# 3.24 FISH VALUES

The Environmental Impact Statement (EIS) analysis area includes watersheds and downgradient aquatic habitats that could be affected by project components from streams to marine waters. Potential direct and indirect impacts to fish and aquatic habitat and aquatic invertebrates include:

- Physical loss of stream, lake, estuarine, and marine habitat.
- Blockage of stream channels preventing fish or other aquatic species passage.
- Aquatic habitat effects due to instream flow reductions from mine water withdrawal or capture and redirection of groundwater.
- Sedimentation of aquatic habitat due to surface erosion of mine and port access roads, stockpiles, or other activities.
- Erosion from vegetation removal; shoreline erosion associated with ship or ferry wakes; benthos disturbance/mortality from docks and pipelines.
- Changes of freshwater and marine water quality such as temperature, turbidity, pH, dissolved oxygen, and metal or chemical contaminants.
- Injury or mortality of fish or other aquatic species.

Permit compliance requirements, including standard and special terms and conditions, best management practices (BMPs), and environmental monitoring, would be established by regulatory agencies and landowners with permitting authority. These requirements would be implemented as part of construction management and facility operations to avoid, minimize, and control risks to fish and aquatic habitat in the project area. Specific measures proposed by the Pebble Limited Partnership (PLP) to mitigate impacts are discussed in Chapter 5, Mitigation.

The EIS analysis area for the mine site includes the North Fork Koktuli (NFK), South Fork Koktuli (SFK), and Upper Talarik Creek (UTC) watersheds, and a 1,000-foot buffer around the mine site to account for blasting disturbance. This area includes all aquatic habitats potentially impacted by changes in streamflow from the diversion, capture, and release of water associated with the project that result in a modeled reduction in streamflow greater than 2 percent. The EIS analysis area for the port, and transportation and natural gas pipeline corridors, includes all aquatic habitats within 0.25 mile of the proposed infrastructure. This is the area where potential effects are expected to occur from construction and operations under all alternatives.

## 3.24.1 Alternative 1 – Applicant's Proposed Alternative

### 3.24.1.1 Aquatic Habitat

**<u>Mine Site</u>**

The mine site would be situated in the Koktuli River and UTC watersheds. The EIS analysis area for the mine site includes the mainstem NFK and the mainstem SFK from reaches adjacent to the mine site downstream to their confluence; the mainstem UTC from the reach adjacent to the mine pit downstream to Iliamna Lake; and tributaries directly draining the mine site (Figure 3.24-1).The 36-mile NFK and 40-mile SFK rivers join to form the Koktuli River, which flows 39 miles downstream into the Mulchatna River. The Mulchatna River continues 44 miles before joining the Nushagak River, which then flows another 109 miles into Bristol Bay. UTC flows for approximately 39 miles into Iliamna Lake, which drains into the Kvichak River, which flows 50 miles downstream into Bristol Bay. The two forks of the Koktuli River and the UTC subbasins encompass approximately 355 square miles, representing approximately 0.9 percent of the

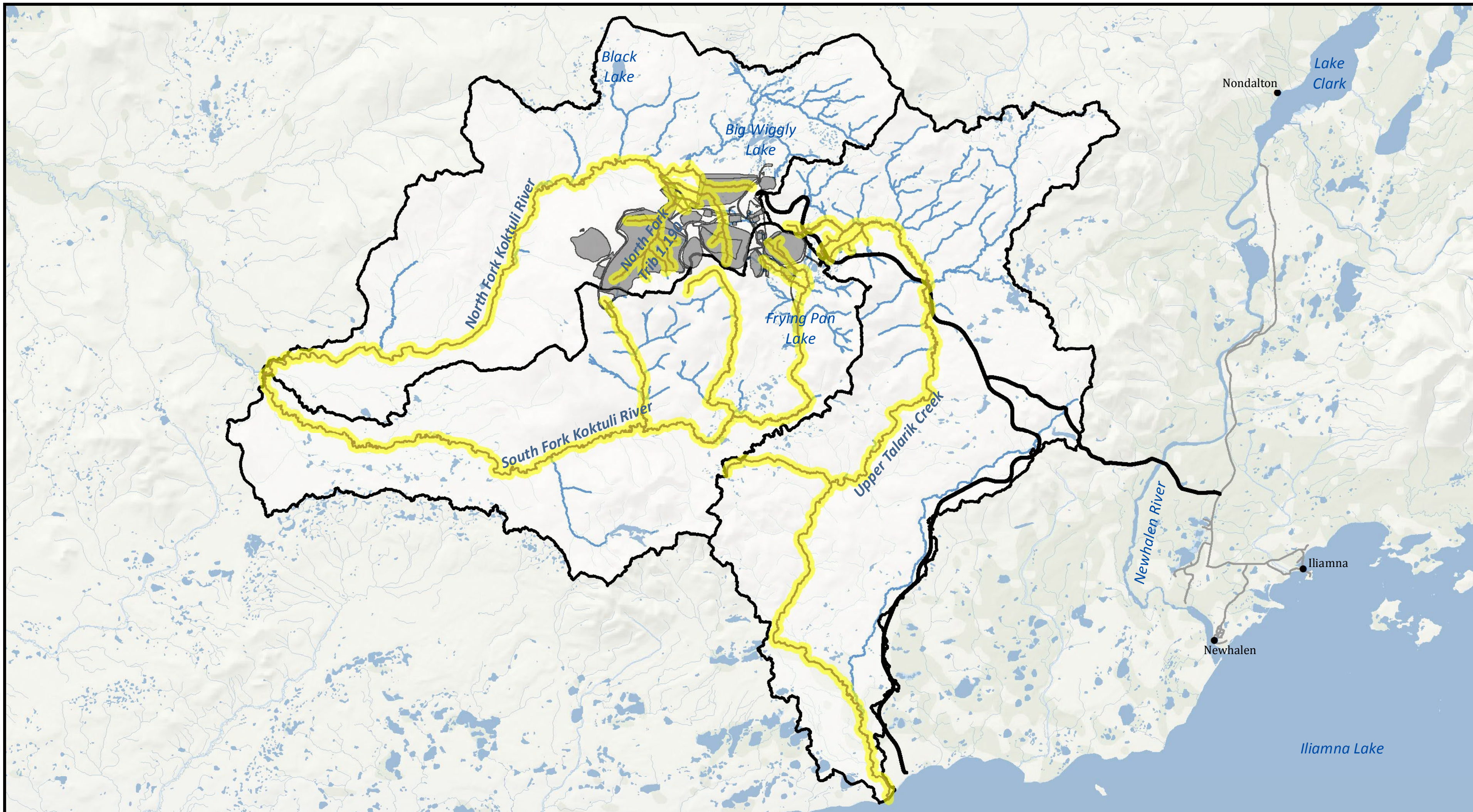
39,184-square-mile Bristol Bay watershed. The general characteristics and features of the NFK, SFK, and UTC drainage basins are described in Section 3.16, Surface Water.

### *North Fork Koktuli River*

The majority of the mine site facilities would be in the NFK watershed, including the most of the tailings storage facility (TSF), pyritic TSF, water management ponds (main and open pit), millsite/camp, and water treatment plant #2 discharge location – north (Figure 3.24-1). The NFK River watershed extends northeast from the confluence with the SFK River to Groundhog Mountain, approximately 7 miles northeast of the mine site (Figure 3.24-1). The NFK drains 64.7 miles of currently documented anadromous stream channels, with a total basin area of about 113 square miles, which represent 0.3 percent of Bristol Bay's 39,184-square-mile watershed area. Approximately 23 percent of the NFK basin area and 8.3 miles of mainstem channel are upstream of tributaries 1.19 and 1.20 and the mine site footprint (Figure 3.24-1). The Alaska Department of Fish and Game (ADF&G) Anadromous Waters Catalog (AWC) (Johnson and Blossom 2018) lists 12 anadromous fish-bearing tributaries entering the NFK, including Tributary 1.19, which would contain the majority of the mine site footprint. More than 20 miles of fish-bearing stream channel would be blocked or filled by mine components, including approximately 7 miles of anadromous waters (see Section 4.24 for habitat loss details).

Mainstem base flows in the NFK at the mine site (just above the Tributary 1.19 confluence) were typically 15 to 20 cubic feet per second (cfs) in winter, and 40 cfs in summer, with Tributary 1.19 contributing another 4 to 5 cfs and 20 cfs in winter and summer, respectively.

Throughout most of its length, the mainstem NFK is a low-gradient (mostly 0.1 to 0.8 percent), unconfined, meandering, single-thread channel bordered by shrub and dwarf shrub riparian species dominated by willows (R2 et al. 2011a). Habitat typing, as listed in Table 3.24-1, shows that the mainstem NFK below the mine site is dominated by riffle habitat with few mainstem pools. Upstream of the mine site, the NFK contains equal proportions of riffle and run/glide habitats, with increasing frequency of beaver-formed pools in headwater reaches where mainstem flows are lower. The upper 10 miles of the NFK flow through a region with small (less than 3 acres) shallow lakes, dominated by Big Wiggly Lake (Figure 3.24-1).




Sources: HDR 2012

US Army Corps of Engineers

2 0 2 4

Miles

Mine Site EIS Analysis Area

Alternative 1 Footprint

Water Basin

## NORTH FORK KOKTULI, SOUTH FORK KOKTULI AND UPPER TALARIK BASINS

PEBBLE PROJECT EIS

FIGURE 3.24-1

**Table 3.24-1: Frequency of Habitat Types in the NFK, SFK, and UTC Mainstem and Off-Channel Areas in the Mine Site Analysis Area[1]**

| Tributary | Mainstem Reach | Riffle | Run/Glide | Pool | Beaver Pond | Other[2] Off-Channel |
|---|---|---|---|---|---|---|
| NFK | A | 0.64 | 0.35 | 0.01 | 0.00 | N/A |
| | B | 0.65 | 0.34 | 0.01 | 0.00 | N/A |
| | C | 0.56 | 0.42 | 0.02 | 0.00 | N/A |
| | Off-Channel | N/A | N/A | N/A | 0.85 | 0.15 |
| SFK | A | 0.65 | 0.32 | 0.03 | 0.00 | N/A |
| | B | 0.44 | 0.54 | 0.02 | 0.00 | N/A |
| | C | 0.27 | 0.64 | 0.05 | 0.04 | N/A |
| | D | 0.55 | 0.24 | 0.03 | 0.18 | N/A |
| | Off-Channel | N/A | N/A | N/A | 0.91 | 0.09 |
| UTC | A | 0.54 | 0.45 | 0.01 | 0.00 | N/A |
| | B | 0.53 | 0.44 | 0.03 | 0.00 | N/A |
| | C | 0.24 | 0.74 | 0.02 | 0.00 | N/A |
| | D | 0.16 | 0.77 | 0.07 | 0.00 | N/A |
| | E | 0.19 | 0.69 | 0.12 | 0.00 | N/A |
| | F | 0.20 | 0.51 | 0.22 | 0.07 | N/A |
| | Off-Channel | N/A | N/A | N/A | 0.93 | 0.07 |

Notes:
[1]Includes mileage from mainstem reaches adjacent to and downstream of the mine site and tributaries draining the mine site (Figure 3.24-1)
[2]Other off-channel habitats include beaver pond outlets, alcoves, isolated ponds, side channels, and percolation channels
N/A = Not Applicable
NFK = North Fork Koktuli
SFK = South Fork Koktuli
UTC = Upper Talarik Creek
Source: R2 et al. 2011a

Beaver ponds and other features are widely distributed in off-channel habitats throughout most of the NFK (Table 3.24-1). Off-channel habitats, which include side channels, percolation channels, alcoves, isolated ponds, riverine wetlands, and beaver ponds, are hydrologically connected to the NFK via surface flows or groundwater upwelling (for groundwater assessment, see Schlumberger 2011a). See Section 3.22, Wetlands and Other Waters, for a description of riverine wetlands in the analysis area.

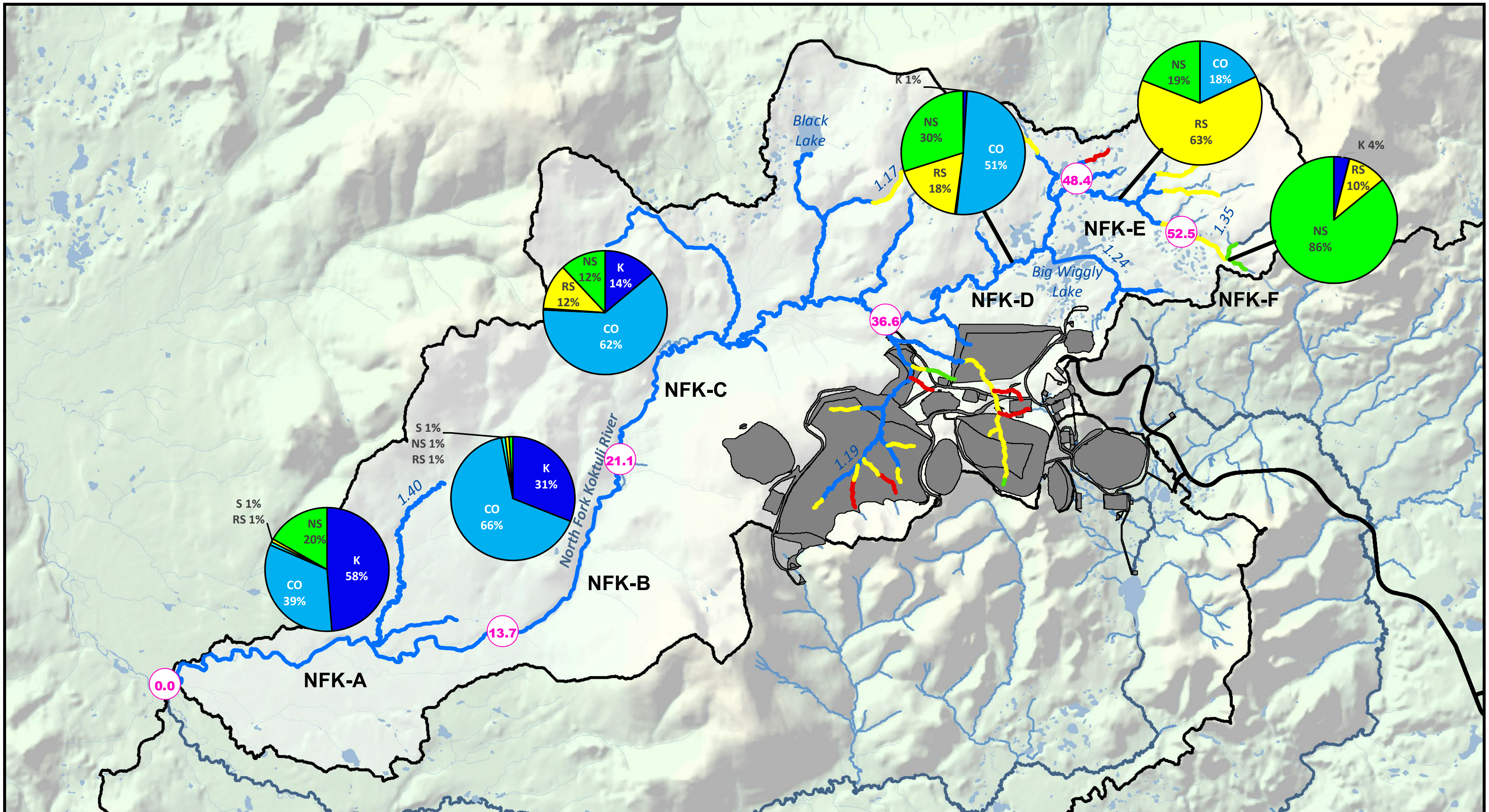
Instream cover for fish rearing is relatively scarce in the mainstem NFK due to the absence of large riparian trees and associated woody debris; but cobble substrates, undercut banks, and overhanging vegetation provide some refugia (R2 et al. 2011a). Small, woody debris and increased depths associated with beaver dams provide cover in many off-channel locations. Substrate is dominated by gravel, with low amounts of fine sediments (less than 10 percent) in reaches below the mine site. The prevalence of non-embedded gravel substrates and dominance of riffle and run/glide habitats provides spawning habitat for salmonids. A summary of anadromous and resident fish habitat for the NFK, SFK, and UTC is provided in Table 3.24-1. In contrast to the lower river, substrate in the mainstem above the mine site contained higher amounts of sand and silt derived from glacial lacustrine and lacustrine deposits underlying the Big Wiggly Lake basin (Schlumberger 2011a).

Chinook salmon (*Oncorhynchus tshawytscha*) spawning habitat occurs throughout the lower 20 miles of the NFK below the mine site (Figure 3.24-2), and extends into the upper NFK adjacent to Big Wiggly Lake. The majority of spawning habitat occurs in the first 10 miles of the NFK (NFK-A), approximately 20 miles downstream from the mine site (R2 et al. 2011a). Juvenile Chinook rearing habitat occurs throughout most of the NFK mainstem (Table 3.24-2), as well as several NFK tributaries, including Tributary 1.40 in the lower reach; Tributary 1.17 below Black Lake; Tributary 1.19 and its primary sub-tributary at the mine site; and Tributary 1.24, which flows through Big Wiggly Lake. Juvenile Chinook were most commonly observed in riffles and other mainstem habitats, but were also found to occupy low-velocity off-channel habitats.

