the Middle Fork Koyukuk River host Pacific salmon EFH with known spawning upstream of the crossing

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[4] The relevant Alaska water quality standard for turbidity (assuming the streams' designated use of Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife) is not to exceed 25 nephelometric turbidity units above natural conditions (ADEC, 2018).

location. The magnitude of impact on these sites could be higher if the release occurs when spawning adults or incubating eggs are present.

The introduction of fuels, lubricants, and other substances to watercourses could occur from leaks and spills from machinery and fueling stations. The introduction of these substances would have toxic effects on fish as well as on the aquatic invertebrates that make up their food supply. The effect of spilled substances on EFH and EFH species would be dependent on what is spilled, the size of the spill, and the season of occurrence. Spills in winter could be easier to clean up if they can be contained to the ice/snow surface, but spills that enter water under ice would be more difficult to contain. Any spills of fuels or lubricants would have a negative effect on fish and fish habitat in close proximity to the spill. The extent of the impact would be dependent on how far downstream the spill moves. Stream productivity could be affected for a number of years in the case of large spills.

Hydrostatic testing would occur for the Mainline Pipeline, PTTL, PBTL, and GTP. Water would be withdrawn from surface freshwater sources, and discharged either back to the source or to an upland location. Discharges of hydrostatic test water could locally increase flows, alter water temperatures, and increase turbidity in receiving waters and those waterbodies downstream of the discharge point. Wastewater generated during operation of the additional work areas and aboveground facilities associated with the Mainline Facilities would be collected and disposed of at an approved disposal facility (industrial wastewater), treated on site and discharged to the ground (gray water), or treated using disinfectants (black water). The wastewater discharges would be subject to the appropriate APDES and United States Environmental Protection Agency (EPA) permitting. Where practicable given the remoteness of a facility, AGDC proposes to use fully contained wastewater treatment facilities that would not discharge into the environment. Discharges are unlikely to reach waterbodies with EFH.

4.1.1.3 Lethal and Sub-lethal Effects

Direct mortality and sub-lethal effects on EFH species could result from several construction-related factors, including direct disturbance during construction of pipeline crossings; dewatering channel segments where fish or incubating eggs are present; blasting in or adjacent to fish-bearing waters; spills of fuel, lubricants, or other deleterious substances; and entrainment in water pumps. The highest likelihood for mortality of EFH species is likely to occur at pipeline crossings where fish or eggs are likely to be overwintering. Typically, streams and rivers in northern Alaska freeze solid to the substrate to depths of up to 6 feet; deeper reaches of streams can remain unfrozen and provide overwintering habitat through the winter (Roberge et al., 2002). These areas are particularly important for Pacific salmon, which spawn in the fall and whose eggs and larvae overwinter in the substrate (Groot and Margolis, 1991). Several species of salmon also rear in streams for multiple years, and require habitat that does not freeze. Salmon spawning has been reported in the vicinity of 55 Mainline Pipeline crossings where designated EFH occurs. About half of those crossings would be constructed in winter when eggs are likely to be incubating in the substrate.

Construction of VSMs to support the PTTL aerial crossing of the Sagavanirktok River–Main Channel and Shaviovik River East would require in-stream construction for the pilings, which would cause the mortality of incubating pink or chum salmon eggs if they occur in the footprint. Known overwintering habitat and spawning occur at or near the crossing location. Mortality of juvenile salmon is also possible, as these individuals would be limited in their ability to move away from the construction activities.

Two types of blasting are anticipated for the Project: material site blasting and trench blasting for Mainline Pipeline construction. Table 4.1.1-2 lists material sites near EFH waters; blasting may occur at all material sites. Table 4.1-1 lists the waterbodies where trench blasting is expected to occur. Trench blasting is more confined than a normal open pit (material site) blast; open pit blasts result in higher explosives consumption per cubic foot of blasted rock. The diameter of trench blast holes is normally smaller, which provides better distribution of the explosive in the rock, avoids excessive over-break outside the trench width, and helps avoid high peak overpressure (noise) and high peak particle velocity (vibration) readings. Trench blasting would produce a one-time vibration and peak overpressure and is very short in duration. Underwater noise effects criteria for fish have been established by the Fisheries Hydroacoustic Working Group (a coalition of NMFS; the U.S. Fish and Wildlife Service; the Federal Highway Administration; U.S. Department of Transportation offices from California, Oregon, and Washington; and national experts on sound propagation). Appendix L-1 of the EIS provides calculations of noise impacts on fish from various construction activities. As shown in this appendix, in-stream VSM installation is unlikely to cause noise disturbances to fish.

Blasting could affect incubating fish eggs and embryos, as well as juvenile and adult fish through mechanical disturbance, barotrauma, and noise (Popper and Hastings, 2009; Kolden and Aimone-Martin, 2013). Barotrauma, which is physical damage caused by quick changes in pressure, can result from blasting, pile driving, seismic testing, and hydroelectric turbines. Barotrauma can rupture the organs and internal structures of fish and could have lethal and sub-lethal effects. Excessive noise could cause habitat avoidance. Mechanical shaking from adjacent blasts could damage fish eggs and embryos incubating in the substrate. The magnitude of trauma would be dependent on the blast proximity as well as the embryonic stage of development.

In-stream blasting could affect fish-bearing streams by redirecting flow out of the existing channel, which would change the stream morphology. Because of the potential impact on fish resources, including EFH, we have recommended that AGDC file an updated Project Blasting Plan with the following requirements for all fish-bearing streams where blasting would occur (see section 4.7.1.7):

- monitoring protocol of stream flow after blasting and prior to completion of in-stream activities;
- implementing contingency measures to remediate loss of stream flow caused by fracturing the rock or permafrost from blasting; and
- indicating the timeframe for response and implementation of contingency measures.

4.1.2 Operation

The potential impacts on freshwater EFH from operational activities are mainly limited to the effects of access roads, permanent granular fill in wetlands, and maintenance activities. Permanent access roads would be used for operational access along the Mainline Pipeline. All access road bridges and culverts would be left in place unless landowners requested to have them removed. Use of roads that cross waterbodies could increase sedimentation and dust from road surface disturbance to those waterbodies. The potential impacts would be similar to those described in section 4.1.1, but would be less significant because new culverts or bridges would not be constructed for operation.

4.1.2.1 Habitat Loss and Alteration

All access roads and associated granular fill would be left in place after construction; therefore, all bridges and culverts would be permanent at waterbody crossings post-construction (except for ice bridges). Placement of granular fill for access roads could permanently affect surface flows by disrupting flow paths. AGDC committed to installing appropriately sized culverts within access roads to maintain streamflow during construction and operation.

Culverts that remain in place over time could impede fish movement if not properly sized from the beginning or maintained over time. Unmaintained culverts can cause blockage to fish movements from washout under the culvert, development of plunge pools at culvert outlets, blockages from seasonal debris flows, and overall failure of the structure (Furniss et al., 1991; O'Doherty, 2015). Maintaining connectivity is important for migratory fishes in Alaska, especially in the Arctic Tundra Ecoregion where fish move between limited overwintering habitats and summer feeding and breeding areas (Sullender, 2017). Long-term impacts on Pacific salmon species from poorly maintained or blocked culverts could occur if permanent culverts should restrict the movement of migrating adult salmon or fry to or from spawning and rearing reaches of tributaries. This fish passage blockage could lead to the gradual erosion and decline of the population and genetic diversity (NMFS, 2018).

Granular fill left in place at riverine wetland areas could permanently impede EFH species migrations (see table 4.1.1-1). In addition, as listed in table 4.1-2, 28 access roads cross waterbodies with EFH and 20 of those would have permanent structures (e.g., culverts or bridges). As described for construction, improper design of culverts and bridges or granular fill left in riverine wetlands with EFH could cause permanent impacts on migratory Pacific salmon and restrict their ability to reach spawning areas or move out of rearing areas. These impacts would be permanent and could significantly impact productivity of those species in the affected waterbody.

After construction, there is a risk of erosion continuing at stream crossings within pipeline rights-of-way. Construction-related effects could continue into operation at some sites that are persistently difficult to stabilize. Effects would be similar to those described for construction, but in limited locations and with longer-term durations, which could lead to stream channel alterations, habitat shifts, and lowered productivity. These sites would be more likely to interfere with fish movement and fish use, and if proximate to important spawning and overwintering areas, could affect local productivity.

Streambank vegetation and structure—such as logs, rocks, and undercut banks—provide important fish habitat. Construction through waterbodies (except with trenchless methods) could permanently remove this habitat, which could displace fish to similar habitats upstream or downstream of the pipeline crossing. Displacement would result in increased competition for habitat and food sources, which could affect fish health and survival.

Potential impacts on fish habitats from operation of the buried Mainline Pipeline would be mostly associated with frost bulb formation induced by chilled gas (see section 4.3.2.5 of the EIS). The formation of frost bulbs at waterbody crossings could affect water flow within the streambed, particularly in late winter at low flow streams. Additionally, downstream water temperatures could be lower for very-low-flow streams as a result of the chilled gas flow and frost bulbs. Operation of a chilled Mainline Pipeline in the substrates of streams could affect local water temperatures and could result in lowered stream productivity during summer. Winter water temperature reductions would pose a higher potential risk, particularly at stream crossings with low, but persistent, winter flows. On the North Slope, crossings of sensitive overwintering areas that remain just above freezing all winter could freeze during exceptionally cold winters with the added thermal drop associated with the below-freezing pipeline. Small drainages with persistent low flows of cool water during winter, most common in the construction spreads between the Brooks Range and the Alaska Range, would be most susceptible to winter reductions in water temperatures. If crossings are able to freeze solid, water would be forced to the surface as ice and downstream overwintering and spawning habitats could be dewatered.

4.1.2.2 Water Quality

The main risks to water quality in EFH streams during operation would come from potential spills of contaminants from vehicles along permanent access roads and from machinery conducting routine maintenance. Impacts would be similar to those described in construction, but would be less likely to be significant due to reduced activity during operation.

4.1.2.3 Lethal and Sub-lethal Effects

Potential impacts on Pacific salmon EFH from operation of the buried Mainline Pipeline would be mostly associated with frost bulb formation induced by chilled gas (see section 4.3.2.5 of the EIS). The formation of frost bulbs at waterbody crossings could affect water flow within the streambed, particularly in late winter at low flow streams. Additionally, downstream water temperatures could be lower for very-low-flow streams as a result of the chilled gas flow and frost bulb. Operation of a chilled Mainline Pipeline in the substrates of streams could affect local water temperatures and could result in lowered stream productivity during summer.

From MPs 0.0 to 180.0, pipeline temperature would be cooled and maintained below freezing throughout the year; therefore, thermal effects of pipeline operation could lead to lower water temperatures above the pipe. From MPs 180.0 to 567.0, the land surface is generally underlain with discontinuous permafrost; the in-line temperature would be maintained at a 32°F year-round average. From MPs 567.0 to 806.6, in areas of predominantly warm, non-permafrost conditions, the natural gas temperature would be kept at above-freezing temperatures. Because the pipe could be either warmer or cooler than ambient conditions, operation could lead to minor changes in sediment temperature, and therefore, water temperature in either direction.

Winter water temperature reductions would pose a higher potential risk, particularly at stream crossings with low, but persistent, winter flows. On the North Slope, crossings of sensitive overwintering areas that remain just above freezing all winter could freeze during exceptionally cold winters with the added thermal drop associated with the below-freezing pipeline. Small drainages with persistent low flows of cool water during winter, most common in the construction spreads between the Brooks Range and the Alaska Range, would be most susceptible to winter reductions in water temperatures. If crossings are able to freeze solid, water would be forced to the surface as ice and downstream overwintering and spawning habitats could be dewatered. Table 4.1-1 identifies Mainline Pipeline and PTTL stream crossings with identified overwintering habitats in anadromous Pacific salmon spawning areas.

Changes in the natural temperature regime could affect fish productivity by affecting bio-energetics. Studies show that fish respond to temperature through physiological and behavioral adjustments that depend on the magnitude and duration of temperature exposure. Fish species have temperature ranges within which they can survive, and optimum temperatures for growth that maximize their ability to convert food into tissue.

As described in section 4.1.1.1, a corridor centered on the pipeline and up to 10 feet wide would be maintained in an herbaceous state for periodic pipeline corrosion/leak surveys. Overall, temperature changes associated with a buried pipeline and removal of riparian vegetation and in-stream debris would not have a significant effect on the quality of habitat for use by fish for feeding and reproduction.

4.2 MARINE ESSENTIAL FISH HABITAT

In the Beaufort Sea, Project components associated with the Gas Treatment Facilities and associated marine infrastructure overlap with marine EFH for arctic cod and chum and pink salmon EFH (NPFMC, 2009; NPFMC et al, 2012). In Cook Inlet, marine EFH for Chinook, chum, coho, pink, and sockeye salmon EFH overlaps with proposed Project infrastructure associated with the Mainline Pipeline and Liquefaction Facilities.

4.2.1 Construction

Construction activities that could affect EFH in the marine environment include screeding, pile driving, pipe laying, infrastructure development, and dredging. In addition, shore-based activities could affect marine EFH through runoff of sediment-laden water or spills of hazardous materials into the marine environment. The potential impacts on marine EFH include:

- habitat loss and alteration through marine infrastructure development, including increased sedimentation and decreased productivity and prey availability;

- water quality effects caused by toxicity from spills or releases of hazardous substances (e.g., fuel, lubricants) and increased sedimentation and turbidity; and

- lethal and sub-lethal effects through barotrauma from pile driving, increased environmental noise, and water withdrawals.

4.2.1.1 Habitat Loss and Alteration

Direct loss of habitat would occur within the footprint of the new Dock Head 4 and berths at the West Dock Causeway in Prudhoe Bay, along the Mainline Pipeline crossing of the Cook Inlet seafloor, at the Mainline MOF, and at the Marine Terminal in Cook Inlet where a temporary MOF and permanent PLF would be constructed. In addition, dredging (Liquefaction Facilities), screeding (West Dock Causeway), and shoreline armoring (Marine Terminal) would result in temporary and permanent losses of marine EFH in both Cook Inlet and Prudhoe Bay.

The loss of marine EFH for arctic cod and Pacific salmon (chum and pink salmon) in Prudhoe Bay is anticipated to be about 166 acres. This loss would be due to West Dock modifications, Dock Head 4 construction, and screeding. The filling of the work area at the West Dock with granular fill would result in a permanent loss of about 149 acres of EFH. EFH would also be temporarily affected by the construction of a barge bridge, ballasted to the sea floor, which would be in place during the open-water seasons to offload materials during the six summer sealift seasons (two pre-construction and four construction sealifts). The potential impact on Pacific salmon includes a loss of migration habitat and possibly marine rearing habitat for juvenile pink and chum salmon. The potential impact on arctic cod EFH includes a loss of summer feeding and rearing habitat. The magnitude of these impacts would likely be minor due to the relative abundance of similar habitat along the Beaufort Sea coastline.