Coho salmon (*O. kisutch*) spawning and rearing habitat is widely distributed in the NFK basin (Table 3.24-2). Preferred coho spawning habitat appears to be in the 10 miles of mainstem immediately downstream of the mine site (NFK-C), based on field observations (R2 et al. 2011a).

Sockeye salmon (*O. nerka*) spawning habitat primarily occurs in the lower 10 miles of the NFK (NFK-A), but the run extends upstream to the vicinity of Big Wiggly Lake (R2 et al. 2011a). Although some spawning habitat has been documented in the upper NFK basin, most juvenile rearing habitat occurs downstream of the mine site, based on field observations.

Fixed hydrologic station data and multiple surveys from 2004 to 2008 show that the mainstem NFK remains perennial during base flow levels at all fish-bearing study sites (R2 et al. 2011a). The NFK's seasonal hydrograph shows periods of maximum flows during spring snowmelt and late summer/fall rain events, with low flows during mid-summer, and minimum base flows in winter/early spring (Knight Piésold et al. 2011a). Mean monthly base flows in the lower reach of the NFK averaged 60 to 90 cfs during winter months (January-March), 700 cfs during spring snowmelt (May), 200 cfs during summer base flow (July), and 350 to 450 cfs during fall rains (September-October). All three tributaries (i.e., NFK, SFK, and UTC) display sequences of losing and gaining reaches due to groundwater percolation and emergence, respectively (Schlumberger 2011a, 2015a).




Sources: USGS; ADF&G; Pebble (R2 et al. 2011)

US Army Corps of Engineers

1 0 1 2
Miles

**Fish Distribution and Relative Composition**

- Anadromous Salmonids (K=Chinook, CO=Coho, S=Sockeye)
- Resident (non-anadromous) Salmonids (RS)
- Non-Salmonid Fish (NS)
- No Fish Observed
- Mainstem Reaches with River Mile
- Alternative 1 Footprint
- Water Basin

**NORTH FORK KOKTULI**
**FISH DISTRIBUTION AND RELATIVE COMPOSITION**

**PEBBLE PROJECT EIS**

**FIGURE 3.24-2**

Groundwater studies indicate that surface waters percolating into the NFK groundwater remain in the NFK subbasin, and do not transfer to either the SFK or UTC subbasins (Schlumberger 2011a). Emerging groundwater is important to aquatic species due to its cooling effect on mainstem flows during summer, its warming effect during winter, and its direct relationship with spawning site selection for several salmonid species. Areas of groundwater upwelling are most evident in the mainstem NFK downstream of the mine site, in a reach 15 to 20 miles upstream of its confluence with the SFK. Seasonal hydrographs for several reaches of the mainstem NFK are presented in Section 3.16, Surface Water Hydrology.

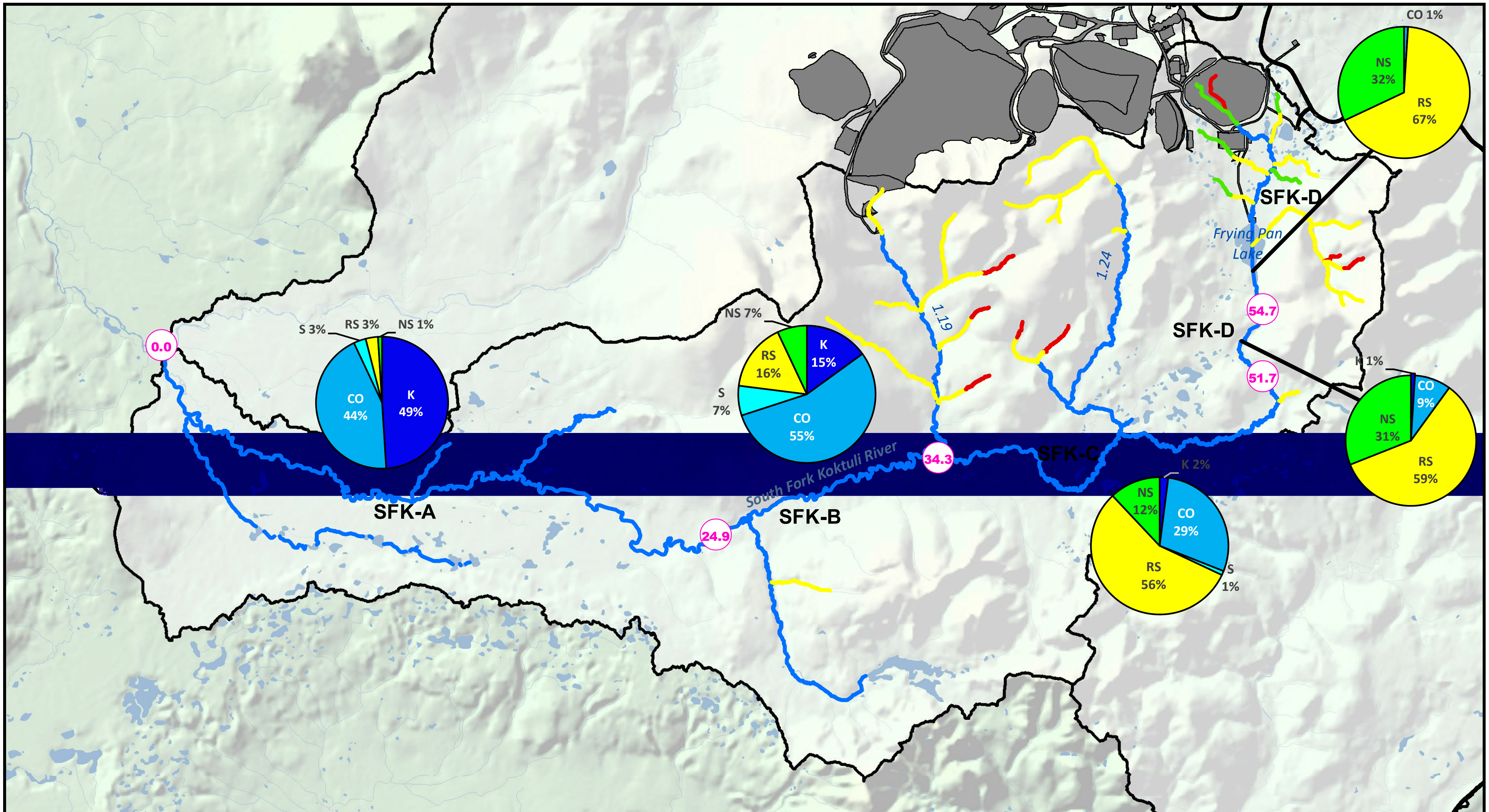
The observed water temperatures in the NFK ranged from a low of 0.3 degrees Celsius (°C) to a maximum of 21.9°C (R2 et al. 2011a). Water temperatures in the NFK downstream of the mine site generally remain cool during the summer and cold during winter months, with mean daily temperatures typically between 10°C and 15°C during July and August. However, maximum summer water temperatures did exceed the Alaska Department of Environmental Conservation (ADEC) 15°C criteria for aquatic life and fish life-stages (ADEC 2018b) at some locations in the upper basin. For a more detailed description of surface and groundwater baseline conditions, see Section 3.16, Surface Water; Section 3.17, Hydrogeology; and Section 3.18, Water and Sediment Quality.

### *Tributary 1.190 and Sub-tributaries*

Tributary 1.190 and it's sub-tributaries to the NFK would contain the majority of the mine site footprint. These streams are incised coarse gravel, cobble, and boulder bed stream flowing through moraine and colluvial deposits with heavily vegetated banks, and a slope of 2 to 3 percent that drains approximately 8 square miles. It is a first-order stream characterized by flashy runoffs during snowmelt and rainstorm events due to higher precipitation, steep catchment in the surrounding uplands, full exposure to incoming storms, and lack of surface flow losses to groundwater in the lower reaches. Channel habitat features are dominated by short rapids/riffle reaches and irregularly spaced scour pools. Documented anadromous fish habitat use includes rearing habitat for Chinook salmon, and rearing and spawning for coho salmon. Resident fish species include Arctic grayling (*Thymallus arcticus*), Dolly Varden (*Salvelinus malma*), rainbow trout (*O. mykiss*) and slimy sculpin (*Cottus cognatus*).

### *South Fork Koktuli River*

The SFK extends approximately 40 miles upstream from the confluence with the NFK to the headwaters, including 60.0 miles of documented anadromous stream habitat and a 107-square-mile drainage area, representing 0.3 percent of the Bristol Bay watershed (Figure 3.24-1). Approximately 18 percent of the mine site footprint occurs in the headwaters of the SFK basin, including the mine pit, overburden stockpile, pit water management and treatment facilities, and miscellaneous facilities (Figure 3.24-3). These mine site components would occupy approximately 1.9 square miles of the upper watershed, or 1.8 percent of the SFK basin area. The mine pit and associated sediment pond embankment are expected to capture or block approximately 1.4 miles of stream channel known to support resident fish habitat.




Sources: USGS; ADF&G; Pebble (R2 et al. 2011)

US Army Corps of Engineers

1 0 1 2

Miles

**Fish Distribution and Relative Composition**

- Anadromous Salmonids (K=Chinook, CO=Coho, S=Sockeye)
- Resident (non-anadromous) Salmonids (RS)
- Non-Salmonid Fish (NS)
- No Fish Observed

- Mainstem Reaches with River Mile
- Alternative 1 Footprint
- Water Basin

**SOUTH FORK KOKTULI**
**FISH DISTRIBUTION AND RELATIVE COMPOSITION**

**PEBBLE PROJECT EIS**

**FIGURE 3.24-3**

Like the NFK, the SFK is a low-gradient (0.03 to 0.6 percent), riffle- and shrub-dominated meandering stream with an abundance of off-channel habitat (R2 et al. 2011a), especially in the lower 20 miles downstream of the mine site where the floodplain broadens (Table 3.24-1). Stream gradient increases in the uppermost 1.5 miles, just downstream and into the footprint of the mine pit. Small, shallow lakes are common adjacent to the mainstem channel in the upper 10 miles of the watershed. The low-gradient and gravel-dominated substrate of the mainstem SFK below the mine site provides spawning and rearing habitat for resident and anadromous salmonids. Gravel quality is suitable for spawning and egg incubation, although the proportion of fines in the mainstem substrate is somewhat higher than in the NFK and UTC basins. The lack of large riparian tree species along the SFK mainstem yields little large, woody debris cover; but undercut banks, overhanging vegetation, instream cobbles, and beaver-related small, woody debris are available as cover for rearing fish.

Streamflow patterns in the SFK reflect those in the NFK, with two base-flow periods (summer post-snowmelt and winter) and two high-flow periods (spring snowmelt and fall rain events). Unlike the NFK, the mainstem SFK has a 10-mile reach from 2 miles below Frying Pan Lake to SFK Tributary 1.19 that frequently exhibits zero or intermittent flows during winter and summer months (R2 et al. 2011a). Dry or intermittent conditions were observed in this reach during January (2008, 2009), February (2006 – 2009), March (2005-2008, 2010, 2012), April (2007, 2008) and May (2012), as well as in July (2007), August (2004, 2005, 2007), and September (2004, 2007) (Knight Piésold 2011g). The duration of intermittent flows varied among years, but sometimes persisted for multiple months in winter and early spring, and up to 40 consecutive days in August to early September 2007 (R2 et al. 2011a). Loss of surface flow in this reach is due to thick, permeable glacial deposits and an average transfer of 22 cfs from the SFK basin into the UTC basin via groundwater exchange. Groundwater remaining in the SFK basin reemerges at the downstream end of the dry reach 20 miles above the NFK confluence (Knight Piésold et al. 2011a).

Chinook salmon spawning habitat has been documented from the SFK/NFK confluence upstream to Frying Pan Lake (Table 3.24-2, Figure 3.24-3), although more recent sampling indicated preferred spawning habitat occurs in the lower 20 miles of the SFK (reaches SFK-A and B) (R2 et al. 2011a). As noted above, the mainstem SFK between SFK Tributary 1.19 and the Frying Pan Lake outlet routinely dries up during base-flow periods; consequently, that reach is not considered quality habitat. Chinook habitat does not extend into the upper SFK basin above Frying Pan Lake or in the footprint of the mine site. However, rearing habitat occurs throughout the mainstem below Frying Pan Lake, and in the lower 4 miles of SFK Tributary 1.19, which drains the southern side of Kaskanak Mountain.

Coho spawning habitat in the mainstem SFK extends almost up to the outlet of Frying Pan Lake, although spawning habitat is limited in the middle intermittent reach. Most spawning habitat was observed via aerial surveys in the lower 20 miles of the mainstem (Figure 3.24-3, reaches A and B), and in two tributaries: SFK 1.13 and SFK 1.19 (R2 et al. 2011a). Juvenile coho rearing habitat occurs throughout the SFK basin, including the mainstem, tributaries, and headwaters upstream of Frying Pan Lake. Juvenile coho in the SFK routinely use off-channel habitats, including beaver ponds, side channels, and alcoves. Juvenile coho overwintering habitat has been documented in reaches SFK-A and SFK-B.

Sockeye salmon spawning habitat is limited to lower reaches SFK-A, SFK-B and SFK-C, and rearing habitat occurs throughout the SFK (Figure 3.24-3).

**Table 3.24-2: Estimated Mileage of Habitat for Pacific Salmon and Rainbow Trout in Tributaries in the Mine Site Analysis Area[1]. (Numbers in parenthesis are percentages of total known anadromous habitat (miles) within subbasin[2]).**

| Subbasin | Species | Spawning (mi)[3] | Rearing (mi)[3] | Present (mi)[3] |
|---|---|---|---|---|
| NFK | Chinook salmon | 21.4 (33%) | 24.8 (38%) | 0.6 (1%) |
| NFK | Coho salmon | 26.4 (41%) | 28.8 (44%) | 0.2 (0%) |
| NFK | Sockeye salmon | 22.5 (35%) | 18.2 (28%) | 0 |
| NFK | Chum salmon | 19.5 (30%) | 4.8 (7%) | 0 |
| NFK | Pink salmon | 0 | 0 | 0 |
| NFK | Rainbow trout[4] | N/A | N/A | 27 |
| SFK | Chinook salmon | 30.0 (50%) | 32.1 (53%) | 1.4 (2%) |
| SFK | Coho salmon | 31.6 (53%) | 43.4 (72%) | 4.3 (7%) |
| SFK | Sockeye salmon | 19.4 (32%) | 24.4 (41%) | 9.0 (15%) |
| SFK | Chum salmon | 19.2 (32%) | 1.9 (3%) | 2.3 (4%) |
| SFK | Pink salmon | 0 | 0 | 0 |
| SFK | Rainbow trout[4] | N/A | N/A | 19 |
| UTC | Chinook salmon | 31.0 (41%) | 24.6 (32%) | 2.7 (4%) |
| UTC | Coho salmon | 34.8 (46%) | 35.6 (47%) | 0 |
| UTC | Sockeye salmon | 32.5 (43%) | 30.9 (41%) | 1.1 (1%) |
| UTC | Chum salmon | 52.0 (68%) | 0 | 2.1 (3%) |
| UTC | Pink salmon | N/A | N/A | 4.0 (5%) |
| UTC | Rainbow trout[4] | N/A | N/A | 42 |

Notes:
[1] Includes mileage from mainstem reaches adjacent to and downstream of the mine site and tributaries draining the mine site (Figure 3.24-1)
[2] Total anadromous mileages per subbasin are 64.7 miles in NFK, 60.0 miles in SFK, and 76.2 miles in UTC
[3] Includes AWC (Johnson and Blossom 2018) listing as "spawning" or "rearing"; lakes not included; additional waters listed as species "present" but not specified by life stage
[4] Stream mileage based on highest reported rainbow trout observation in AWC (Johnson and Blossom 2018) (life-stages not specified)
AWC = Anadromous Waters Catalog
N/A = Not Applicable
NFK = North Fork Koktuli
SFK = South Fork Koktuli
UTC = Upper Talarik Creek

Chum (*O. keta*) spawning habitat is limited to the lower 20 miles of the river, downstream of the seasonally dry channel (Table 3.24-2). Adult chum salmon appear to target areas of rising groundwater during redd site selection; consequently, the highest densities of chum salmon redds occurred in the reach immediately downstream of the dry channel (SFK-C), where accretion of groundwater is most evident (R2 et al. 2011a). Rainbow trout habitat occurs in several reaches of the SFK, including upstream of Frying Pan Lake and tributaries; however, densities of this species were lower than for other resident salmonids (R2 et al. 2011a).