In Cook Inlet, permanent losses of Pacific salmon (i.e., Chinook, chum, coho, pink, and sockeye) EFH would be associated with laying the Mainline Pipeline across the seafloor and construction of the PLF, Mainline MOF, and Marine Terminal MOF. Permanent habitat loss would total about 355 acres. Temporary habitat losses would occur as a result of construction of the Mainline Pipeline, Marine Terminal MOF, and dredging (through both dredging and dredged sediment disposal, including maintenance dredging). Temporary habitat losses would total about 6,351 acres of seafloor. Pacific salmon in Upper Cook Inlet primarily use these habitats for migration to and from spawning streams and rivers (Moulton, 1997). Juvenile salmon densities tend to be higher on the north side of the inlet than the south side. Juveniles move relatively quickly out of Cook Inlet once they enter the marine environment, likely because of the highly turbid conditions and low productivity that is characteristic of Upper Cook Inlet (Moulton, 1997). As a result, the loss of some Pacific salmon EFH in Cook Inlet is expected to be minor.

Shading of the seabed would occur from the addition of Dock Head 4 at the West Dock Causeway in Prudhoe Bay and of the Mainline MOF and Marine Terminal PLF and MOF in Cook Inlet. Shading caused by temporary structures could cause fish to avoid areas, but permanent structures could have a more substantial effect on fish use of an area. Shading could cause changes to prey abundance at the site and disrupt fish migratory behavior (Ono et al., 2010). Pacific salmon would be less likely to use the habitat under these over-water structures (Ono et al., 2010). An assessment of over 60 studies by Simenstad et al. (1999) found evidence that juvenile salmon react to shadows and other artifacts in the shoreline environment created by over-water structures. Because juvenile salmon (especially Chinook salmon) tend to migrate through shallow-water habitats along shorelines, over-water structures can impact migration. Simenstad et al. (1999) found that juvenile salmon use both natural refuge and shaded areas as refuge, but generally migrate along the edges of these areas rather than entering them. In response to predators, however, they will seek refuge within shaded areas. Upon encountering over-water structures, juvenile salmon could exhibit behavioral changes, including splitting into smaller schools and seeking alternate pathways, which could cause a delay in migration (Simenstad et al., 1999).

Shading generated by Project construction of over-water structures would likely cause changes in salmon behavior near the structures for multiple seasons. These effects would not have a significant impact on salmon communities during construction because they would be localized and the structures would be removed after a few years.

Artificial lighting used during construction could affect marine EFH in the Beaufort Sea and in Cook Inlet. Sources of artificial light that could affect Pacific salmon or arctic cod during construction include lighting on docks, anchored marine barges, and vessels, and facility lighting. Lighting is used to illuminate working areas, including areas over and within water (e.g., screeding and pile driving), and for security purposes. Construction work on the offshore component of the Mainline Pipeline across Cook Inlet would require lighting mounted on vessels used for work. Lighted markers (e.g., buoys) would be used as well as shoreline lighting to support nearshore work.

The response of fish to artificial lighting can be quite variable depending on a number of factors. Specific responses of fish to light seem dependent on the light intensity and the species and age-class of the fish (Hoar et al., 1957). Schools of juvenile chum salmon show a marked preference for light while juvenile sockeye retreat to darker areas. Juvenile coho are indifferent to light of moderately high intensities but become inactive in low light. While the responses of fish to light are sometimes based on innate behaviors, in other cases, these responses may be based on the presence of prey items. For example, artificial lighting is documented to decrease the daily vertical migration of zooplankton that come to the surface to feed on algae under the cover of darkness, while other invertebrates congregate under light sources (McConnell et al., 2010).

4.2.1.2 Water Quality

Potential water quality impacts on marine EFH in Cook Inlet and the Beaufort Sea include increased turbidity and suspended sediment, water discharges, and release of contaminants such as fuel and lubricants.

Screeding and pile driving at West Dock would cause increased turbidity and sedimentation in the surrounding area. Sediments in Prudhoe Bay are typically fine grained and are likely to remain suspended for longer, allowing them to travel further from their source once disturbed. Increased suspended sediments can clog fish gills and make it more difficult for predator species to find prey and for prey species to avoid predators. Small juvenile fish are more susceptible to clogged gills than larger adult fish, and since suspended sediments can reduce the amount of dissolved oxygen in the water, the reduced efficiency of clogged gills can lead to greater mortality rates (Wenger et al., 2017).

Screeding can release contaminated sediments from the seabed, which could have toxic effects on EFH species rearing or migrating in the area. The effects of contamination on EFH species would depend on the amount of exposure a fish has; thus, impacts would be more likely for juvenile arctic cod rearing and feeding in nearshore areas than for pink salmon, which would likely only migrate through the area. AGDC collected sediment samples in 2014 from five locations in Prudhoe Bay near West Dock,[5] and analyzed each sample for physical and chemical parameters. Metal concentrations were found to be below both the Seattle Dredged Material Management Program (DMMP) (U.S. Army Corps of Engineers [COE], 2016) screening levels and ADEC-recommended permissible exposure limits, as well as within the range of background sediment concentrations for the Beaufort Sea coastal area. Arsenic, copper, and nickel concentrations in some samples exceeded their marine threshold effects levels, but Beaufort Sea sediments are naturally high in these three metals and the observed concentrations were well within the established range for background.

No evidence of petroleum contamination was observed in the samples; concentrations of both diesel-range organics and residual range organics in all samples were found to be below ADEC-recommended soil cleanup levels for the Arctic. Overall, concentrations of petroleum hydrocarbons in the sediment samples were found to be low and well within the range of natural background levels. Petroleum hydrocarbon concentrations were well below DMMP guidance and sediment quality guideline levels, and showed no evidence of anthropogenic inputs or contamination. Very low levels of pesticides were observed in some samples, but generally, there was no indication of contamination from chlorinated pesticides or polychlorinated biphenyls of the test trench sediments. These data support other recent findings that the West Dock area of Prudhoe Bay is generally free of contamination with metals or hydrocarbons (Oasis Environmental Inc., 2006; Trefry, 2003). The results indicate that the potential impacts on arctic cod and Pacific salmon EFH in Prudhoe Bay related to the release of contaminated sediments from the seabed during project related disturbances are likely to be minor.

While the majority of the Mainline Pipeline in Cook Inlet would be laid directly on the seafloor, the pipe would be trenched in at the shoreline. For the shore approaches, the Mainline Pipeline would be buried from the shoreline out to a depth such that the top of the pipe is sufficiently protected from major hazards. This depth is expected to be from about -35 to -45 feet mean lower low water. Trenching activities would increase turbidity and suspended sediment in the local area. Similarly, dredging and pile driving in the area of the Liquefaction Facilities are anticipated to temporarily increase turbidity locally. Upper Cook Inlet experiences some of the most extreme tides in the world (Moulton, 1997). Tidal cycles create significant turbulence and vertical mixing of the water column in the inlet (COE, 2013), and are reversing, meaning that they are marked by a period of slack tide followed by an acceleration in the opposite direction. This, combined with the high inputs of glacial silt from surrounding rivers, means that Upper Cook Inlet has high natural turbidity, as well as high flushing rates. These factors would limit the potential effects of high turbidity due to construction on Pacific salmon EFH in Cook Inlet.

Dredging in Cook Inlet could release contaminants into the water column. Examination of sediment samples collected in Cook Inlet sites in the general area of the Liquefaction Facilities indicates that dredged sediments are not anticipated to contain significant levels of contaminants. The sediments were generally found to contain metal concentrations at or near regional background levels. All samples

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[5] AGDC's 2014 *Marine Sampling Program: Evaluation of Test Trench Dredging and Disposal Reuse* was included as appendix R2 of Resource Report 2 (Accession No. 20170417-5357). This document can be viewed on the FERC website at http://www.ferc.gov. Using the "eLibrary" link, select "Advanced Search" from the eLibrary menu and enter 20170417-5357 in the "Numbers: Accession Number" field.

were below screening level guidelines established for the Seattle DMMP (COE, 2016), which is used by the Environmental Protection Agency and COE to evaluate dredged material in Alaska in lieu of an Alaska-specific program. Most samples were also below ADEC's recommended sediment quality guidelines. Several metals (nickel, copper, chromium, arsenic) exceeded threshold levels, but were below permissible exposure limits and within the range of background concentrations. Release of contaminants during dredging is not expected to result in negative impacts on Pacific salmon EFH in Cook Inlet because Pacific salmon mainly use Cook Inlet as migratory habitat, and are therefore less likely to come into contact with any contaminants.

Pacific salmon EFH in Cook Inlet could be affected by sedimentation from dredged material disposal in Cook Inlet (see figure 2.1.5-7 of the EIS for disposal locations). AGDC evaluated the impacts of the Marine Terminal MOF construction dredging and disposal over four seasons on sedimentation and water quality using both near-field and far-field sediment transport modeling.[6] Based on all cases simulated, the maximum modeled sedimentation thickness was about 3.3 inches, which would cover no more than 0.2 square mile. Disposal of dredged sediments would cause a localized, short-term increase in turbidity and sedimentation near the disposal site for the duration of disposal activities. Currents would then be expected to rapidly entrain and remobilize any sediments deposited. Adult Pacific salmon could be temporarily displaced from the disposal area, but these impacts would be minor.

About 42 million gallons of hydrostatic test water for the Liquefaction Facilities would be withdrawn from Cook Inlet or the City of Kenai water supply. Hydrostatic test water would be discharged to Cook Inlet. Hydrostatic testing for the marine portion of Cook Inlet is planned to occur during the summer; therefore, AGDC does not propose to use test-water additives. The volume of Cook Inlet varies from about 270 trillion to 244 trillion gallons during high and low tides, respectively. Any effects on fisheries from hydrostatic test water withdrawals or discharges (such as changes in water depth, salinity, or temperature) would be minor and short term because Cook Inlet is a large waterbody with considerable tidal fluctuation and mixing, which would dilute any changes to a negligible level. In addition, discharges of hydrostatic test water would comply with state permits (e.g., the Alaska Pollutant Discharge Elimination System by ADEC) and are not expected to affect marine EFH.

Spills of fuel and other hazardous substances could occur from vessels or from shore-based construction and operation. Similar to freshwater, releases of hydrocarbons and other deleterious substances could result in decreased water quality in the vicinity of the spill, and could lead to decreased productivity, lethal, and sub-lethal effects on EFH species. The effect of spilled substances on EFH and EFH species is dependent on the size of the spill. Spills of fuels or lubricants can be expected to have a negative effect on fish and fish habitat in close proximity to the spill, and the extent of the impact would be dependent on how far the spill spreads, as well as how it reacts with air, water, and substrates. Exposure of EFH species would depend on the season and spill location. In Cook Inlet, Pacific salmon migrate fairly quickly through the inlet from spring through fall and are unlikely to spend time in any one spot (Moulton, 1997). In the Beaufort Sea, arctic cod distribution varies with the season and inter-annual variation in habitat use could mean that exposure to a spill could be very limited or very extensive (Moulton and Tarbox, 1987; Gallaway et al., 2017).

4.2.1.3 Lethal and Sub-lethal Effects

Construction of the marine infrastructure in Cook Inlet and the Beaufort Sea is expected to occur during the summer months when waterbodies are free of ice. Marine fish, such as arctic cod, often congregate near the sea ice edge for foraging (ADF&G, 2015). Construction activities in Cook Inlet would

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[6] AGDC's *Sediment Modeling Study Material – Offloading Facility Construction* was included in Information Request No. 118 (Accession No. 20180611-5159). This document can be viewed on the FERC website at http://www.ferc.gov. Using the "eLibrary" link, select "Advanced Search" from the eLibrary menu and enter 20180611-5159 in the "Numbers: Accession Number" field.

not occur when there is ice cover; therefore minimizing impacts on foraging EFH species. However, summer construction conflicts with habitat use by EFH species (e.g., summer arctic cod rearing in the Beaufort Sea, and juvenile and adult Pacific salmon migration in Cook Inlet and along the Arctic coast). Similar activities occur throughout Cook Inlet and Prudhoe Bay during the summer, and additional construction activities could have a cumulative impact on Pacific salmon EFH. Potential impacts could include habitat avoidance and reduced feeding efficiency due to noise and increased turbidity.

Water would be withdrawn from Cook Inlet for hydrostatic testing of the Mainline Pipeline and LNG tanks at the Liquefaction Facilities during construction. Water withdrawal activities could lethally affect juvenile Pacific salmon by drawing them into intake pipes or onto screens. Juvenile salmon mortality can be avoided by selecting screens with a mesh size that excludes juvenile fish, and a pump that limits suction so that fish accidentally drawn toward the intake are able to swim away.

Underwater noise in EFH would be generated by pile driving and vessel traffic in Prudhoe Bay and Cook Inlet, trench excavation for Mainline Pipeline installation in Cook Inlet, screeding in Prudhoe Bay, and dredging in Cook Inlet. Dock Head 4 construction in Prudhoe Bay would require installation of piles (sheet piling), most of which would be placed using an impact hammer in summer, as well as four dolphins required for affixing the temporary barge bridge across the causeway. Impact and vibratory pile driving would occur for Mainline MOF construction in Cook Inlet. Impact pile driving would also occur for construction of the Marine Terminal MOF and PLF in Cook Inlet.

Noise effects on fish can include behavioral responses, masking, physiological stress responses, hearing loss, injury, and mortality. Percussive effects from activities such as pile driving can damage fish swim bladders and cause temporary or permanent injury. There is evidence that pile driving causes increased acute stress responses with repeated exposures, reducing the overall fitness of exposed fish (Debusschere et al., 2016). Pile driving has been shown to have lethal and sub-lethal effects on nearby fish through barotrauma and noise (Popper and Hastings, 2009; Kolden and Aimone-Martin, 2013).

Direct Project impacts would include potential mortality/injury to migrating juvenile and adult fish near the noise-generating activities. The impacts of sound on marine fish species can be pathological, physiological, and/or behavioral. Pathological effects include physical damage to fish, physiological effects include stress responses, and behavioral effects include changes in fish behavior. Pacific salmon juveniles and adults migrating through the area could be exposed to unnatural sounds; however, they would likely avoid the ensonified area. Dock Head 4 piles and sheet piles would be installed in summer, when arctic cod and Pacific salmon would be in shallower waters along the coast and in estuaries. Pile driving at the Marine Terminal would occur between April and August, and would overlap with juvenile and adult Pacific salmon migrations in Cook Inlet.