Water temperature in the SFK ranged from an observed low of 0.7°C to a maximum of 24.4°C. Similar to the NFK, water temperatures tended to be warmer in the upper watershed, where lakes are prevalent; and cooler in the lower reaches, due to emerging groundwater (R2 et al. 2011a). Average daily temperatures during July and August were typically 13°C to 16°C in the upper half of the SFK mainstem, but only 8°C to 12°C below the intermittent reach. Maximum summer water temperatures exceeded the ADEC 15°C criteria for aquatic life and fish life-stages (ADEC 2018b) at several water quality stations in the upper SFK.

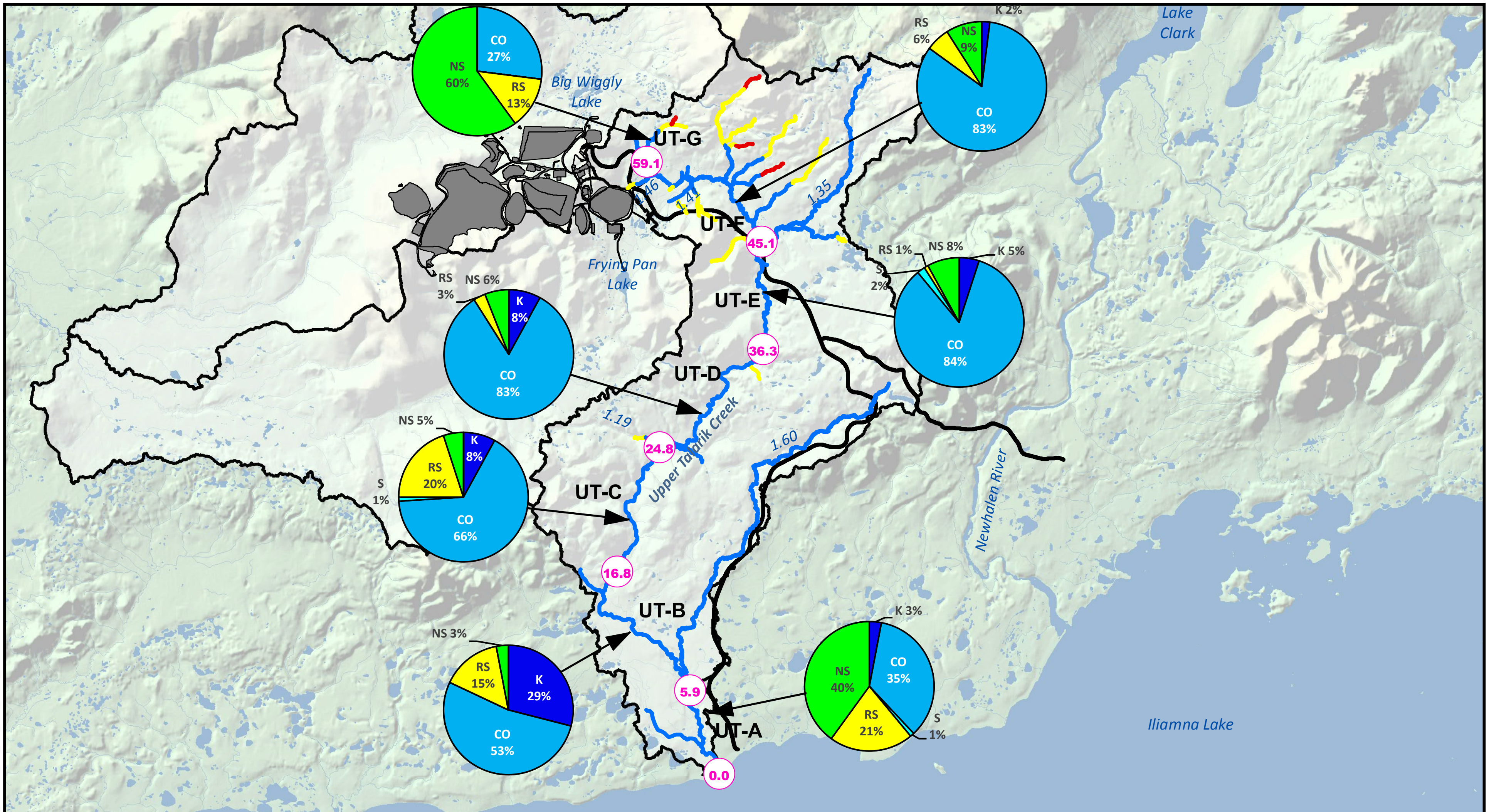
### *Upper Talarik Creek*

UTC flows south approximately 39 miles from its headwaters on the eastern edge of the mine site downstream into Iliamna Lake near the town of Iliamna (Figure 3.24-4). The UTC watershed contains 76.2 miles of documented anadromous habitat in a 135-square-mile watershed, which represents 0.3 percent of the entire Bristol Bay watershed area. Mine site facilities in the UTC basin would be limited to the mine access road and a water treatment discharge pipe, or less than 0.5 percent of mine site footprint. However, the eastern edge of the mine pit is at the SFK and UTC watershed boundary; consequently, the mine pit (primarily through pit dewatering) and associated roads and facilities, could affect aquatic habitat in the UTC. Stream channel gradient is steeper in the UTC, compared to the NFK and SFK, at less than 1 percent to 2 percent (R2 et al. 2011a). Aquatic habitat in the UTC varies from riffle-dominated to run/glide-dominated reaches, with relatively few mainstem pools (Table 3.24-1). The upper reach and much of the lower reach of the UTC possess relatively wide floodplain, with associated off-channel habitat; but the middle reach is more confined, and largely restricted to a single channel. Unlike the NFK and SFK, this middle reach of the UTC is forested, which contributes large, woody debris into the stream channel (R2 et al. 2011a); whereas shrub and dwarf shrub species (including willows [*Salix* spp.]) dominate the upper and lower reaches of the UTC. In addition to large, woody debris, undercut banks, overhanging vegetation, and small, woody debris associated with beaver dams also provide instream and overhead cover. The UTC mainstem contains an abundance of gravel substrate relatively free of fine sediments, providing spawning habitat.

Chinook salmon spawning and rearing habitat is interspersed throughout the entire length of the 39-mile mainstem UTC; however, Chinook spawning habitat in UTC tributaries is limited to a very short reach of UTC Tributary 1.41, and in UTC Tributary 1.19, which receives groundwater flow from the SFK (R2 et al. 2011a). Juvenile Chinook rearing habitat was observed in mainstem habitat features such as run/glide, pool, and riffles in reaches UT-C through UT-E; juvenile Chinook overwintering habitat has been documented in reaches UT-C, UT-D, and UT-E of the UTC (Figure 3.24-4).

Coho salmon spawning habitat extends almost the entire length of the mainstem UTC and into several tributaries (UTC tributaries 1.60, 1.35, 1.31, and 1.41). The distribution of juvenile coho was similar to that for spawning, with the addition of several minor tributaries. Densities of juvenile coho were generally similar in mainstem and off-channel habitat; and maximum densities were observed in UTC Tributary 1.41, which drains the western side of the upper basin immediately proximal to the mine pit (R2 et al. 2011a). Coho were observed in November, and again the following April, in reaches UT-D through UT-F, suggesting these reaches may provide overwintering habitat (Figure 3.24-4).

Sockeye spawning habitat has been documented in most of the mainstem UTC up to the headwaters bordering the mine site; and also encompassed several tributaries, including 1.60, 1.90, 1.35, 1.39, and 1.41 (Table 3.24-2). Although the spawning habitat is widespread in the UTC, preferred spawning habitat occurs in reaches UTC-A (R2 et al. 2011a); and in Tributary 1.60, where up to 43 percent of the UTC sockeye run spawned in 2008 (Figure 3.24-4). Sockeye rearing habitat is also widespread in the UTC basin, although field observations indicate habitat is somewhat limited in the mainstem and tributaries, likely due to the early emigration of juveniles into Iliamna Lake. Rainbow trout use multiple habitats, including riffle, glides, pools, and beaver ponds throughout all reaches of the UTC.




Sources: USGS; ADF&G; Pebble (R2 et al. 2011)

US Army Corps of Engineers

2 0 2 4
Miles

**Fish Distribution and Relative Composition**

- Anadromous Salmonids (K=Chinook, CO=Coho, S=Sockeye)
- Resident (non-anadromous) Salmonids (RS)
- Non-Salmonid Fish (NS)
- No Fish Observed
- Mainstem Reaches with River Mile
- Alternative 1 Footprint
- Water Basin

**UPPER TALARIK**
**FISH DISTRIBUTION AND RELATIVE COMPOSITION**

**PEBBLE PROJECT EIS**

**FIGURE 3.24-4**

The annual hydrograph for the UTC shows the two high-flow and two base-flow periods, similar to the NFK and SFK (Knight Piésold et al. 2011a). An exception is UTC Tributary 1.19, which receives groundwater accretion from the SFK. Mean monthly streamflows in this tributary were consistently 20 to 30 cfs throughout the year. The groundwater inflow from Tributary 1.19 also reduced water temperatures in the lower mainstem UTC, which generally remained below 10°C. Measured water temperatures in the UTC ranged from a low of 2.5°C to a maximum of 18.8°C (R2 et al. 2011a). Although summer water temperatures did sometimes exceed the ADEC 15°C criteria for aquatic life and fish life-stages (ADEC 2018b), summer water temperatures in the UTC were generally 3°C to 5°C cooler than comparable temperatures in the NFK and SFK, due in part to the abundance of groundwater emergence and the relative lack of inflow from warm, shallow lakes.

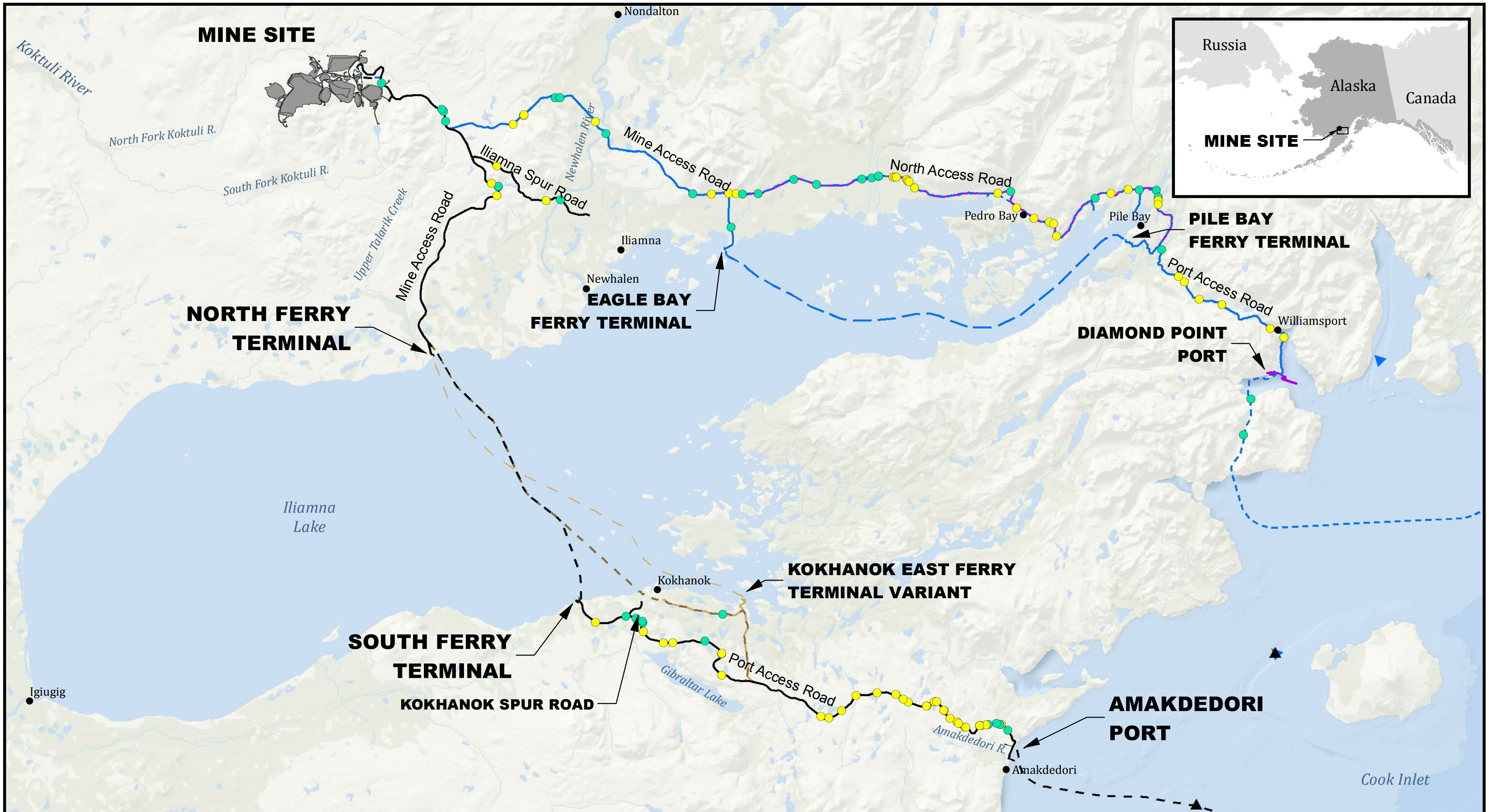
## Transportation and Natural Gas Pipeline Corridors

The EIS analysis area for the transportation and natural gas pipeline corridors and port location includes all aquatic habitats within 0.25 mile of the proposed infrastructure, and all habitats within 1,000 feet of blasting areas (Figure 3.24-5). This is the area where potential effects are likely to occur from construction and operations under all alternatives. The corridor, including mine access and port access roads, would cross a total 44 waterbodies documented to support fish.

Table 3.24-3 lists the 16 anadromous streams that would be crossed by the access roads from the mine site to Amakdedori port.

### *Mine Access Road*

The mine access road, including the Iliamna spur road, would cross 16 waterbodies documented to support fish, 6 of which are classified as anadromous fish habitat (Figure 3.24-5, Table 3.24-3). The road would cross the major drainages of UTC and the Newhalen River. As previously described, the UTC and tributaries support spawning, rearing, and migratory habitat for all five species of Pacific salmon and resident fish species. The Newhalen River provides important migratory fish habitat for sockeye and Chinook salmon migrating between Iliamna Lake and Lake Clark. Chinook salmon spawning habitat has been documented 0.75 mile downstream from the Newhalen River crossing. Tributaries of the Newhalen River upstream of the crossing provide spawning and rearing habitat for both resident and anadromous species. Arctic char (*Salvelinus alpinus*) are also known to inhabit the Newhalen River between Six Mile Lake and Iliamna Lake. The species and life-stages known to occur at each crossing location were identified from AWC listings or recent field sampling by Pebble Limited Partnership (PLP 2018b).




Sources: PLP 2018; ADF&G; ADNR

**Stream Crossings**
- Anadromous Fish
- Resident Fish

**Alternative 1**
- Lightering Locations
- Transportation Corridor
- Natural Gas Pipeline
- Ferry/Port Site
- Mine Site

**Kokhanok East Ferry Terminal Variant**
- Transportation Corridor
- Ferry Route
- Natural Gas Pipeline
- Ferry Terminal

**Alternative 2**
- Lightering Location
- Transportation Corridor
- Ferry Route
- Natural Gas Pipeline

**Alternative 3**
- Transportation Corridor
- Port Site

US Army Corps of Engineers®

5 0 5 10
Miles

**TRANSPORTATION CORRIDOR FISH STREAM CROSSINGS**

**Table 3.24-3: Anadromous Waters Crossed by Access Roads and Pipeline along the Alternative 1 Transportation and Natural Gas Pipeline Corridor**

| Road | Tributary[1] | AWC Code | R.M.[2] | Feature | Species/Life-stage[3] |
|---|---|---|---|---|---|
| Mine Access Road | UTC 1.36 | 324-10-10150-2183-3057 | 0.4 | culvert | COr |
| Mine Access Road | UTC mainstem | 324-10-10150-2183 | 17 | bridge | Ks, Kr, Ss, Sr, COs, COr, CHs, Pp |
| Mine Access Road | UTC 1.34 | 324-10-10150-2183-3050 | 0.1 | culvert | COr |
| Mine Access Road | UTC 1.60 (2 crossings) | 324-10-10150-2183-3010 | 14 | Bridge + culvert | COs |
| Mine Access Road (Iliamna Spur) | Newhalen River | 324-10-10150-2207 | 9 | bridge | Kp, Ss, COp |
| Port Access Road | Gibraltar River | 324-10-10150-2196 | 1.2 | bridge | Ss, COp, CHs, ACp |
| Port Access Road | trib to Gibraltar River | N/A[4] | N/A | culvert | COr |
| Port Access Road | trib to Gibraltar River | N/A[4] | N/A | culvert | COr |
| Port Access Road | trib to Gibraltar River | N/A[4] | N/A | bridge | COr |
| Port Access Road | trib to 324-10-10150-2206 | N/A[4] | N/A | bridge | COr |
| Port Access Road | N/A | N/A[4] | N/A | culvert | COr |
| Port Access Road | N/A | N/A[4] | N/A | culvert | COr |
| Port Access Road | trib to Amakdedori Creek | 243-40-10010-2008 | 2.2 | bridge | Ss, COs |
| Port Access Road | trib to 243-40-10010-2008 | N/A[4] | <0.1 | culvert | COr |
| Port Access Road | trib to 243-40-10010-2008 | N/A[4] | 0.6 | culvert | COr |
| Port Access Road (Kokhanok East Variant section only) | trib to Kokhanok Bay | 324-10-10150-2206 | 1.0 | bridge | Ss, ACp |

Notes:
[1] Tributary name from R2 et al. 2011a, if available
[2] R.M. = river miles at crossing above mouth or confluence of tributary (approx.); n/a = distance unknown, channel not defined on map
[3] Species/Life-stage at crossing from AWC or PLP sampling. Species: K=Chinook, S=sockeye, CO=coho, CH=chum, P=pink; AC=Arctic char; Life-stage: s=spawning, r=rearing, p=present (life-stage not specified)
[4] New observation not listed in AWC at time of writing; lifestage based on species observation
AWC = Anadromous Waters Catalog
N/A = Not Applicable
UTC = Upper Talarik Creek

In addition to the channel crossings listed above (Table 3.24-3), two additional anadromous tributaries to UTC occur within 0.25 mile of the mine access road corridor or project facilities, and could be affected by mine operations (UTC tributaries 1.46 and 1.35).

### *Iliamna Lake*

Iliamna Lake is a large lake with a surface area of 1,012 square miles. Iliamna Lake and its numerous tributaries provide spawning and rearing habitat for all five species of Pacific salmon and resident salmonid species, including Dolly Varden and rainbow trout. Major tributaries associated with the project area include the Newhalen River, UTC, and the Gibraltar River. The western half of Iliamna Lake is wide, with linear margins and few islands; whereas the eastern half (particularly the far northeastern end) has a contorted shoreline with an abundance of bays, islands, and rocky shoals. The majority of tributaries, including those supporting anadromous species, enter Iliamna Lake on the northern shoreline and surrounding the eastern basin, including Kokhanok Bay; tributaries are relatively uncommon on the western shoreline.

Geomorphic studies conducted in 2018 describe beaches and nearshore lake habitats of the terminal locations (Paradox 2018b). The north ferry terminal site is characterized by a wide, gently sloping sand/gravel beach. Beach slopes averaged 13 to 18 percent at three measured transects; substrate consists of sand and rounded gravel with some cobbles at depth. The south terminal site consists of a gravel beach backed by a 20- to 30-foot bluff that transitions to a boulder beach at the bedrock point to the east. Average gradients at the three transects range from 11 to 17 percent. A small stream to the west of the terminal infiltrates the gravelly beach and provides a potential source of upwelling groundwater in the lake. Physical characteristics of Iliamna Lake are described in Section 3.16, Surface Water Hydrology.

Of the anadromous salmonids, sockeye is the most common species in Iliamna Lake, where they are known to use shoreline habitat for spawning (EPA 2014), particularly in the northeastern portion of the lake (Figure 3.24-5). Juveniles also immigrate to the lake from spawning tributaries to use lacustrine rearing habitats, particularly in the eastern half of the lake. Iliamna Lake is also heavily used by rainbow trout, which use a variety of lake habitats for summer foraging (PLP 2018b; Minard et al. 1992).

### *Port Access Road*

The port access road would extend from the south ferry terminal on the southern shore of Iliamna Lake to Amakdedori port, and includes eight material sites (Figure 3.24-5). The port access road would cross 39 fish-bearing streams, 10 of which are anadromous fish habitat (Table 3.24-3). The first would be a multi-span bridge over the Gibraltar River approximately 1.2 miles upstream of where it flows into Iliamna Lake. The Gibraltar River and Gibraltar Lake drainage and tributaries provide spawning and rearing habitat for sockeye, coho, chum, Arctic char, whitefish, and other resident species, including Dolly Varden and lake trout (*S. namaycush*). No stream crossings would occur on the 1.4-mile spur road that connects the south access road to the town of Kokhanok. In addition to the streams crossed by the port access road and pipeline, the lower mainstem Amakdedori Creek passes within 0.25 mile of the port facilities.

### *Kokhanok East Ferry Terminal Variant*

This variant brings the ice-breaking ferry to a terminal in the more protected waters of Kokhanok Bay, approximately 10 miles east of the south terminal (Figure 3.24-5). The ferry route would pass within 0.2 to 1.5 miles of several islands and Lookout Peninsula, over depths mostly between 60 and 150 feet. The shoreline of this variant location is generally rocky and deepens rapidly, suggesting that it is unlikely to be preferred spawning habitat (PLP 2018-RFI 078). The pipeline corridor in Iliamna Lake would mostly follow the same path as Alternative 1, but would come ashore east of Kokhanok, joining a road corridor extending east 5.4 miles to the ferry terminal variant, then south 6 miles to join the Alternative 1 route to Amakdedori port, 21 miles to the east. The variant portion of the road and pipeline corridor would cross seven non-anadromous channels requiring culverts, and one bridge crossing an anadromous stream supporting sockeye salmon spawning and the presence of Arctic char. The road and pipeline route is six miles shorter, and would avoid 18 crossings that occur under Alternative 1, including six channels with resident fish species, and five channels with anadromous fish, and the bridge crossing over the Gibraltar River.

### *Cook Inlet Portion of Natural Gas Pipeline Corridor*

Cook Inlet is a semi-enclosed estuary in southcentral Alaska that extends northeast approximately 180 miles from the Gulf of Alaska north to Anchorage. Cook Inlet is fed by a wide variety of rivers, the largest being the Susitna River at the northern end of the inlet, and the Kenai River draining into the middle reach of the inlet. The substrate composition of Cook Inlet is mostly mudflats along the margins, with sand, clay, pebbles, and cobbles farther offshore. Rocky outcrops and shoals occur in many areas, especially in association with bays and islands. An assessment of nearshore substrate composition between Cook Inlet and Shelikof Strait showed extensive boulder armoring, with approximately 49 percent exposed rocky shore, 31 percent mixed sand and gravel, 12 percent gravel beaches, 3 percent exposed tidal flats, and 2 percent coarse-grained sand (BOEM 2016). General flow patterns include a net inflow along the eastern side of the inlet, including the Alaska Coastal Current, with net outflow along the western side (Burbank 1977). Inflow of turbid glacial streams generally produces low visibility, particularly in proximity to river mouths and along the western outflow. Cook Inlet is subject to large tidal fluctuations (up to 40 feet), which results in strong rips and currents in many locations. Winter temperatures result in extensive ice formation in the upper inlet and in isolated bays, with maximum ice coverage in January; breakup typically occurs between March and May.

The natural areas of Cook Inlet most likely to be affected by the pipeline are the Lower Cook Inlet central zone and Kamishak Bay (Science Applications, Inc. 1977). The lower central zone is defined as the region north of the Barren Islands between Kamishak and Kachemak bays, and south of a line from Anchor Point to Chinitna Bay. This zone is an area dominated by tidal circulation, with mostly poorly sorted sands as bottom sediments (Science Applications, Inc.1977). Approximately half of the 104-mile pipeline route would traverse depths of 200 feet or more, with a substrate largely composed of sand, shells, and pebbles.

## <u>Amakdedori Port</u>

The Amakdedori port would be in the central portion of Kamishak Bay, which is a relatively shallow, rocky bay with low-energy tidal circulation (Science Applications, Inc. 1977). The southward net transport of water from upper Cook Inlet along the western shore carries heavy loads of suspended matter into Kamishak Bay. This transportation of water also results in the movement of drift ice, which forms in the shallow tidal flats of upper Cook Inlet, into Kamishak Bay. The drift ice thoroughly scours extensive stretches of the intertidal zone, resulting in relatively poor development of eelgrass beds (Science Applications, Inc. 1977). Rocky substrates (intertidal reefs and subtidal rocky substrate) occur along a substantial portion of the shorelines of Kamishak Bay, and on many offshore reefs and islets (GeoEngineers 2018b,c). Rock is the dominant substrate into the intertidal zone. Mud or other unconsolidated sediments composing beaches extend from the toe of the rocky habitat down into the subtidal zone.

Amakdedori Beach has a number of distinct reef complexes that occur in the vicinity of the port site, with varying proximity to the mainland nearshore environment. These range from rock reefs immediately adjacent to land (North Reef), to detached; but near the mainland (Thumb and Thumbnail) to offshore (Palmaria Plains and No Name). In the immediate vicinity of the port site is a moderate-gradient sand-gravel beach extending for approximately 5 miles (GeoEngineers 2018b,c). The environmental sensitivity index is defined as mixed sand and gravel beaches; and the coastal class is sand and gravel flat fan and/or narrow sand and gravel beach (NOAA 2018g).

The backshore is composed of a storm berm formed by large, woody debris with a broad flat riparian upland composed primarily of dune grass transitioning to low/dwarf shrub vegetation (GeoEngineers 2018b, 2018c). A substantial sandy-silt flat is present immediately south of the mouth of Amakdedori Creek. Along the periphery of the beach (north, south, and offshore) lie extensive intertidal and subtidal reefs that extend as much as 8 miles offshore, with gaps of deeper subtidal habitat mostly less than 30 feet between them. These reef habitats support dense marine macrovegetation dominated by rockweed, red algae, and kelps. The nearest documented eelgrass (*Zostera* spp.) bed to the Amakdedori port location is in a small cove about 4.4 miles south (NOAA 2018h).

Subtidal habitats are composed primarily of sand, cobbles, boulders, and bedrock. South of Amakdedori is an extensive reef complex dominated by Nordyke Island and Chenik Head Reefs (GeoEngineers 2018b, 2018c). The rocky shores of Nordyke Island and the large reef systems to north, east, and south of the islands include a complex of conglomerate rock with lower-elevation intrusions of sandstone, providing a variety of elevations and exposures. Broad reefs are also found south of Chenik Head into Amakdedulia Cove. Between Chenik Head and Nordyke Island, the subtidal habitat consists of mixed fines. North Reef is an extended reef system that starts at the northern end of Amakdedori Beach, and continues to Contact Point. The area of reef most proximal to the project is the southern periphery of the reef adjacent to the broad cobble-gravel habitat of Amakdedori Beach.

### 3.24.1.2 Resident and Anadromous Fishes

This section describes fish species that have the potential to occur in the EIS analysis area. Expected periodicity for each species and life-stage in the project area is shown in Table 3.24-4. Other fish life history characteristics are available through the ADF&G fish webpages (ADF&G 2018u). For a description of Bristol Bay and Cook Inlet commercial fisheries, refer to Section 3.6, Commercial and Recreational Fisheries.

## <u>Mine Site</u>

### *North Fork Koktuli River*

Chinook salmon, coho salmon, sockeye salmon, and chum salmon have been documented in the NFK watershed (Johnson and Blossom 2018). Pink salmon (*Oncorhynchus gorbuscha*) are documented in the mainstem Koktuli River and the UTC, but do not occur in the NFK. Other species found in the NFK watershed include rainbow trout, Dolly Varden, Arctic grayling, threespine stickleback (*Gasterosteus aculeatus*), ninespine stickleback (*Pungitius pungitius*), sculpins (including species such as slimy and coast range sculpin [*Cottus aleuticus*]), northern pike (*Esox lucius*), and whitefish (various species, including round whitefish [*Prosopium cylindraceum*], humpback whitefish [*Coregonus pidschian*], and least cisco [*Coregonus sardinella*]). The approximate stream mileage listed in the AWC (Johnson and Blossom 2018) for anadromous species and rainbow trout in the NFK by life-stage is given in Table 3.24-2. The relative distribution and composition of anadromous and resident salmonid species, based on AWC data (Johnson and Blossom 2018) and 2004-2008 Environmental Baseline Document s(EBD) (R2 et al. 2011a), is shown in Figure 3.24-2. Blue channels represent anadromous waters; yellow channels contained resident salmonids (RS), but anadromous fish were not recorded; green channels only contained resident non-salmonid fish species (NS). Red channels represent sampled stream reaches where no fish were captured or observed. Note that resident salmonids and non-salmonids generally occurred throughout the distribution of anadromous species.

**Table 3.24-4: Estimated Life-Stage Periodicities of Select Fish Species in NFK, SFK, and UTC Waterbodies**

| Species[1] | Life Stage | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chinook salmon | Adult Migration | | | | | | | ■ | ■ | | | | |
| | Spawning | | | | | | | ■ | ■ | | | | |
| | Fry Emergence | | | | ■ | ■ | | | | | | | |
| | Juvenile Rearing | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | Outmigration | | | | ■ | ■ | ■ | | | | | | |
| Coho salmon | Adult Migration | | | | | | | | ■ | ■ | ■ | | |
| | Spawning | | | | | | | | ■ | ■ | ■ | ■ | |
| | Fry Emergence | | | | ■ | ■ | | | | | | | |
| | Juvenile Rearing | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | Outmigration | | | | ■ | ■ | ■ | | | | | | |
| Sockeye salmon | Adult Migration | | | | | | | ■ | ■ | ■ | | | |
| | Spawning | | | | | | | ■ | ■ | ■ | ■ | ■ | |
| | Fry Emergence | | | | ■ | ■ | | | | | | | |
| | Juvenile Rearing | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | Outmigration | | | | ■ | ■ | ■ | | | | | | |
| Chum salmon | Adult Migration | | | | | | ■ | ■ | | | | | |
| | Spawning | | | | | | | ■ | ■ | | | | |
| | Fry Emergence | | | | ■ | ■ | | | | | | | |
| | Juvenile Rearing | | | | ■ | ■ | | | | | | | |
| | Outmigration | | | | ■ | ■ | | | | | | | |
| Pink salmon | Adult Migration | | | | | | | ■ | ■ | ■ | | | |
| | Spawning | | | | | | | ■ | ■ | ■ | | | |
| | Fry Emergence | | | | ■ | ■ | | | | | | | |
| | Juvenile Rearing | | | | | | | | | | | | |

**Table 3.24-4: Estimated Life-Stage Periodicities of Select Fish Species in NFK, SFK, and UTC Waterbodies**

| Species[1] | Life Stage | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Outmigration | | | | | | | | | | | | |
| Rainbow trout | Adult Rearing | | | | | | | | | | | | |
| | Spawning | | | | | | | | | | | | |
| | Fry Emergence | | | | | | | | | | | | |
| | Juvenile Rearing | | | | | | | | | | | | |
| Dolly Varden | Adult Rearing | | | | | | | | | | | | |
| | Spawning | | | | | | | | | | | | |
| | Fry Emergence | | | | | | | | | | | | |
| | Juvenile Rearing | | | | | | | | | | | | |
| Arctic grayling | Adult Rearing | | | | | | | | | | | | |
| | Spawning | | | | | | | | | | | | |
| | Fry Emergence | | | | | | | | | | | | |
| | Juvenile Rearing | | | | | | | | | | | | |
| Whitefish[2] | Adult Rearing | | | | | | | | | | | | |
| | Spawning | | | | | | | | | | | | |
| | Fry Emergence | | | | | | | | | | | | |
| | Juvenile Rearing | | | | | | | | | | | | |
| Northern[2] pike | Adult Rearing | | | | | | | | | | | | |
| | Spawning | | | | | | | | | | | | |
| | Fry Hatching | | | | | | | | | | | | |
| | Juvenile Rearing | | | | | | | | | | | | |

[1] Unless otherwise noted, periodicities taken from project baseline data documents or agency recommendations
[2] Periodicities estimated from Morrow 1980.
NFK = North Fork Koktuli
SFK = South Fork Koktuli
UTC = Upper Talarik Creek

The Nushagak drainage, which includes the NFK and SFK, supports the largest run of Chinook salmon in the Bristol Bay watershed, with annual escapements averaging about 80,000 fish (Brookover et al. 1997; ADF&G 2018w). The NFK supports greater numbers of Chinook and chum salmon than the SFK and UTC, and is second only to UTC for coho salmon. The majority of Chinook spawn in the first 10 miles of the NFK (NFK-A, Figure 3.24-2), approximately 20 miles downstream from the mine site (R2 et al. 2011a). Adult Chinook salmon have been documented entering the NFK as early as July 12, with peak documented spawner counts occurring between July 23 and August 4. Juvenile Chinook salmon are present year-round in the project area, consisting of three age classes, young-of-the-year (0+), yearlings (1+), and 2+. Surveys have shown highest abundance of summer and overwintering juvenile Chinook in the mainstem, 30 miles downstream of the NFK Tributary 1.19 and the mine site.

Adult sockeye have been documented entering the NFK as early as July 5, with peak documented spawner counts occurring in a 1-week window between July 27 and August 4. Juvenile sockeye salmon were observed in April, July, and August; and based on length frequency distributions, were young-of-the-year fish. Juvenile densities were low throughout the NFK, suggesting typical downstream migration to lake-rearing habitat soon after emergence.