Underwater noise effects criteria for fish have been established by the Fisheries Hydroacoustic Working Group. Appendix L-1 of the EIS provides calculations of noise impacts on fish from various Project construction activities. As shown in this appendix, dredging activities in Cook Inlet and screeding activities in Prudhoe Bay would be unlikely to cause noise disturbances to fish. Impact and vibratory pile driving generate sound that would cause behavioral effects and injury to fish. The Project proposes to drive piles with vibratory and/or impact hammers. Pile driving activities in Prudhoe Bay could cause injury to fish at distances from 0 to 159 feet from the pile, and behavioral effects at distances from 2 feet to 2.3 miles. Pile driving activities in Cook Inlet could cause injury to fish at the source and up to 446 feet from the pile, and behavioral effects at distances from 33 feet to 13.4 miles. Pile-driving techniques have been shown to cause serious injury to nearby fish, including damaged swim bladders, barotrauma, and temporary hearing loss (Wenger et al., 2017; Popper and Hastings, 2009; Halvorsen et al., 2012). Fish are most likely to experience behavioral effects, such as moving away from the source of the noise, and experiencing a reduced ability to find prey or avoid predators due to masking of natural sounds (Dickerson et al., 2001).

Impacts from pile placement (impact and vibratory hammers) would be intermittent and short term, and would therefore not be expected to cause serious or long-term impacts on EFH species.

Noise related to vessels travelling to and from the Liquefaction Facilities and GTP is the only impact on most EFH and EFH species outside Prudhoe Bay and Cook Inlet. Sound generated by vessels could have negative impacts on fish similar to those described for pile driving. Fish have been shown to react when engine and propeller sounds exceed a certain level (Ona and Godø, 1990; Slabbekoorn et al., 2010). Avoidance reactions have been observed in fish such as cod and herring when vessel sound levels range from 110 to 130 decibels (dB) (Ona and Toresen, 1988; Ona and Godø, 1990). Others have found that fish may be attracted to stationary vessels (silent, engines running, and in dynamic-positioning) and vessels underway (Røstad et al., 2006). Any avoidance reactions would likely last only minutes longer than the vessel is at a particular location as it transits through, and would be limited to a relatively small area.

Transiting Project vessels and sound from anchor handling during the Mainline Pipeline pipelay across Cook Inlet could affect EFH species. Noise from anchor handling could cause behavioral effects on fish within 277 feet of the activity. When activated, in-hull bow thrusters produce large bursts of cavitation sound. Fish exposed to unnatural sounds would be expected to avoid the area of active pipelay. Vessels in transit would likely cause behavioral disturbance to fish in the area. This would not be expected to cause a significant impact on fish in Cook Inlet because the area is mostly a transition zone to other river locations and the sounds would be similar to existing sounds in Cook Inlet. Transiting vessels would have minor impacts since the disturbance to fish would only occur temporarily near the ship. We note there are other vessels that routinely transit Cook Inlet, so fish may already be acclimated to short-term noise disturbances from vessels. Cook Inlet is a relatively industrialized area in Alaska, subject to routine sound-generating activities such as dredging, gas and oil drilling, marine seismic surveys, pile driving, and vessel traffic (as reviewed in Norman [2011]). In Cook Inlet, the lowest ambient sound levels measured away from industrial areas averaged 95 dB relative to 1 microPascal (re 1 µPa), and reached as high as 124 dB re 1 µPa north of Point Possession during the incoming high tide (Blackwell and Greene, 2003). The highest noise levels measured were from a tug docking a gravel barge and were 149 dB re 1 µPa (Blackwell and Green 2003).

4.2.2 Operation

The main potential impacts on marine EFH during the operational phase of the Project include:

- habitat loss and alteration resulting from maintenance dredging operation;
- water quality impacts due to accidental spills or releases of deleterious substances (e.g., fuel and lubricants) or intentional releases of water from vessel ballast; and
- lethal and sub-lethal effects resulting from maintenance dredging and from water intakes.

4.2.2.1 Habitat Loss and Alteration

No disturbance of marine EFH is anticipated during operation of the Gas Treatment Facilities. Materials, supplies, and personnel would use ground or air transportation; no vessels would be used during operation and the barge bridge would not be used by AGDC. Shading of the seabed from permanent structures such as the Mainline MOF and Marine Terminal PLF in Cook Inlet would be similar as described above for construction facilities (see section 4.2.1.1). These permanent structures could make the area less preferable for salmon, which could avoid the area due to the change in prey composition and behavioral avoidance of the shaded areas.

Facility lighting would consist of normal and essential lighting panels and lighting fixtures to provide lighting for working areas and for security requirements at the Marine Terminal and PLF. During operation of the Marine Terminal, LNG carriers would be docked at the PLF for about 24 hours. While LNG carriers are docked at the PLF, over-water lighting would be required on the docking facilities during the evening and during low-light conditions, and could be required during daytime hours. Operational lighting impacts on marine EFH in Cook Inlet would be similar to construction lighting impacts described in section 4.2.1.1, but would occur year-round for the life of the Project.

LNG carriers calling at the Liquefaction Facilities during operation could act as vectors for transmission of aquatic invasive organisms from ballast water and hull fouling. Potential impacts on marine EFH include competition with native species, alteration of physical habitat (e.g., hardening of substrates caused by invasive bivalves), and introduction of pathogens (Bax et al., 2003).

4.2.2.2 Water Quality

Marine EFH could be affected by spills and leaks of fuel and other deleterious substances from fuel storage tanks at the Gas Treatment Facilities, from LNG carrier vessels, and fuel and chemical storage facilities at the Liquefaction Facilities. The increase in vessel traffic would result in an increased risk of spills in marine fish habitats. Vessels associated with Liquefaction Facilities operation would include LNG carriers and up to five assist tugs that would be used for docking and undocking, vessel escorts, ice management, and firefighting. LNG carriers would call at the Liquefaction Facilities year-round, 204 to 360 times per year depending on capacity. LNG carriers could therefore potentially add 204 to 360 port calls per year to vessel traffic in Cook Inlet. Project LNG carrier traffic could therefore potentially result in a 42- to 74-percent increase in large ship traffic in Cook Inlet during operation.

As described in section 4.3.3.3 of the EIS, accidental gas releases from the Mainline Pipeline are not anticipated. However, during operation, the pipeline would follow industry standards for safety and pipeline monitoring, as detailed in sections 2.5.2.1 and 4.18 of the EIS, that would minimize the duration of an accidental release and result in a brief and localized impact on marine waters.

During Liquefaction Facilities operation, water intake for cooling on LNG carriers would affect ichthyoplankton in Cook Inlet. About 8 million gallons of seawater would be withdrawn from Cook Inlet per LNG carrier. A study by Moulton (1997) found that ichthyoplankton and surface insects peaked in early July and decreased thereafter. The study found that the most abundant larval fish caught in tow-net samples taken during one season of sampling in Upper Cook Inlet were (in descending abundance) threespine stickleback (*Gasterosteus aculeatus*), Pacific herring, pink salmon, eulachon, and chum salmon. Impingement and entrainment of ichthyoplankton of EFH species by LNG carriers from cooling water intake would not be expected to contribute to population level declines in EFH species.

In addition to intake water, 2.9 billion to 3.2 billion gallons per year of ballast water collected from international waters would be discharged into Cook Inlet. Based on LNG carrier design, a significant difference in temperature between ballast water and ambient waters of Cook Inlet is not anticipated (see section 4.3.3.3 of the EIS for additional details). Ichthyoplankton entrained in the discharge plumes could experience mortality due to the stress associated with pressure changes (Barker et al., 1981; Johnson et al., 2008).

4.2.2.3 Lethal and Sub-lethal Effects

Noise impacts on marine EFH from vessels in Cook Inlet would be similar to those described for construction (see section 4.2.1.3). LNG carriers would transit through Cook Inlet to the Marine Terminal year-round. Sound from routine Marine Terminal operation would be associated with LNG carrier operation, including hoteling, maneuvering, and tug vessels when moored to the Marine Terminal. Sound generated by LNG carriers could have negative direct impacts on fish; calculated and modeled sound levels for these activities are between 170 and 185 dB at the source (McKenna et al., 2012; McCrodan and Hannay, 2013). As discussed above, potential impacts of sound exposure on fish could include death or injury, including physical damage, physiological stress responses, and behavioral responses such as startle response, alarm response, or avoidance.

Because fish are mobile organisms, only behavioral effects would be expected to occur during Project operation. The effects of noise on marine EFH would likely be greatest during periods of migration for juvenile and adult Pacific salmon transiting to and from spawning streams along the south shore of Cook Inlet. Due to the noise generated by the LNG carriers and supporting tugs visiting the Marine Terminal, behavioral noise effects on fish would be expected to occur within about 328 feet around the Marine Terminal, making this habitat less preferable for some fish for the life of the Project (McCrodan and Hannay, 2013).

Water would be withdrawn and discharged from and to Cook Inlet for LNG carrier cooling water. Cooling intake by LNG carriers at the Marine Terminal is estimated to remove 13.3 million gallons of water from Cook Inlet per vessel over a 24-hour period. Ballast water would be discharged from the LNG carriers as they take on LNG at the Marine Terminal. 2.9 billion to 3.2 billion gallons per year of ballast water collected from international waters would be discharged into Cook Inlet.

For water withdrawals, juvenile salmon could become entrained or entrapped within the pumping system or become impinged on the intake structure at the point of withdrawal. LNG carrier intakes are usually screened to reduce impingement and entrainment of fish. The estimated velocity at the opening of the intake is typically less than 0.5 foot per second. Typically, screening of the intakes would prevent large fish from becoming entrained, but would not prevent juvenile fish from becoming entrained in the pumps or intakes. In the summer, pink and chum salmon juveniles would be in Cook Inlet and could be passively transported via rip currents. If pink and chum salmon swam too close to a passing LNG carrier's water intake, or if rip currents transported them into an LNG carrier's water intake, these fish could also be impinged or entrained. Most juvenile salmon in Cook Inlet are found in shallower nearshore areas, however, and the LNG carriers would dock in natural water depths greater than -53 feet mean lower low water and would be about 3,300 feet from shore. The potential impacts of impingement and entrainment are expected to be limited to a small area around the intake pipes, and would not be expected to have a significant impact on Pacific salmon EFH in Cook Inlet.

5.0 CONSERVATION MEASURES

Several management plans have been developed by AGDC that include best management practices (BMPs) to minimize Project impacts on EFH:

- Project Upland Erosion Control, Revegetation, and Maintenance Plan (Project Plan);
- Project Procedures;
- Revegetation Plan;
- Blasting Plan;
- Fugitive Dust Control Plan;
- Gravel Sourcing Plan and Reclamation Measures;
- DMT Inadvertent Release Plan;
- Site-Specific Waterbody Crossing Plans;
- Spill Prevention, Control, and Countermeasures Plan (SPCC Plan);
- Stormwater Pollution Prevention Plan (SWPPP);
- Waste Management Plan;
- Water Use Plan; and
- Noxious/Invasive Plant and Animal Control Plan.

The following sections describe the specific management and mitigation measures that would be implemented to avoid, reduce, or offset the potential impacts of the Project on EFH.

5.1 FRESHWATER ESSENTIAL FISH HABITAT

Mitigation measures that AGDC would implement to reduce the effects on freshwater EFH during construction and operation include:

- avoiding in-stream activities during sensitive life stage periods for Pacific salmon;
- implementing water withdrawal restrictions and guidelines;
- controlling pipeline temperature;
- following the Project Plan, Procedures, and Revegetation Plan;
- implementing appropriate culvert design; and
- adopting the Alaska Blasting Standards (Timothy, 2013).

The primary mitigation measure to avoid direct mortality in EFH streams would be the timing of construction. FERC has recommended that AGDC develop a Fisheries Conservation Plan that includes the following measures to minimize impacts on EFH.

- Avoid in-stream construction in the winter (i.e., when frozen conditions limit stream flow) in waterbodies with known overwintering habitat (as listed in tables 4.1-1 and 4.1-2).[7]

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[7] Streams that have overwintering habitat present would be crossed in summer. Tables do not reflect this change to crossing method.

- Conduct in-stream construction in the timeframes provided by the ADF&G, as listed below, in waterbodies listed as AWC, including EFH, or with known populations of Chinook, sockeye, coho, pink, and/or chum salmon:
    - Interior Region
        - Middle Fork Koyukuk River/South Fork Koyukuk River/Prospect Creek/Jim River drainages: May 15 to July 10
        - Yukon River to Nenana: May 15 to July 10
        - Nenana River drainage: May 15 to October 1
    - South-Central Region
        - Coho/Chinook/Sockeye
            - Lower Susitna Drainage: May 15 to July 15
            - Upper Chulitna Drainage: May 30 to July 30
        - Pink/Chum only
            - Wherever found: May 1 to July 30
        - Resident Fish
            - rainbow trout (*Oncorhynchus mykiss*) spawning present: avoid May through August, if possible
            - no suitable spawning habitat present and no uniquely high value overwintering habitat: December 1 to February 15 (contingent on water and/or water quality suitable for fish)
- Avoid extraction in material sites within or near waterbodies listed as AWC, including EFH, during sensitive spawning time periods, as determined in consultation with the ADF&G (see table 4.1.1-2).

In addition, FERC has recommended that AGDC develop measures in consultation with the U.S. Fish and Wildlife Service and the ADF&G to minimize long-term impacts from material sites south of the Brooks Range that are hydrologically connected to streams with EFH. Measures would include creating ponded areas after restoring the material sites to create overwintering fish habitat.

FERC has also recommended that AGDC include the following measures in the Fisheries Conservation Plan to minimize impacts on fish resources, including EFH, during water withdrawals (see table 4.1.1-3):

- withdraw no more than 20 percent of current flow rates in waterbodies listed as AWC, including EFH, or with known populations of Chinook, sockeye, coho, pink, and/or chum salmon, to reduce the risk of low water levels and downstream impacts;

- do not exceed 0.5-foot-per-second water withdrawal velocities at the operating pump intake in waterbodies listed as AWC, including EFH, or with known populations of Chinook, sockeye, coho, pink, and/or chum salmon, if water withdrawals would occur when sensitive fish fry and/or juveniles would be in-stream;

- raise water withdrawal pump intakes from the stream bed to avoid the entrainment of eggs or fry from the gravel bed; and

- use screen openings on all water withdrawal equipment of 0.25 inch (0.1 inch or less in areas with sensitive life stages, e.g., pink and chum salmon fry, whitefish fry, and arctic grayling [*Thymallus arcticus*] fry) to reduce the risk of impingement of small or juvenile fish.

FERC has recommended AGDC complete fish surveys at waterbodies where fish survey data are not available. Surveys would identify waterbodies with Pacific salmon so the above conservation measures could be implemented to minimize impacts on these EFH species.

To prevent thaw settlement of the Mainline Pipeline in the continuous permafrost region, and to limit changes in sediment and stream temperature surrounding the pipelines, AGDC would maintain the pipeline temperature at varying temperatures to minimize impacts on permafrost. AGDC would implement several measures to prevent and monitor frost bulb obstructions, including conducting investigations along the Mainline Pipeline to determine areas susceptible to frost bulb formation and ensuring adequate burial depth of the pipeline at those locations to minimize impacts on waterbodies. At trenched crossings, the pipeline would be buried 5 feet below the streambed and concrete coated, minimizing any potential temperature effects on the stream water.