Adult coho salmon have been documented entering the NFK as early as August 15, with peak documented spawner counts occurring between September 5 and September 28. Juvenile coho salmon are present year-round in the project area, consisting of four age classes: young-of-the-year (0+), yearlings (1+), 2+, and 3+ age; with the preponderance young–of-the-year overwintering and outmigrating as 1+ fish. Juvenile coho were the most common Pacific salmon inhabiting the NFK basin, where they used most of the mainstem and nearly all of the surveyed tributaries, including the upper headwaters.

Adult chum salmon have been documented entering the NFK as early as July 5, with peak documented spawner counts occurring between July 12 and July 20. In addition to Pacific salmon, rainbow trout were observed at several locations in the mainstem NFK downstream of the mine site, as well as in NFK Tributary 1.19, but their relative abundance was low compared to most other salmonids (R2 et al. 2011a).

### *South Fork Koktuli River*

Chinook, coho, sockeye, and chum salmon have been documented in the SFK watershed (Johnson and Blossom 2018). Pink salmon have not been documented in the SFK. Other fish species documented in the SFK watershed include rainbow trout, Dolly Varden, Arctic grayling, lamprey, threespine and ninespine stickleback, sculpin (may include slimy and/or coastrange sculpin), northern pike, whitefish (round whitefish, humpback whitefish, and/or least cisco), and burbot (*Lota lota*). Arctic char have also been documented in the SFK; however, fish surveys did not encounter this species (R2 et al. 2011a). Overall, the SFK supports more fish species than either the NFK or UTC. The approximate stream mileage listed in the AWC (Johnson and Blossom 2018) for anadromous species and rainbow trout in the SFK analysis area by life-stage is given in Table 3.24-2. The relative distribution and abundance of anadromous and resident salmonid species, based on AWC (Johnson and Blossom 2018) and EBD data (R2 et al. 2011a), are shown on Figure 3.24-3.

No anadromous fish were documented in the mine pit and associated sediment pond area during sampling in 1991, 2004, or 2008, although coho juveniles were observed in the mainstem SFK immediately downstream of the southern edge of the open pit and associated service road in a 2008 survey (Johnson and Blossom 2018).

Adult Chinook salmon have been documented entering the SFK as early as July 5, with peak documented spawner counts occurring between July 20 and August 1. Juvenile Chinook salmon are present year-round in the project area, consisting of 3 age classes: young-of-the-year (0+), yearlings (1+), and 2+. Densities of juvenile Chinook were higher in the mainstem SFK than in off-channel habitats, similar to the distribution seen in the NFK. Adult sockeye have been documented entering the SFK as early as July 5, with peak documented spawner counts occurring between July 23 and August 3. Densities of adult sockeye salmon were highest in the lower 20 miles of the mainstem SFK, as was noted for both Chinook and coho salmon (R2 et al. 2011a). Juvenile sockeye salmon were observed in April, July, and August; based on length frequency distributions, two age classes are indicated: young-of-the-year, and 1+ age fish. Juvenile densities were low throughout the SFK, suggesting typical downstream migration to lake rearing habitat soon after emergence. Adult coho salmon have been documented entering the SFK as early as August 15, with peak documented spawner counts occurring between September 5 and September 28. Coho salmon are more abundant and widely distributed in the SFK than are the other species of Pacific salmon (Table 3.24-2). Juvenile coho salmon are present year-round in the project area, consisting of four age classes: young-of-the-year (0+), yearlings (1+), 2+, and 3+ age; with the preponderance young–of-the-year overwintering and outmigrating as 1+ fish. The known upper limit of juvenile coho above Frying Pan Lake extends to the immediate region of the mine pit; however, juvenile densities are highest in the most-downstream reaches. Juvenile coho were observed in the lower reaches of the SFK during overwintering surveys.

Adult chum salmon have been documented entering the NFK as early as July 5, with peak documented spawner counts occurring between July 11 and July 26. Juvenile chum salmon were only observed in the vicinity of high redd densities, likely due to the abbreviated rearing periodicity of this species.

Ten resident fish species, including burbot and lamprey species, are found in low abundance throughout the SFK, with Dolly Varden and Arctic grayling considered the most widely distributed (R2 et al. 2011a).

### *Upper Talarik Creek*

In addition to the four species of Pacific salmon found in the NFK and SFK, the UTC also contains an intermittent run of pink salmon in the lower reaches. The UTC is also known as important habitat for large, adfluvial rainbow trout. Other resident species found in the UTC include Dolly Varden, Arctic grayling, whitefish (may include round whitefish, humpback whitefish, and/or least cisco), sculpin (may include slimy and/or coastrange sculpin) and two species of stickleback (i.e., threespine and ninespine). Arctic char have been documented in the UTC; however, no Arctic char were observed in environmental baseline studies (R2 et al. 2011a). The approximate stream mileage listed in the AWC (Johnson and Blossom 2018) for anadromous species and rainbow trout in the UTC by life-stage is given in Table 3.24-2. The relative distribution and abundance of anadromous and resident fish species, based on AWC data (Johnson and Blossom 2018) and EBD surveys (R2 et al. 2011a), are shown on Figure 3.24-4.

Pink salmon, which follow a strict 2-year lifecycle, are not common to the project area. However, more than 300 adult pink salmon were documented in the lower 4 miles of the UTC in 2006. Because only three pinks were observed in 2007, and zero in 2004, 2005, 2008, and 2009 (PLP 2018b), it is uncertain if the migrants represented a native run, or if they were strays from other watersheds. No juvenile pink salmon were observed during fish sampling surveys, which is not unexpected given that particular species' rapid seaward emigration as newly emerged fry.

Adult sockeye salmon were the most abundant salmonid in the UTC basin, which drains directly into Iliamna Lake, a major spawning and rearing area for sockeyes. Abundance of sockeye salmon in the UTC exceeded abundance in both the SFK and the NFK basins combined (R2 et al. 2011a). Chum salmon occur in the mainstem UTC up to Tributary 1.35, about 25 miles above the UTC mouth (Table 3.24-2) (Johnson and Blossom 2018). Chum salmon were the least-abundant salmonid species in the UTC basin (R2 et al. 2011a), with most observations of adult fish made during aerial surveys; terrestrial surveys documented very few juveniles, likely due to this species' early seaward migration.

The distribution of juvenile Chinook in the UTC is similar to the distribution of spawning, although juveniles have been observed higher in the headwater reaches, and also are known to inhabit additional tributaries, including UTC 1.35 and a west-side tributary immediately adjacent to the mine pit (R2 et al. 2011a). Chinook are also presumed to use the lower reaches of the UTC's largest tributary—First Creek or UTC 1.60—which flows into UTC 4 miles above Iliamna Lake.

Adult Chinook salmon have been documented entering the UTC as early as July 6, with peak documented spawner counts occurring between July 31 and August 8. Juvenile Chinook salmon are present year-round in the project area, consisting of three age classes: young-of-the-year, (0+), yearlings (1+), and 2+. Adult sockeye have been documented entering the UTC as early as July 5, with peak documented spawner counts occurring between July 17 and August 3. Juvenile sockeye salmon were observed in April, July, and August; and based on length frequency; distributions indicate two age classes: young-of-the-year, and 1+ age fish. Juvenile densities were low throughout the UTC, suggesting typical downstream migration to lake-rearing habitat soon after emergence.

Adult coho salmon have been documented entering the UTC as early as August 8, with peak documented spawner counts occurring between September 2 and September 5. Juvenile coho salmon are present year-round in the project area, consisting of four age classes: young-of-the-year (0+), yearlings (1+), 2+, and 3+ age; with the preponderance young–of-the-year overwintering and outmigrating as 1+ fish. Juvenile coho were observed in the upper reaches of the UTC during overwintering surveys.

Adult chum salmon have been documented entering the NFK as early as July 15, with peak documented spawner counts occurring between July 31 and August 3. Low numbers of juveniles have been observed in the UTC, consistent with the species life history of abbreviated river residence time after emergence.

Rainbow trout, Dolly Varden, slimy sculpin, and Arctic grayling are the only resident fishes documented in the headwater reaches near the mine site during baseline field surveys. Unlike the NFK and the SFK, rainbow trout were relatively common and widely distributed in the UTC basin, although only juveniles were observed in the headwater reaches near the mine site. Overall, densities of rainbow trout in surveyed reaches were low compared to most of the Pacific salmon species (R2 et al. 2011a). Non-migratory stream-resident rainbow trout are thought to occur in all three tributaries, but UTC also supports an adfluvial population of large trout that migrate between UTC, Iliamna Lake, and other lake tributaries. This species was targeted in a radio telemetry study in 2007 and 2008, where 97 adult trout were captured and tagged in UTC; 70 fish were subsequently tracked throughout the western half of Iliamna Lake and many of the lake's western tributaries through spring of 2009 (PLP 2018b). UTC-tagged trout visited 10 tributaries to western Iliamna Lake, with most detections in UTC, Lower Talarik Creek, Pete Andrews Creek, the Newhalen River, and the Kvichak River. Migration patterns included spring immigration into tributaries (presumably for spawning), and summer foraging throughout the western half of Iliamna Lake or in several tributaries; followed by fall immigration and overwintering in the lower mainstem reaches or outlet lagoon habitats of the five tributaries listed above (Minard et al. 1992). Only 12 to 13 percent of tagged trout returned to UTC for spring spawning or summer foraging, suggesting that some of the tagged fish were transients from other natal tributaries. Relatively few tag detections in Iliamna Lake occurred east of the line between Gibraltar Creek and the Newhalen River; however, a large proportion of detections occurred in offshore areas of western Iliamna Lake, suggesting a pelagic migratory pattern.

## Transportation and Natural Gas Pipeline Corridors

### *Mine Access Road*

Anadromous fish distributed in the UTC basin include Chinook, coho, sockeye, and pink salmon. Resident salmonid species found in the UTC include Dolly Varden, Arctic grayling, rainbow trout, and whitefish (may include round whitefish, humpback whitefish, and/or least cisco). Resident non-salmonid fishes observed during sampling in the 1990s and 2004-2008 were sculpin (may include slimy and/or coastrange sculpin) and two species of stickleback (threespine and ninespine). The AWC (Johnson and Blossom 2018) also lists Arctic char in the UTC; however, sampling conducted in the 1990s and in 2004-2008 did not encounter this species (R2 et al. 2011a).

As noted in Table 3.24-3, the mine access road would cross channels tributary to the UTC that support rearing and/or spawning by coho salmon, and the mainstem UTC at the bridge location is listed for spawning and rearing for Chinook, coho, and sockeye salmon, as well as spawning by chum and pink salmon. The crossing at First Creek (UTC 1.60) has coho-spawning life-stage in the immediate vicinity of the crossing, but there is also sockeye spawning and coho rearing downstream, and Chinook are listed as present. Sockeye spawning is the only life-stage specified at the Newhalen River bridge crossing, but the AWC lists unspecified life-stages for Chinook and coho as present at that location. Arctic char are also known to inhabit the Newhalen River between Sixmile Lake and Iliamna Lake. The Newhalen River serves as an important link between Iliamna Lake and Lake Clark, which supports large populations of sockeye salmon. Resident fish identified at that location include Arctic grayling, humpback and round whitefish, longnose sucker (*Catostomus catostomus*), rainbow trout, and slimy sculpin (Frissel 2014).

### *Iliamna Lake*

Over 20 fish species have been reported from Iliamna Lake, including all five anadromous Pacific salmon (Chinook salmon, coho salmon, chum salmon, pink salmon, and sockeye salmon), Arctic char, and lamprey spp. Eight non-anadromous salmonids (adfluvial populations of rainbow trout, Dolly Varden, lake trout, Arctic grayling, humpback whitefish, round whitefish, pygmy whitefish (*P. coulterii*), and least cisco) occur in Iliamna Lake, along with numerous non-salmonid species, including northern pike, slimy sculpin, threespine and ninespine stickleback, burbot, Alaska blackfish (*Dallia pectoralis*), longnose sucker, and pond smelt (*Hypomesus olidus*). The most common subsistence fishery is for sockeye salmon; but targeted fisheries also include Arctic grayling and whitefish (Holen and Lemons 2012). See Section 3.9, Subsistence, for more information on subsistence use.

The Kvichak Basin supports a genetically diverse assemblage of sockeye salmon, including 4 sub-stocks and 22 genetically distinct populations (T. Dann, Fisheries Geneticist, ADF&G, Anchorage, personal communication). Iliamna Lake is noted for supporting still-water spawning by large numbers of sockeye salmon. With some exceptions, annual aerial surveys of spawning salmon areas have been conducted since 1920 by ADF&G (Morstad 2003), which have detected shoreline spawning in most areas of Iliamna Lake, with heaviest spawning along island and bay habitats in the eastern lake basin. Aerial counts have shown wide annual and spatial variability, with index estimates for Woody Island (for example) ranging from 500 spawners to over 194,000 fish. Index counts from Knutson Bay have ranged from 1,000 to 1,000,000. Spawning in Iliamna Lake has typically represented between 1 to 3 percent of sockeye escapement in the Kvichak watershed (Morstad 2003). Input of marine-derived nutrients from carcasses of spawned-out salmon (particularly sockeye) is an important factor in the productivity of Iliamna Lake and its primary spawning tributaries (EPA 2014). The migration of juvenile sockeye leaving Iliamna Lake in late May and early June after lake ice-melt has been estimated at over 200 million fish over a 3-week period.

Fish and habitat surveys were conducted in 2018 near the ferry terminal locations in Iliamna Lake (Paradox 2018b, 2018c, 2018d). Nearshore fish were surveyed May through August near the ferry terminal locations using seine nets, snorkel surveys, and aerial visual surveys from a helicopter. The two most abundant species captured or observed in the seine and snorkel surveys were threespine stickleback and sockeye salmon. Other species captured or observed near the ferry terminal sites were chum salmon, coho salmon, pink salmon, Dolly Varden, longnose sucker, ninespine stickleback, pond smelt, and sculpin. No salmon spawning or pre-spawning behaviors were observed at the north or south ferry terminal locations, although adult sockeye salmon were observed from aerial surveys at every location in July and August.

Rainbow trout are widely distributed in the Iliamna Lake basin. Seventy of 97 radio-tagged adult trout were tracked throughout the western half of Iliamna Lake and many of the lake's western tributaries through spring of 2009 (PLP 2018b). UTC-tagged trout migrated from 10 tributaries to western Iliamna Lake, with most detections in UTC, Lower Talarik Creek, Pete Andrews Creek, the Newhalen River, and the Kvichak River. Migration patterns included spring immigration into tributaries (presumably for spawning), and summer foraging throughout the western half of Iliamna Lake or in several tributaries, followed by fall immigration and overwintering in the lower mainstem reaches or outlet lagoon habitats of the five tributaries listed above (Minard et al. 1992). Relatively few tag detections in Iliamna Lake occurred east of the line between Gibraltar Creek and the Newhalen River; however, a large proportion of detections occurred in offshore areas of western Iliamna Lake, suggesting a pelagic migratory pattern.

### *Port Access Road*

Four anadromous species/life-stages are listed in the AWC (Johnson and Blossom 2018) for the lower Gibraltar River (Table 3.24-3): coho present, chum spawning, sockeye spawning, and Arctic char present. Adult pink salmon were observed by snorkelers in the Gibraltar River in July 2018. Whitefish are also distributed throughout the lower Gibraltar River. The Amakdedori Creek tributary is an anadromous stream listed for coho spawning and sockeye spawning life-stages at the crossing location, and chum spawning is listed downstream of the location. Juvenile coho were the only salmon observed in the other eight streams with anadromous fish. Resident fish species observed in the 44 fish-bearing streams during 2018 sampling included chars (Dolly Varden or Arctic char), rainbow trout, Arctic grayling, stickleback (threespine and ninespine), northern pike, longnose sucker, burbot, and sculpin (not identified to species).

### *Kokhanok East Ferry Terminal Variant*

Specific fish sampling data are not currently available on fish resources for the Kokhanok East Ferry Terminal Variant or the seven channels crossed via culverts along the Kokhanok east section of the transportation and natural gas pipeline corridor; however, a single bridge crossing occurs over AWC stream 324-10-10150-2206, which is listed as supporting sockeye spawning and the presence of Arctic char.

### *Cook Inlet Portion of Natural Gas Pipeline Corridor*

All five species of Pacific salmon, Pacific herring (*Clupea pallasii*) and pond smelt are found in the Cook Inlet management area (Hammarstrom and Ford 2009 ). The Cook Inlet area also supports several important groundfish species, including sablefish (*Anoplopoma fimbria*), Pacific cod (*Gadus macrocephalus*), walleye pollock (*G. chalcogrammus*), lingcod (*Ophiodon elongatus*), and pelagic shelf rockfish species (*Sebastes* spp.). Other fish species includes sculpins, skates (*Rajidae*), sharks, commander squid (*Berryteuthis magister*), giant Pacific octopus (*Enteroctopus dofleini*), shortspine thornyhead (*Sebastolobus alascanus*), and numerous other rockfish species (Rumble et al. 2016). Flatfish species known to occur in Cook Inlet and/or Kamishak Bay include flathead sole (*Hippoglossoides elassodon*), rock sole (*Lepidopsetta bilineata*), arrowtooth flounder (*Atheresthes stomas*), and Pacific halibut (*H. stenolepis*), the latter of which are highly valued in both commercial and recreational fisheries. Other marine forage species that may occur proximal to the Cook Inlet pipeline route and/or the Amakdedori port include capelin (*Mallotus villosus*), Pacific sand lance (*Ammodytes hexapterus*), eulachon (*Thaleichthys pacificus*), gunnels (*Pholidae*), Pacific sandfish (*Trichodon trichodon*), pricklebacks (*Stichaeidae*), and lanternfish (*Myctophidae*).