To reduce the potential for erosion after the design grade is obtained, AGDC would stabilize cut slopes immediately, and streambanks would be restored according to the Project Plan, Procedures, and Revegetation Plan. To protect streambanks and beds from scour erosion, AGDC would implement site-specific BMPs based on scour and erosion potential at each site. In addition, AGDC would collaborate with ADF&G to apply appropriate in-stream bank erosion structures to provide post-construction bank stability and reduce erosion. AGDC would conduct routine inspections to identify areas of erosion, exposed pipeline, and nearby construction activities to allow for early identification of bank stability problems and minimize the potential for continuing environmental effects during pipeline operations.

AGDC would install appropriately sized culverts within access roads to allow surface flow and maintain the hydrologic characteristics of adjacent wetlands. In addition, granular fill work pads would be contoured to allow natural drainage and hydrologic connectivity. We have recommended that AGDC develop a culvert design plan as part of its Fisheries Conservation Plan (see section 4.7.1.6 of the EIS). This plan would follow the guidance in Anadromous Salmonid Passage Facility Design (NMFS, 2011) for design of culverts and bridges and mitigation of impacts on fish passage in all fish bearing streams, including EFH waterbodies (see table 4.1-2). The Fisheries Conservation Plan would also include plans for permanent maintenance of culverts and bridges.

To limit the impact of hydrostatic testing on water quality in EFH waterbodies, AGDC would discharge hydrostatic test water to upland or wetland areas through erosion control devices to reduce the potential for scour, erosion, and sedimentation into nearby waterbodies in accordance with the Project Procedures and the APDES permit requirements. Except as discussed below, hydrostatic testing is planned to occur in the summer using water without additives. Hydrostatic testing on the North Slope could occur year-round and, if completed in the winter, would require non-toxic additives to prevent the test water from freezing. Test water for the Gas Treatment Facilities, with the exception of the PTTL, would be discharged to the underground injection control (UIC) wells, which would avoid impacts on surface waters. The water used to hydrostatically test the PTTL would be discharged into uplands and wetlands in accordance with applicable federal and state permit requirements.

In the event of an inadvertent release of drilling fluid during DMT operations at EFH waterbodies, AGDC would implement the corrective action and cleanup measures outlined in its DMT Inadvertent Release Contingency Plan to minimize potential impacts on fish resources. This could include the installation of berms, silt fences, and/or hay bales to prevent silt-laden water from flowing into EFH, or in the event of an in-water release, the use of temporary dams to isolate the drilling fluid and vacuum trucks to remove the released drilling fluid.

In 2013, ADF&G adopted revised blasting standards to be applied to projects where the impacts of blasting on fish and embryos in fish-bearing waterbodies cannot be avoided or mitigated (Timothy, 2013). AGDC has committed to implementing the Alaska Blasting Standards (Timothy, 2013).

The Project Blasting Plan does not include measures to monitor and prevent stream flow changes as a result of blasting prior to completion of in-stream construction activities. Blasting could alter stream flow by changing the stream morphology by redirecting flow out of the existing channel affecting fish-bearing streams. Therefore, we have recommended AGDC file an updated Project Blasting Plan with the following requirements for all fish-bearing streams where blasting would occur:

- monitoring protocol of stream flow after blasting and prior to completion of in-stream activities;

- contingency measures to remediate loss of stream flow caused by fracturing the rock or permafrost from blasting; and

- timeframe to implement the contingency measures.

All fuel and hazardous material handling needed for Project operation would be in accordance with ADEC requirements and the Project SPCC Plan, minimizing the risk of spills reaching waterbodies where EFH is present.

5.2 MARINE ESSENTIAL FISH HABITAT

Mitigation measures that AGDC would implemented to reduce effects on marine EFH during construction and operation include:

- maintaining fish passage at the barge bridge on West Dock;

- directing lighting, timers, and motion sensors to minimize stray light and avoid unnecessary lighting at times of non-use;

- adhering to ballast water regulations;

- implementing spill response plans; and

- using fish screens for water withdrawals from Cook Inlet.

The placement of the barge bridge ballasted to the seafloor at West Dock in Prudhoe Bay could affect arctic cod EFH, as well as migration and rearing habitat for pink and chum salmon. AGDC would maintain migration pathways by creating open areas between the barges to facilitate fish movement. The barge bridges would only be in place during the open-water season, and would be removed prior to the onset of ice in the fall to limit the impact on EFH.

During the crossing of Cook Inlet, the majority of the Mainline Pipeline would be laid on the seafloor bottom and would not be trenched in. For the shoreline approaches, however, the Mainline Pipeline would be trenched in, causing increased turbidity. To reduce impacts, we have recommended that AGDC incorporate the use of the DMT continuation methodology for the shoreline crossings at Beluga Landing and Suneva Lake, or provide a site-specific justification demonstrating that this methodology is not feasible (see section 4.3.3.3 of the EIS). This construction method would avoid disturbing EFH habitat in shallower nearshore areas where Pacific salmon are typically found in Cook Inlet. Use of the DMT method at the shorelines would eliminate turbidity increases, but there could be a risk of an inadvertent return of drilling fluid. The temporary and localized increase in turbidity from a potential inadvertent return in marine waters would not likely have a significant impact on EFH due to the high rate of exchange in Cook Inlet.

As described in the Project Lighting Plan, to avoid and minimize lighting effects during construction, lights would be shielded and directed as needed to illuminate the work areas and meet safety requirements, but to avoid extending off site unnecessarily. Safety, security, and maintenance of the construction schedule would be AGDC's primary considerations for construction lighting. Lighting used at permanent facilities and during construction activities could affect fish behaviors, but due to the limited areas of lighting that would be used, and the proposed measures to reduce light from spreading to off-site areas, significant impacts are not expected on EFH.

Invasive aquatic organisms on or in LNG carriers would be minimized by adhering to existing ballast water regulations. All vessels brought into the state of Alaska or federal waters would be subject to U.S. Coast Guard regulations (33 CFR 151, subpart D and 46 CFR 162.060 on *Standards for Living Organisms in Ships' Ballast Water Discharged in U.S. Waters; Final Rule* [77 Federal Register (FR) 17254 (Mar. 23, 2012)] and *Navigation and Vessel Inspection Circular* 01-18), which are intended to reduce the transfer of aquatic invasive organisms. AGDC does not have the authority or control over independent vessels that would be used for Project construction and operation. However, the LNG carriers and marine barges would be commercial maritime vessels obligated to meet the requirements of the Coast Guard and EPA VGP[8] regulations (for additional details, see section 4.3.3.3 of the EIS and the Project Ballast Water Management Plan). In addition to these federal requirements, vessels calling on Alaska ports must also comply with state ballast water exchange rules and laws (see section 4.3.3.3 of the EIS). AGDC would require that visiting vessels possess documentation to demonstrate compliance with ballast water regulations before allowing any ballast water to be discharged into the Project's berthing areas. Habitat loss and alteration due to erosion and sedimentation along the Cook Inlet shoreline would be mitigated through shoreline armoring in critical locations around the Marine Terminal. AGDC would mitigate and control runoff from the Liquefaction Facilities and associated roads and onshore infrastructure using the measures described in the Project Plan, Procedures, and Revegetation Plan.

AGDC would ensure that all contractors comply with the Project SPCC Plan and SWPPP, which would reduce the likelihood of spills in the marine environment and potential impacts on marine EFH. Oil spill response plans would be available for vessel groundings or other accidental releases of oil. Potential impacts on marine EFH would also be avoided through AGDC's compliance with ADEC water quality permitting regulations. In addition, LNG carriers are required to develop and implement a Shipboard Oil Pollution Emergency Plan, which includes measures to be taken when an oil pollution incident has occurred or is at risk of occurring.

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[8] General Permit for Discharges Incidental to the Normal Operation of Vessels

Lethal and sub-lethal effects on fish in marine EFH in the Beaufort Sea and Cook Inlet could result from entrainment or impingement in water pumps, barotrauma, and other sub-lethal effects from pile driving and blasting, direct mortality during dredging and trenching activities, uptake of ballast and cooling waters by LNG carriers, and vessel noise. To decrease the potential for entrainment and impingement of marine life during construction water withdrawals in Cook Inlet, AGDC stated it would screen its intake hoses with 0.25-inch mesh and place the screened intake in a water column deep enough to ensure adequate suction head at low tides, but well above the seafloor. Fish screens would be used to prevent entrainment of adult fish from LNG carriers; cooling water intakes would be screened with 4.5-millimeter bars spaced every 25 millimeters.

Construction of the marine infrastructure in Cook Inlet and the Beaufort Sea is expected to occur when EFH species are present, but AGDC would employ soft start/ramp-up procedures for pile driving, which would allow fish to leave the area before maximum sound energy is produced. Some sheet piles could also be driven, at least partially, with a vibratory hammer before switching to an impact hammer to minimize potential noise impacts.

6.0 EFFECTS DETERMINATION SUMMARY

Construction of the Mainline Pipeline, the PTTL, and their associated infrastructure could affect EFH for Pacific salmon in 191 waterbody locations (including Mainline Pipeline crossings, riverine wetland crossings, and water withdrawal locations). Potential impacts include permanent and temporary habitat loss, decreased water quality, and lethal and sub-lethal effects from construction and operation.

Permanent and temporary habitat loss or alteration could result from the construction of pipeline crossings, especially those that use open-cut or frozen cut methods. Substrate disturbance could affect local habitat and result in decreased habitat quality. Flow diversions would maintain adequate flow rates to downstream areas, and would minimize sediment transport. Habitat usage could be temporarily interrupted during construction. Compliance with the Project Plan, Procedures, and Fisheries Conservation Plan are anticipated to limit the potential impacts of erosion on in-stream habitat.

Culverts and bridges would be installed on access roads, but with implementation of the Anadromous Salmonid Passage Facility Design (NMFS, 2011), culverts would be expected to allow continuous fish passage during construction and operation

Lethal and sub-lethal effects on EFH species would be limited through the timing of construction, avoidance of impacts on overwintering habitat, restrictions to water withdrawals, and adherence to the Project Plan and Procedures. The impact on EFH species at sites with summer in-stream construction and on frozen waterbodies is expected to be minimal and dry-ditch crossings would minimize overall impacts on EFH.

Direct adverse impacts on EFH would be limited to temporary disturbance of freshwater EFH from Mainline Pipeline installation, and permanent disturbance from facilities in Cook Inlet and Prudhoe Bay. With AGDC's implementation of the mitigation measures, Project plans, and BMPs described in this document, we have determined that the Alaska LNG Project would have minor impacts on EFH. Table 6-1 provides a summary of potential impacts for freshwater EFH.

TABLE 6-1

Impact Summary for Freshwater Essential Fish Habitat

Essential Fish Habitat	Project Component	Potential Effect	Proposed Mitigation	Impact Level
Pacific salmon	Mainline Pipeline	Habitat loss and alteration	Follow Project Plan, Procedures, and Revegetation Plan. Design culverts and bridges to allow fish passage.	Minor
		Water quality	Maintain pipeline temperature to minimize impacts on permafrost. Follow Project Plan and Procedures, Revegetation Plan, SPCC Plan, and DMT Plan.	Minor
		Lethal and sub-lethal effects	Avoid constructing in-stream during sensitive periods for EFH species. Limit water withdrawals. Follow Alaska Blasting Standards.	Minor

Construction and operation of Dock Head 4 and associated infrastructure in Prudhoe Bay would have potential effects on marine EFH for arctic cod and Pacific salmon. These effects include both temporary and permanent habitat loss and alteration, decreased water quality due to increased turbidity and potential spills, and lethal and sub-lethal effects from pile driving. The effects of habitat loss on arctic cod EFH would be permanent, but because similar habitat is available throughout Prudhoe Bay and along the Beaufort Sea coastline, the significance would be minor. The effects of habitat loss on Pacific salmon EFH would also be permanent, but because the area is mostly used for migration, it is likely that fish would move around the facilities. The maintenance of migration corridors through the temporary barge bridge would also aide in maintaining migration pathways for fish, and the removal of the barge bridge in winter would limit the impact duration.

Spills have the potential to cause minor impacts on marine EFH in Prudhoe Bay and Cook Inlet, but AGDC's adherence to the Project Plan and Procedures, as well as the Project SPCC Plan, SWPPP, and Waste Management Plan would reduce the likelihood of these events occurring. The potential impacts of increased sediment related to in-water construction, pile driving, screeding, and dredging is expected to be minor due to the short duration, localized setting, and existing conditions. Water quality would be protected through compliance with the Project Plan and Procedures, as well as the Project SWPPP, SPCC Plan, and related ADEC permit requirements. Hydrostatic test water would be diverted into sediment control devices in upland areas to reduce the potential for scour in Cook Inlet. The DMT Inadvertent Release Contingency Plan would contain corrective and mitigation measures in the event of a drilling fluid release during DMT operations.

Lethal and sub-lethal effects can result from pile driving noise/barotrauma, entrainment in water pumps, and vessel noise. These impacts would be mitigated through the use of fish screens and soft start/ramp-up procedures for impact pile driving. Table 6-2 provides a summary of potential impacts for marine water EFH.

Based upon the largely temporary, short-term impacts associated with construction and operation of the Project and the conservation measures described above, we determine that there would be no adverse effects on EFH.

TABLE 6-2

Impact Summary for Marine Essential Fish Habitat

EFH	Project Component	Potential Effect	Proposed Mitigation	Impact Level
Arctic cod and Pacific salmon	Gas Treatment Facilities	Habitat loss and alteration	Comply with Project Plan, Procedures, and Revegetation Plan. Maintain fish passage in barge bridge. Use directed, task-specific lighting with timers and motion-sensors, where appropriate.	Minor
		Water quality	Follow Project SPCC Plan, SWPPP, and Waste Management Plan. Adhere to ballast water regulations.	Minor
		Lethal and sub-lethal effects	Implement soft start/ramp up of impact pile drivers.	Minor
Pacific salmon and Forage Fish Complex	Mainline Pipeline and Liquefaction Facilities	Habitat loss and alteration	Use DMT method at Cook Inlet shoreline crossing. Comply with Project Plan, Procedures, and Revegetation Plan. Use directed, task-specific lighting with timers and motion-sensors, where appropriate.	Minor
		Water quality	Follow Project SPCC Plan, SWPPP, Waste Management Plan, and Shipboard Oil Pollution Emergency Plan. Install shoreline armoring at Marine Terminal.	Minor
		Lethal and sub-lethal effects	Use fish screens on intake structures. Implement soft start/ramp up of impact pile drivers.	Minor

7.0 REFERENCES

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