Robards et al. (1999) conducted beach seines and mid-water trawls in nearshore habitats of lower Cook Inlet, and found a diverse near-shore fish community of at least 52 species. Spatial differences in species diversity and abundance were observed in Cook Inlet, likely due to local oceanographic conditions and sediment inflow. The study also found significant changes in fish community abundance and diversity between 1976 and 1996, apparently related to large-scale climate changes in the North Pacific.

Clams are abundant along many Cook Inlet beaches. Stocks of razor clams (*Siliqua patula*) are concentrated in the Polly Creek area on the western side of Cook Inlet, and along the eastern side from Anchor Point to Kasilof River. Other clam species include littleneck (*Protothaca staminea*) and butter clams (*Saxidomus giganteus*), (Szarzi et al. 2007). Several species of crab are found in the Cook Inlet area, including Tanner (*Chionoecetes bairdi* and *C. opilio*), and Dungeness crabs (*Metacarcinus magister* or *Cancer magister*) (ADF&G 2002b). Several species of shrimp are also found in Cook Inlet, including pink (*Pandalus borealis*), sidestripes (*P. dispar*), humpy shrimp (*P. goniurus*), coonstripe shrimp (*P. hypsinotus*), and spot shrimp (*P. platyceros*) (ADF&G 2002b). Other shellfish species include octopus, green urchin (*Strongylocentrotus droebachiensis*), sea cucumber (*Echinozoa*), and scallops (*Pectinoidea*). The predominant octopus species in Cook Inlet is the giant Pacific octopus (*Enteroctopus dofleini*).

## Amakdedori Port

Sockeye are abundant in several tributaries to Kamishak Bay, including the Kamishak, Paint, and McNeil rivers, and Kirschner, Mikfik, and Chenik lakes. The Amakdedori port site is in the historic floodplain of Amakdedori Creek, which currently enters Kamishak Bay 0.7 mile south of the port site. Amakdedori Creek had average annual sockeye salmon runs of 1,200 fish between 1970 and 1980, which increased to an average of 2,364 fish over the past 10 years (Hollowell et al. 2017). The recent 10-year average escapement of pink salmon to Amakdedori Creek was 7,500 fish (Hollowell et al. 2017). Other basins supporting strong runs of pink salmon in Kamishak Bay include the Bruin Bay River, Sunday Creek, and Browns Peak Creek. Principal chum salmon streams entering Kamishak Bay include the McNeil, Bruin, Iniskin, Kamishak, and Little Kamishak rivers, and Cottonwood Creek. See Section 3.6, Recreational and Commercial Fisheries, for more details on salmon runs and commercial fisheries proximal to the port site.

The existing fishery data were expanded by fish community sampling (March-July 2018) conducted by GeoEngineers (2018d) at seven locations, including Amakdedori Beach. In total, 27 beach seine samples were collected from the transportation and natural gas pipeline locations. Over 20 fish species (>1,400 specimens) were collected, with juvenile salmonids as the dominant group in all three areas. The number and density of species differed between areas. At Amakdedori Beach, 23 species were collected with juvenile salmonids (mostly pink and chum salmon), larval and adult surf smelt (*H. pretiosus*), juvenile whitespotted greenling (*Hexagrammos stelleri*), and starry flounder (*Platichthys stellatus*), making up 95 percent of the catch. Other species collected in low numbers included walleye pollock, flatfish (no ID), several sculpin species (*Cottidae*), Pacific sandlance (*Ammodytes hexapterus*), tomcod (*Microgadus proximus*), threespine stickleback, tubesnout (*Aulorhynchus flavidus*), and tubenose poacher (*Pallasina barbata*). Catch of larval surf smelt suggested drift of these larvae from other locations. Focused spawning surveys (8 sediment samples) at suitable spawning substrate at Amakdedori Beach yielded no forage fish eggs. These findings are similar to those from the earlier sampling. Trawl sampling at several locations in 2013 and 2018 produced relatively low catch rates (2 to 3 fish/set) near Amakdedori, in comparison to sets in the Iliamna and Iniskin Estuaries (IIE) and Ursus Cove areas.

Pacific herring spawning surveys in 2018 (GeoEngineers 2018d) were undertaken at low tides searching for eggs on eel grass and marine algae along Amakdedori Beach. Pacific herring spawn survey data suggested that the Amakdedori port facility is isolated from known spawning areas. Seine hauls along Amakdedori Beach caught an average of only 0.75 herring/set in 2018, compared to catches in the hundreds per set in surveys in the IIE. Due to low stock size, the commercial fishery for herring roe in Kamishak Bay has been closed since 1999 (Hollowell et al. 2017). Herring spawn primarily on eelgrass and rockweed, which is found predominantly south of the port facility around reefs associated with Nordyke Island and Chenik Head, and also north of the port near Contact Point. The reefs associated with areas closer to the Amakdedori port facility (North Reef, Palmaria Plains, and Thumb/Thumbnail) were dominated by *Palmaria* spp., kelp, and other species that are little used by spawning herring. Pacific herring have been documented to spawn on marine macrovegetation, particularly in May, along the northern and southern edge of the Amakdedori Beach sampling area. In 2018, however, no spawning activity was observed in or near the project footprint at Amakdedori Beach (GeoEngineers 2018d). The only observed spawning activities were more than 5 miles to the south of the port site near Nordyke Island in late April and mid-May; with heaviest spawning activities associated with a large contiguous bed of eel grass. Spawning was also observed on other species including rockweed (*Fucus distichus*).

### 3.24.1.3 Aquatic Invertebrates

#### <u>Mine Site</u>

Macroinvertebrates and periphyton (freshwater organisms attached to or clinging to plants and other objects projecting above the bottom sediments) community assemblages are an important component of the aquatic food web for salmonids, and effective indicators of habitat and water quality (Barbour et al. 1999). Due to their mobility, long lifecycle, and sensitivity to environmental conditions, macroinvertebrates have been frequently used for long-term monitoring, and have demonstrated their sensitivity to changes in ecological conditions (EPA 2002). Macroinvertebrate biological assessment indices have been developed for Cook Inlet Basin Ecoregion streams (Rinella and Bogan 2007), which demonstrated important macroinvertebrate community response to disturbance intensity in the region. Metrics such as number of taxa, percentage Ephemeroptera, Plecoptera, and Trichoptera genera (together referred to as "EPT genera"), and Shannon's Diversity Index (SDI) were found to decrease at sites with increased disturbance intensity, while other metrics such as percentage of dominant taxa increased with disturbance intensity (Rinella and Bogan 2007).

The Koktuli River watershed supports a rich and diverse macroinvertebrate community (Bogan et al. 2012). Sampling of wadeable streams of the Kvichak and Nushagak watersheds in the Bristol Bay region of Alaska, including the Koktuli and UTC watersheds, found mean site richness to be similar across four subwatersheds (ranging between 23 and 30 taxa), with Chironomidae family members the most common across all sites (Bogan et al. 2012).

Freshwater macroinvertebrate and periphyton surveys were conducted between 2004 and 2008 in the project area to characterize species diversity, abundance, density, and community structure. Study locations included the NFK River, SFK River, Kaskanak Creek, UTC, Chulitna River, Frying Pan Lake, and Big Wiggly Lake. Study locations correspond to monitoring sites for water quality, hydrology, and fisheries (Figure 3.24-2).

The methodological details for the 2004 to 2008 study period can be found in Chapter 15, Chapter 40, and Appendix F of the Pebble Project EBDs (R2 et al. 2011a). The resulting inventories serve as a basis for assessing potential project impacts.

### *Macroinvertebrates*

A total of 132 primary macroinvertebrate samples and duplicates at a minimum frequency of 10 percent were collected from the monitoring sites established in the project area. Macroinvertebrate metrics, as described in the Alaska Stream Condition Index (ASCI) protocol (Major et al. 2001) were calculated from macroinvertebrate data collected using the ASCI method and the Surber method (R2 et al. 2011a). These metrics are indicators of habitat change (Major et al. 2001), and include taxa richness, percentage EPT taxa; percentage Chironomidae family taxa (Chironomidae is within order Diptera); percentage other Diptera order taxa; percentage dominant taxon; and Community Tolerance Index (CTI).

The overall results for both the Surber method and the ASCI method indicate that Diptera, including the Chironomidae family, is the dominant taxon in the mine site project area; and Ephemeroptera is the majority taxa of EPT. Macroinvertebrate populations with a high proportion of Chironomidae family members in the population can indicate a more stressful aquatic habitat in general (Barbour et al. 1999). The aquatic conditions at the mine site include high numbers of Chironomidae family, which is considered typical for this area (Oswood et al. 1995).

These observations are consistent with aquatic-habitat surveys, which indicate that the analysis locations in the mine site area are composed mainly of riffle/cobble stream habitats with few to no human-caused effects. Measurements of habitat parameters at each location were found to be within ranges considered good to optimal for aquatic habitat (Major et al. 2001). Analysis of water quality results indicated good to optimal parameter levels for diverse macroinvertebrate communities, as is generally the case.

CTI reflects aquatic habitat quality, and is based on the relative tolerance of macroinvertebrate taxa to stressful conditions. CTI scores in 2004, 2005, and 2007 ranged from 3.9 through 6.1, 4.9 through 6.0, and 4.5 through 6.6, respectively (possible range of values 0-10).

### *Periphyton*

A total of 115 periphyton samples were collected, and additional duplicate samples were collected at a frequency of approximately 10 percent. The 2004 data indicated relatively uniform taxa richness across all seasons. Periphyton metrics were based on the taxa identifications. Taxa richness at all sample locations ranged from 12 to 19. The percentage dominant taxon at all sample locations ranged from 21 to 72 percent. The percentage dominant taxon in periphyton samples at times totaled more than 50 percent. This result is generally considered a negative indicator for stream health (Wehr and Sheath 2003). However, the stream reaches sampled are considered representative of unimpaired conditions, and occur in a region of minimal human effect. Measurements of water-quality parameters consistently fell within ranges considered good to optimal for aquatic habitat health. These results exhibit the natural variability in these environments.

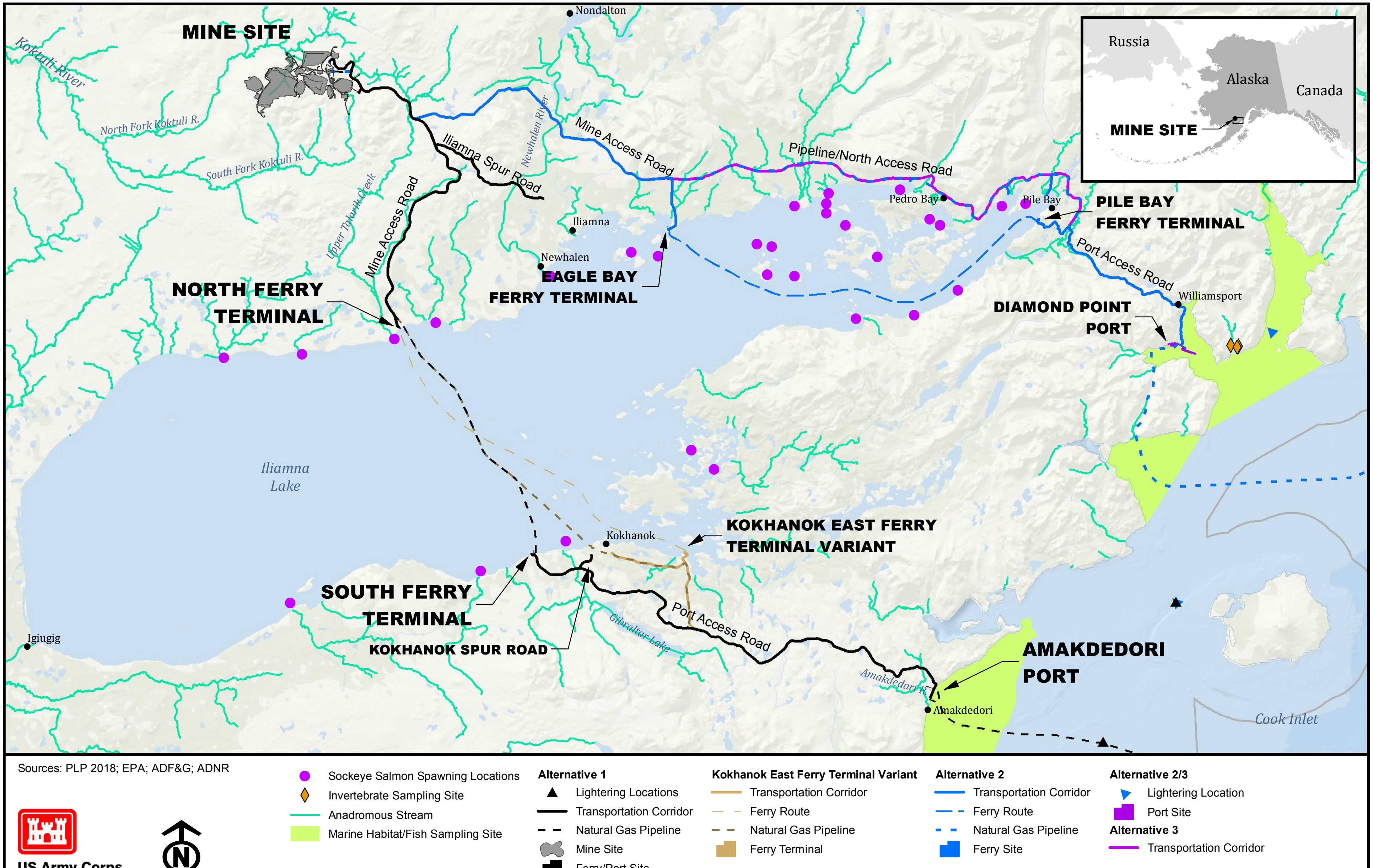
In 2005 and 2007, periphyton samples were analyzed for chlorophyll-a to quantify productivity. In 2005, average chlorophyll-a concentrations ranged from 2.1 milligrams per square meter ($mg/m^2$) to 17.0 $mg/m^2$, with variability among the samples. In 2007, average chlorophyll-a concentrations ranged from 2.3 $mg/m^2$ to 30.2 $mg/m^2$. No consistent temporal trends were observed in the chlorophyll data between 2005 and 2007, nor was there a trend found between macroinvertebrate taxa richness or percentage EPT and chlorophyll-a concentrations. However, Chironomidae often made up a high percentage of the taxa composition; and in many cases, was the dominant taxon, encompassing more than 50 percent of the sample. Some Chironomidae genera feed on periphyton, or prey on taxa that consume periphyton. In 2005, percentage Chironomidae was found to be highly correlated with chlorophyll-a concentrations ($R^2 = 0.7908$), but this trend was not as evident in 2007 ($R^2 = 0.1157$).

The survey results show that sample locations were composed largely of riffle/cobble habitat. Riffle/cobble is the preferred habitat of EPT taxa. The sampling results for the mine site indicate low-percentage EPT, high-percentage Chironomidae, and high-percentage dominant taxon, conditions which have been associated with poor stream health in other Alaska-based studies (Ott and Morris 2008). No statistically significant relationship was found between most water quality results and the macroinvertebrate metrics data. However, taxa richness in ASCI samples was negatively correlated with temperature.

## Transportation and Natural Gas Pipeline Corridors

Locations for macroinvertebrate and periphyton studies were selected to characterize conditions in the project area. Sampling was conducted at two sites: Y Valley Creek, and an unnamed creek site (see Figure 3.24-6). Because a relatively small portion of the transportation corridor would be in Cook Inlet drainages, only two locations were established for macroinvertebrate and periphyton sampling. Sample locations in the project area were selected based on undisturbed habitat with few to no human-caused effects. The methodological details for the 2004 to 2008 study period can be found in Chapter 15, Chapter 40, and Appendix F of the Pebble Project EBDs (R2 et al. 2011a).

Macroinvertebrate taxa richness was higher in the ASCI samples than in the Surber and the drift samples; and community assemblages were largely driven by Diptera taxa; and in most cases, Chironomidae. Of the Diptera taxa, the Orthocladiinae subfamily (within the Chironomidae family) tended to make up a large percentage of the samples. Of the EPT taxa, the Heptageniidae, Baetidae, Chloroperlidae, and Brachycentridae families were well represented in the Surber samples. The presence of these sensitive species is indicative of the comparatively optimal conditions at the site for macroinvertebrate colonization (Merritt and Cummins 1996).




**MARINE & INVERTEBRATE SAMPLING LOCATIONS AND ILIAMNA LAKE ALTERNATIVES**

PEBBLE PROJECT EIS

FIGURE 3.24-6

A range of macroinvertebrate habitats was sampled using the ASCI method, while only riffle/cobble habitat was sampled using Surber samplers. Taxa richness was greater in ASCI samples (15 to 16 taxa) than compared with Surber and drift samples (five and seven taxa, respectively). The difference in taxa richness indicates that greater taxa diversity is to be found in habitats other than riffle/cobble habitat. Macroinvertebrate studies in other regions have documented variability in taxa richness among samples (DePauw et al. 2006). However, there are insufficient data from this study area to statistically define trends or relationships with respect to particular sampling method variability, or timing of sampling.

An assessment of parameters related to habitat quality indicates optimal conditions at the unnamed creek and Y Valley Creek locations during all sampling events. Standard water quality parameter results were in the optimum range for aquatic life (Hem 1985). Dissolved oxygen (DO) levels at the unnamed creek were slightly supersaturated, indicative of cool stream temperatures and swift water conditions at the location. The locations sampled in this study were in an undisturbed area with few to no human-caused effects.

Periphyton metrics for the 2004 data were based on the taxa identifications. Taxa richness was greater for Y Valley Creek than for the unnamed creek (17 and 8 taxa, respectively). The percentage dominant taxon was much higher for the unnamed creek than for Y Valley Creek (79 percent and 35 percent, respectively). The percentage dominant taxon in periphyton samples at times totaled more than 50 percent. This result is generally considered a negative indicator for stream health (Wehr and Sheath 2003). However, the stream reaches sampled are considered representative of unimpaired conditions, pristine, and in a region of minimal human effect. Measurements of water-quality parameters consistently fell within ranges considered good to optimal for aquatic habitat health. These results exhibit the natural variability in these environments.

In 2004, one periphyton sample was collected from each of the two sampling locations, and then analyzed for diatom taxa composition. Results of this analysis indicate 19 diatom genera were present in the project area. In 2005, 10 periphyton samples were collected at one location (Y Valley Creek) and analyzed for chlorophyll-a to quantify productivity. In 2005, average chlorophyll concentrations were 2.4 $mg/m^2$. Diatom analysis revealed a diverse set of taxa present. Average chlorophyll-a concentrations for Y Valley Creek were in the normal range, compared to other studies in Alaska.

### *Cook Inlet Portion of Natural Gas Pipeline Corridor*

Coastal assessment studies in lower Cook Inlet have shown the area supports a healthy benthic community with balanced populations of species. Species abundance, richness, and diversity indexes are similar to undisturbed habitats and estuaries (Saupe et al. 2005). Investigations of the entire Cook Inlet area have found the lower Cook Inlet to be exposed to fewer contaminants than other locations in Alaska (Saupe et al 2005). Overall, Shannon-Weaver Diversity (H') for benthic communities (Saupe et al. 2005) ranged from 0.91 to 5.64. Polychaete worms have been found to be the most dominant taxonomic group in benthic communities.

Macroinvertebrates such as crabs, butter clams, little neck clams, shrimp, and octopus are present in the habitats of lower Cook Inlet, but are no longer commercially harvested; however, scallops are commercially harvested in lower Cook Inlet. Cook Inlet supports a large numbers of razor clams and a popular sport fishery on the western side of Cook Inlet. The eastern side of Cook Inlet has been closed to clamming since 2015, due to low population levels. This area does include sessile invertebrates such as coral, sponges (*Phylum Porifera),* sea whips (*Protoptilum sp*.), and sea pens (*Order Pennatulacea)* which are known to be import habitat for groundfish and crab and shrimp species. There are extensive sea whip and sea pen colonies in lower Cook Inlet, and these are known to increase survival of early settled weathervane scallops and Tanner crab. Pacific halibut and Pacific cod, two of the most important groundfish species in the area, consume a diverse diet of marine invertebrates, many of which are not commercially fished.

## Amakdedori Port

Assessment studies of the marine habitat area of Kamishak Bay have shown that the area largely consists of unconsolidated sediment habitats. These habitats vary widely, and support many species of marine invertebrates. The habitats vary from high-energy, relatively steep, cobble/gravel beaches to very fine silt/clay flats. The cliff bases and mountainsides largely have “mixed-fine” beach types that are often relatively productive due to the rock component, allowing development of epibiota and sediment that provide microhabitats for infauna (GeoEngineers 2018c).

Intertidal unconsolidated habitats were assessed as part of the baseline studies. The beach at Amakdedori is largely devoid of macrobiota, except where barnacles and ephemeral algae attach to larger boulders. This is due to substantial wave energy generated by wind waves and swells. Studies indicated that the lower beach face remains damp at low tides, and harbored epilithic bacterial and diatom films that potentially support smaller grazing crustaceans, which are known to provide prey for smaller fish that feed during high tides. Storm berms at the beach top were dominated by large amounts of large, woody debris interspersed with marine debris. Lower on the beach, accumulations of detached macro-algae were present, deposited by currents and waves that form wrack lines that harbor amphipods and insects feeding both terrestrial birds and shorebirds.

Off the mouth of Amakdedori Creek, a finer-grained delta flat extended out into the subtidal zone. This area supported a population of razor clams. The infauna of the lower beach included a limited variety of polychaetes and bivalves. This finer sand/silt beach supported a number of crustaceans, especially crangonid shrimp that are prey for fish and diving birds.

The area north of Amakdedori Beach includes a sharply rising upland that forms an eroding bluff. The upper beach face was a moderately high-energy boulder-cobble beach with occasional outcrops of bedrock. Elevation and wave energy combine to limit biological activity, except for beach hoppers (gammarid amphipods) associated with the wrack line and decaying algal fragments under boulders. Lower tidal elevations included beach hoppers, barnacles, two barnacle predators (6-rayed seastars, and drills) and scavenger hermit crabs. Grazing and ice scour likely prevented establishment of multi-year barnacles in this habitat. Boulder tops in some areas were coated with green and red algae.

A mix of soft habitat types occupied areas in North Reef, where sediment has accumulated in channels or over underlying bedrock to a depth that allowed the settlement and persistence of infauna, including a variety of bivalves, polychaetes, tube-building taxa, and cockles. The spoonworm was abundant in deeper, harder clay sediments adjacent to the southern portion of North Reef. Cobbles and gravel set in a hard clay matrix in this area limited the numbers of bivalves and polychaetes. Common algal species were present, including sugar kelp, acid kelp, and several reds. Subtidal unconsolidated habitats were assessed as part of the baseline studies. The unconsolidated habitats in subtidal areas of Amakdedori Bay vary. Study samples collected in the area yielded little actual sediment, indicating coarse gravel dominates. Shell fragments from sampling indicate a number of bivalves and several gastropods in this study area. The presence of these gastropods suggested substrate has a substantial hard substrate component (i.e., gravel and or cobble dominance). Samples collected in soft sediments yielded abundant gammarid amphipods, sand dollars, and polychaetes, dominated by relatively large species of Nephtys. Gravel and rock surfaces exposed above the sediment often support encrusting coralline algae, along with encrusting bryozoans and hydroids. Larger cobbles and boulders often were encrusted with barnacles, tube worms, and social tunicates.

### 3.24.1.4 Fish Tissue Trace Element Analysis

Data collected during the 2004-2008 period indicate that the concentrations of trace elements in fish tissue are generally low, and reflective of the natural conditions of the mine site area drainages. Some trace elements were detected at elevated concentrations. However, these concentrations are attributed to natural conditions, and are documented as existing or baseline conditions.

Fish samples collected between 2004 and 2008 included 345 whole body, 236 muscle, and 87 liver samples. These samples were collected from the waterbodies (NFK, SFK, and UTC) and several lakes in the mine site area, and represented several species of fish, including northern pike, Dolly Varden, Arctic grayling, coho and Chinook salmon, and whitefish. Most of the 14 target trace elements were detected in the samples, including methylmercury. Copper and zinc were present at the highest concentrations across different waterbodies. A wide variability of elemental concentrations was apparent over time and among waterbodies, fish species, and tissue types.

Differences in tissue copper concentrations appeared to reflect the differences in the underlying geology of the drainages. For example, whole-body copper concentrations in coho and Chinook salmon were higher in SFK than in the other two rivers. Copper-rich bedrock in the headwaters of SFK may explain this observation, because the underlying geology contributes significantly to the elemental concentration in the surface water and sediment substrates; and aquatic organisms and the fish uptake of trace elements occur via these environmental media and the food chain. Elemental concentrations were typically higher in liver than in muscle; substantially, for some elements (e.g., zinc).

The existing baseline data on fish tissue elemental concentrations represent the baseline or existing conditions that are reflective of the natural variabilities in the mine site area that arise due to various factors, such as biogeochemical differences among the major drainages, species- and element-specific differences in uptake, and accumulation of different trace elements by different fish species.

**Amakdedori Port Fish Tissue**

Most inorganic chemicals analyzed were detected in the fish (whitespotted greenling and starry flounder) collected near Amakdedori Beach; except antimony, beryllium, and thallium, which were not detected. Mercury slightly exceeded the tissue screening level in starry flounder. Starry flounder mostly forage on benthic communities found in soft or mixed-soft habitats, which suggests that the source of mercury in this system may be associated with fine-grained sediment habitats. This is supported by the sediment data, where mercury was detected in samples at both sampling sites with concentrations near screening levels. Simple bioaccumulation can explain the presence of mercury at these tissue concentrations (GeoEngineers 2018a.)

Selenium exceeded its screening level in whitespotted greenling. There is no clear source for selenium, based on sediment/water results for the same analyte. The magnitude of the exceedance is likely due to the higher trophic level at which greenling feed; generally, one level higher than starry flounder. Tin exceeded the screening level in the tissue from both marine fishes collected. No other inorganic chemicals were detected above the screening levels in marine fishes analyzed. Concentrations in tissue are representative of existing or background conditions, and are unlikely to represent a risk to the fishes sampled. Mercury may be a possible exception in that regional and global sources have contributed to elevated fish tissue concentrations; however, the exceedances of the screening level were low. In the case of the concentration in white-spotted greenling, it was lower than the average concentration ADEC reported in greenling from Alaskan waters. For a detailed report on fish tissue trace metals analysis, refer to EBD Chapter 10, Section 10.3.

### 3.24.1.5 Alternative 1 Variants

**Alternative 1 – Kokhanok East Ferry Terminal Variant**

See "Aquatic Habitat" section for descriptions of habitat and fishery resources associated with the Kokhanok East Ferry Terminal Variant.

**Alternative 1 – Summer-Only Ferry Operations Variant**

Aquatic habitat and fish distribution would be the same for this variant as that described in Alternative 1.

**Alternative 1 – Pile-Supported Dock Variant**

Aquatic habitat and fish distribution would be the same for this variant as that described in Alternative 1.

## 3.24.2 Alternative 2 – North Road and Ferry with Downstream Dams

**Mine Site**

The affected environment as described under Alternative 1 is applicable to Alternative 2.

### 3.24.2.1 Aquatic Habitat

**Transportation Corridor and Natural Gas Pipeline Corridor**

The Alternative 2 transportation corridor includes; the northernmost section the Alternative 1 mine site road, a spur road to a ferry terminal at Eagle Bay on Iliamna Lake, a stand-alone section of natural gas pipeline corridor north of Iliamna Lake, a ferry terminal at Pile Bay, and a spur road from Pile Bay to Diamond Point port following the existing Williamsport-Pile Bay Road alignment. Alternative 2 would include a total of 117 waterbody crossings, including 24 crossings of anadromous habitat and 32 crossings over resident fish habitat. Of this total, 82 drainages, including 34 fish stream crossings (15 over anadromous waters) would be crossed by the natural gas pipeline only (i.e., no adjacent road).

The stand-alone overland portions of the natural gas pipeline corridor are north of Iliamna Lake between Eagle Bay and Pile Bay ferry terminals (see Chapter 2). The gas pipeline would cross 82 stream channels, with 15 crossings over anadromous waters, 19 crossings over resident fish habitat, and 48 small channels designated as fishless (Table 3.24-5). The total number of crossings for this alternative is largely identical to Alternative 3, except in this alternative most crossings involve only the natural gas pipeline corridor (e.g., the ferry replaces most road crossings), whereas all of the Alternative 3 crossings involve both the road and adjacent natural gas pipeline. In addition to the anadromous channels crossed by the natural gas pipeline, the transportation corridor passes within 0.25 miles upslope of 3 other anadromous waters; a tributary to Pedro Bay (AWC 324-10-10150-2317-3035), Russian Creek (AWC 324-10-10150-

2323), and a tributary to Lonesome Bay (AWC 324-10-10150-2335), each of which are designated as sockeye spawning habitat.

Because of the large number of stream crossings associated with the Alternative 3 road and pipeline corridor (and the Alternative 2 pipeline corridor, Table 3.24-5), habitat and fish sampling was conducted and summarized according to six watershed groupings (R2 et al. 2011a, R2 and HDR 2011). The Isolated Watershed Group includes two watersheds that drain the southwestern flanks of Roadhouse Mountain; however, these isolated watersheds did not appear to have any surface connection to the Newhalen River or Iliamna Lake. The Roadhouse/Northeast Bay/Eagle Bay Watershed Group includes three watersheds that drain into Iliamna Lake: Roadhouse Creek, an unnamed tributary to Eagle Bay, and Eagle Bay Creek. The Youngs/Chekok/Canyon Watershed Group includes three watersheds that drain into the northern edge of Iliamna Lake: Youngs Creek, Chekok Creek, and Canyon Creek. The Knutson Bay/Pedro Bay Watershed Group consists of Knutson Creek and eleven unnamed tributaries that drain the western and southern sides of Knutson Mountain into Pedro Bay. The Pile Bay/Lonesome Bay Watershed Group includes the Pile River and two unnamed tributaries that flow into Lonesome Bay. The Iliamna River Watershed Group originates on the western side of the Chigmit Mountains and flows southwest into Pile Bay. Williams Creek is the only stream associated with the northern access corridor that drains into Cook Inlet.

The affected environment as described under Alternative 1 for the Cook Inlet portion of the natural gas pipeline is applicable to Alternative 2.

### *Mine Access Road*

The mine access road follows the Alternative 1 route from the mine site to 1 mile south of the bridge crossing the mainstem UTC (see Chapter 2); it then follows a route across the Newhalen River to the ferry terminal in Eagle Bay. Along this route, the road and adjacent pipeline would cross 22 stream channels, 8 of which are listed in the AWC as anadromous waters (Table 3.24-5), with another 7 channels inhabited by resident fish species. As noted above, the Newhalen River provides a migratory connection between Iliamna Lake and Lake Clark for large numbers of adult and juvenile sockeye salmon. Beyond the Newhalen River, the road and pipeline skirt the western and southern flanks of Roadhouse Mountain, where the road turns south to Eagle Bay, and the pipeline continues east towards Williamsport. See “Alternative 3 – North Road Only” section, below, for a description of the natural gas pipeline route east of Eagle Bay.

**Table 3.24-5: Anadromous waters crossed by access roads and pipeline along the Alternative 2 and Alternative 3 Transportation and Natural Gas Pipeline Corridor[1]**

| Tributary[2] | AWC Code | R.M.[3] | Feature | Species/Life-stage[4] |
|---|---|---|---|---|
| UTC 1.36, 1.34, and mainstem | See Table 3.24-2 for details | | | |
| N/A (tributary to Newhalen River) | 324-10-10150-2207-3027-4011 | 1.9 | culvert | COp |
| N/A (tributary to Newhalen River) | 324-10-10150-2207-3027-4011-5005 | 0.6 | culvert | COr |
| Newhalen River | 324-10-10150-2207 | 15.5 | bridge | Kp, Ss, COp |
| N/A (tributary to Eagle Bay) | 324-10-10150-2235 | 5.8 | culvert | Ss, ACp |
| Eagle Bay Creek[5] | 324-10-10150-2239 | 0.8 | n/a | COr, Ss, ACp |
| N/A (tributary to Eagle Bay Creek)[6] | 324-10-10150-2239-3005 | 2.4 | bridge | Ss, ACp |
| N/A (tributary to Chekok Bay)[6] | 324-10-10150-2261 | 5.6 | bridge | COp, Ss, ACp |
| N/A (tributary to Chekok Bay)[6] | 324-10-10150-2261-3006 | 1.0 | bridge | COp, Ss, ACp |
| N/A (tributary to Chekok Bay)[6] | 324-10-10150-2267-3001 | 2.7 | culvert | COp, Ss, ACp |
| Chekok Creek[6] | 324-10-10150-2267 | 3.3 | bridge | COp, Ss, ACp |
| Knutson Creek[6] | 324-10-10150-2301 | 1.6 | bridge | Ss, ACp |
| N/A (tributary to Lonesome Bay)[6] | 324-10-10150-2333 | 0.9 | bridge | Ss |
| Pile River[6] | 324-10-10150-2341 | 1.6 | bridge | Ss, ACp |
| Long Lake outlet[6] | 324-10-10150-2343 | 1.8 | bridge | Kp, Sp |
| N/A (3 crossings)[6] | 324-10-10150-2343-3006 | 0.4, 0.7, 0.9 | Culvert, bridge, culvert | Sp |
| Iliamna River | 324-10-10150-2402 | 4.1 | bridge | CHp, COp, Kp, Pp, Ss |
| Browns Peak Creek[7] | 248-10-10040 | 3.8 | N/A[7] | COr |
| Un-named[7] | 248-20-10030 | 0.2 | N/A[7] | CHp |

Notes:

[1] Listing represents stream crossings for Alternative 2 mine and port access roads and pipeline, and Alternative 3 north access road and pipeline
[2] Tributary name from R2 et al. 2011a, if available
[3] R.M. = river miles at crossing above mouth or confluence of tributary (approx.)
[4] Species/Life-stage at crossing (from AWC). Species: K=Chinook, S=sockeye, CO=coho, CH=chum, P=pink; AC=Arctic char; Life-stage: s=spawning, r=rearing, p=present (life-stage not specified)
[5] Eagle Bay Creek crossed by mine access road at RM 0.8 (Alternative 2 only) and pipeline at RM 4.0
[6] Streams crossed by pipeline only for Alternative 2, by both pipeline and north access road for Alternative 3
[7] Streams crossed only by pipeline for Alternatives 2 and 3; crossing feature not specified
AWC = Anadromous Waters Catalog
N/A = Not Applicable
UTC = Upper Talarik Creek

### *Iliamna Lake*

This alternative includes a ferry terminal site at Eagle Bay, approximately 20 miles east of the terminal for Alternative 1, with another ferry terminal site further east in Pile Bay (see Chapter 2, Alternatives). The 29-mile ferry route is adjacent to sockeye salmon spawning beaches on the southern side of Pile Bay (Southeast Beaches and Finger Beaches), and the along the islands important to spawning sockeye salmon (Porcupine Island, Flat Island, Ross Island, Triangle Island, and Eagle Island) (Morstad 2003). Although the islands contain extensive littoral shoal habitat, the ferry route would remain well offshore, where depths range from 200 to over 900 feet. Annual aerial surveys of spawning sockeye salmon in littoral habitats along Iliamna Lake have been conducted by ADF&G since 1920 (Morstad 2003). Spawning surveys have shown heavy use of the northeastern arm of Iliamna Lake, with highest densities associated with the main island archipelagos, Pedro Bay, and the Newhalen shoreline. Lower densities of spawning have been observed near Eagle Bay or along the southern shore of Pile Bay, which possesses minimal littoral habitat. Consequently, the midwater route of the ferry would not intersect known sockeye spawning habitat, except at the ferry terminal site in Eagle Bay. However, Pile Bay serves as a migration route for upstream migrant salmon (and trout) to the Iliamna River, Pile River, and several other anadromous tributaries, as well as an outmigration pathway for ocean-bound juvenile salmon.

Geomorphic studies conducted in 2018 describe beaches and nearshore lake habitats at the ferry terminal locations, including Eagle Bay North and Eagle Bay South (Paradox 2018a). Two habitat transects were measured at the Eagle Bay North location, which revealed an average slope of 13 percent, and substrates dominated by clean rounded gravel with few fines. The two Eagle Bay South transects had average gradients of 10 and 11 percent, with substrates ranging from rounded gravel on the beach sub-angular cobbles and boulders below depths of 5 feet.

### *Port Access Roads*

The Pile Bay ferry terminal site would connect to the existing Williamsport-Pile Bay Road via a 2-mile spur road. Realignments and improvements would be made to the existing road to Williamsport. From Williamsport, a new 3-mile spur road would extend south to the Diamond Point port site. No stream crossings are associated with the Pile Bay spur road, and a single crossing of a channel with resident fish species is associated with the Diamond Point spur road. The existing Williamsport-Pile Bay Road between the two spur roads contains 12 stream crossings, including a bridge over the anadromous Iliamna River (Table 3.24-5). Three other bridges and two culverts cross resident fish streams, with six culverts crossing fishless streams. Although the existing Williamsport-Pile Bay Road or natural gas pipeline would not cross Chinkelyes Creek, it would parallel anadromous waters for approximately 2 miles.

## <u>Diamond Point Port</u>

The port site at Diamond Point would be at the intersection of Iliamna and Cottonwood bays. Both bays are relatively shallow (mostly less than 40 feet in depth), with rocky substrates (intertidal reefs and subtidal rocky substrate) along a substantial portion of the shorelines and on many offshore reefs and islets (GeoEngineers 2018b, 2018c). Rock is the dominant substrate into the intertidal zone. Mud or other unconsolidated sediments composing beaches extend from the toe of the rocky habitat down into the subtidal zone. North of Diamond Point, the western side of Iliamna Bay has generally angular rubble or rocky upper reaches transitioning to mudflats at mid-tidal elevations. An extensive rock buttress projects into the intertidal zone from the base of a high cliff at the face Diamond Point. At the lower edge of this rock habitat, a sand/mud flat extends to the west into Cottonwood Bay, and to the north into Iliamna Bay. The lower elevations at Diamond Point are composed in part of bedrock similar to that at higher elevations. However, boulder /cobble habitat is found at the base of the bedrock and forms the upper edge of the lower mudflat. Scattered eelgrass is present along the shoreline between Diamond Point and Williamsport, as well as west of the point in Cottonwood Bay. More extensive reefs and eelgrass beds are found in the larger Iniskin Bay to the north of Iliamna Bay. Compared to IIE, minimal rock habitat exists on the northern shore of Ursus Cove in the vicinity of the natural gas pipeline route. Occasional ribs of bedrock and a few large boulders break up the generally uniform gravel and cobble beach.

### 3.24.2.2 Resident and Anadromous Fish

**<u>Transportation Corridor and Natural Gas Pipeline Corridor</u>**

The affected environment as described under Alternative 1 for the Cook Inlet portion of the natural gas pipeline is applicable to Alternative 2.

#### *Mine Access Road*

The eight anadromous streams that would be crossed by the mine access road and adjacent natural gas pipeline between the mine site and Eagle Bay have been documented to contain Chinook, coho, sockeye salmon, and Arctic char (Table 3.24-5). Resident species include slimy sculpin, rainbow trout, Dolly Varden, longnose suckers, and ninespine stickleback. See "Alternative 3 – North Road Only" section, below, for a description of fish resources along the natural gas pipeline route east of Eagle Bay.

#### *Iliamna Lake*

The ferry route for this alternative traverses the eastern portion of Iliamna Lake, including the vicinity of Eagle Bay and Eagle Islands, as well as the full length of Pile Bay. Lower densities of spawning have been observed near Eagle Bay or along the southern shore of Pile Bay—which possesses minimal littoral habitat—than in other bays and islands in the eastern basin (Morstad 2003). Fish and habitat surveys were conducted in 2018 near the ferry terminal locations in Iliamna Lake (Paradox 2018b, 2018c, 2018d). Nearshore fish were surveyed May through August, with spawning surveys conducted into September at the ferry terminal locations, using seine nets, snorkel surveys, and aerial visual surveys from a helicopter. The two most abundant species captured or observed in the seine and snorkel surveys were threespine stickleback and sockeye salmon. Other species captured or observed near the ferry terminal locations were Chinook salmon, coho salmon, ninespine stickleback, pond smelt, and sculpin.

Adult sockeye were observed swimming along the northern and southern shorelines of the Eagle Bay terminal site in July and August, with greater abundance of fish along the northern margin, and reduced numbers of fish in August (Paradox 2018c, 2018d). Although small areas of cleaned substrate was observed by snorkelers along the margin near the terminal site, none were subsequently developed into redds. A repeat survey in September revealed few adult sockeyes along the northern margin, and no further evidence of spawning or spawning behaviors was observed, although heavy spawning activities had already commenced in Knutson Bay during August. Additional information on fish resources in Iliamna Lake is described under Alternative 1, above.

Two anadromous tributaries flow into Eagle Bay, including Eagle Bay Creek (AWC 324-10-10150-2239), which is listed for coho rearing, sockeye spawning, and presence of Arctic char. The AWC tributary 324-10-10150-2235 is on the opposite shore of Eagle Bay from the port site, and is listed for sockeye spawning and presence of Arctic char. Historical spawner counts in Eagle Bay Creek have ranged from zero in 1963 to over 30,000 fish in 1975 (Morstad 2003).

### *Port Access Roads*

The port access road serving the Pile Bay ferry terminal would cross the Iliamna River approximately 4 miles above its mouth (Table 3.24-5). The Iliamna River supports all five species of Pacific salmon, including important spawning habitat for sockeye salmon. The Iliamna River and Chinkleyes Creek are important habitat spawning habitat for sockeye salmon. Aerial survey estimates indicate that hundreds of thousands of spawning sockeye salmon use the system in some years (Morstad 2003). Chinkelyes Creek is listed for sockeye spawning and presence of coho, with rainbow trout, Dolly Varden, and slimy sculpin also known to be present. The spur road from Williamsport to Diamond Point crosses a channel supporting resident fish species. All other streams crossed contain only resident fish species, or are expected to be fishless.

## Diamond Point

Pacific salmon return to numerous rivers in Kamishak Bay in proximity to the Diamond Point port site, including rivers entering Bruin Bay, Ursus Cove, Cottonwood Bay, and Iniskin Bay. Additional information on salmon runs in Kamishak Bay can be found under Alternative 1, above.

Marine fish and invertebrates were sampled in the IIE by beach seining, otter trawling, and gill or trammel netting in two different time periods (2004 to 2008, and 2010 to 2012) to establish baseline conditions and temporal variations in species composition and abundance in the marine habitat (Pentec Environmental/Hart Crowser 2011b). Additional sampling occurred in 2012 outside of the IIE, in the adjacent Cottonwood Bay, and immediately south in Rocky and Ursus coves for preliminary characterizations of the fish community (Hart Crowser 2015b). The use of multiple sampling gears provided a better coverage of several habitat types, potential spawning area, nursery areas, species distribution, and use in and outside of embayment in marine and estuarine environments.

Beach seine capture data from the IIE indicate that in the nearshore sandy/cobble habitats, 41 fish species were collected; however, not all species were captured at all stations and months. Overall, Pacific herring, juvenile pink salmon, juvenile chum salmon, Dolly Varden, surf smelt, and Pacific sand lance were the most common species captured in beach seines. The fishes captured in otter trawl represented fauna of open water and deeper waters than represented by seine. Some 28 species were captured, dominated by snake prickleback (*Lumpenus sagitta*), yellowfin sole (*Limanda aspera*), starry flounder, Pacific herring, and walleye pollock. In gill nets, Pacific herring (multiple-year classes) dominated the catch, followed by Dolly Varden in both sampling periods. Trammel nets mostly captured spiny dogfish (*Squalus acanthias*), starry flounder, Pacific halibut, and whitespotted greenling.

The capture of young Pacific herring and salmonids suggests that these species use these areas for rearing. The Pacific herring supported a strong commercial fishery for roe until 1998; it was closed for fishing in 1999 due to low abundance. However, biomass of Pacific herring has not improved to historical levels (ADF&G 2009). Pacific Herring spawning surveys in 2018 (GeoEngineers 2018a) were undertaken at low tides searching for eggs on eel grass and marine algae in the IIE. Surveys conducted in both 2013 and 2018 indicate that herring spawn primarily on eelgrass and rockweed in May. In the IIE, a light density of herring eggs was documented on eel grass in a small area containing depressions in the mudflat habitat. No other spawning events were documented in the IIE. Past and present surveys suggest that the IIE represents a minor contribution to Pacific herring spawning in Cook Inlet (Owl Ridge et al. 2019). Due to low stock size, the commercial fishery for herring roe in Kamishak Bay has been closed since 1999 (Hollowell et al. 2017). However, the capture of young Pacific herring and salmonids suggests that these species use these areas for rearing.

Studies conducted in 2018 involved 27 beach seine samples, from which over 20 fish species (>1,400 specimens) were collected, with juvenile salmonids as the dominant group in all three areas. The number and density of species differed between areas. Focused spawning surveys in IIE yielded no forage fish eggs. These findings are similar to those from the earlier sampling (GeoEngineers 2018d). The presence of both juvenile and larger salmonids indicated that species use the nearshore locations as migration corridors between marine and freshwater environments. Catch of larval surf smelt suggested drift of these larvae from other locations.

### 3.24.2.3 Aquatic Invertebrates

Locations for macroinvertebrate and periphyton sampling were selected to characterize diversity, abundance, and density in freshwater habitats in the transportation and natural gas pipeline corridor study area. The sampling locations are representative of streams in the Bristol Bay drainage. The study area for macroinvertebrates and periphyton consists of three stream-sampling sites. These sites occurred in unnamed streams that were named Bear Den Creek, Red Creek, and Ursa 100B for reporting purposes. The transportation corridor study area extends eastward beyond the Bristol Bay drainages into the Cook Inlet drainages. Section 15.4 in Chapter 15 (EBD) describes the macroinvertebrate and periphyton studies in the Bristol Bay drainages study area.

Aquatic habitat surveys indicate that the sample sites consisted largely of riffle/cobble habitat, which is the highest-quality habitat for EPT taxa. At sites sampled in 2005, the proportion of riffle/cobble habitat in each stream reach ranged from 70 to 85 percent.

A range of macroinvertebrate and periphyton sample-collection methods was employed during the field sampling. Slightly more taxa per site were collected using the ASCI method in 2004 than in 2005, indicating possible inter-annual variability. The number of taxa collected in 2005 from riffle/cobble areas by Surber sampler was generally less than in the ASCI samples, which were collected in more diverse habitats. Macroinvertebrate studies in other regions have documented variability in taxa richness among samples (DePauw et al. 2006). However, there are insufficient data from this study area to statistically define trends or relationships with respect to particular sampling method variability, or timing of sampling.

There were 235 macroinvertebrate taxa, including 64 Chironomidae taxa, identified in the Bristol Bay drainages study area (which includes both the mine and the transportation corridor study areas). Three of the non-Chironomidae macroinvertebrate taxa and three of the Chironomidae taxa were identified only in transportation corridor study area samples. The differences in numbers of taxa collected between the two sampling years are attributed to changes in the sampling program.

Dipteran taxa were not dominant at sampling sites in the transportation corridor study area. In 2005, Diptera composed a higher percentage than EPT in ASCI samples from all the sites, while EPT taxa composed a higher percentage than Diptera in Surber samples from all the sites. This may indicate that there were more Dipteran taxa in the variable habitats sampled using ASCI methods. Periphyton taxa richness and chlorophyll-a concentrations were both higher at Bear Den Creek than at the other two sites.

In 2005, Diptera comprised a higher percentage than EPT in ASCI samples from all the sites, while EPT taxa comprised a higher percentage than Diptera in Surber samples from all the sites.

Measurements of water-quality and habitat-quality parameters at each site fall within ranges considered good to optimal for aquatic and riparian habitat (Major et al. 2001). The concentration of DO was consistently high at all sites, and supersaturation (DO higher than 100 percent) was found at some sites. Water temperature ranged from 5.5°C to 13.2°C, and was much lower in 2005 than in 2004, except at Ursa l00B. No statistical analyses were performed on water quality and macroinvertebrate metric data because of limited data, and no trends were noted.

## Epibiota

Epibiota surveys were conducted in intertidal zones representing a wide range of habitats (Figure 3.24-6). Diverse intertidal habitat types provide feeding areas for numerous pelagic fish (which live in the open ocean) and demersal fish (which live close to the ocean floor), and invertebrates in lower Cook Inlet. In the rocky intertidal habitats, the distribution of vegetation and invertebrates is determined by elevation, substrate, season, and exposure to physical stressors, such as waves, sun, and ice scour. Diversity of both plants and animals among the rocky stations tend to increase with declining wave exposure and salinity, and increasing sediment load. Ice is another major stressor of the biologic communities, because winter ice can severely reduce or completely remove sessile epibiota (immobile organisms that live on the surface of other organisms) each winter.

Baseline sampling results indicated several trends in the data. Fewer species of algae less tolerant of saline and variable light (i.e., more estuarine) conditions were present; and areas with high wave exposure had the greatest potential for high macroalgal diversity due to the high levels of disturbance, and greatest exposure to a larger recruiting stock, particularly at Cook Inlet waters.

Subtidal sampling for epifauna had limited visibility and detected relatively sparse epifaunal abundance. Kelp was prevalent closest to shore. Rocky substrate dominated most diver transects; therefore, invertebrate fauna was dominated by mobile organisms. Common attached invertebrates included sponges, hydroids, sea anemones, rock jingle, and bryozoans. Common mobile invertebrates included snails, chitons, nudibranchs, crabs, and sea stars. Few demersal fish were observed. Bottom-oriented fish like whitespotted greenling, starry flounder, and other flatfishes were common.

## Infauna

Intertidal infauna (animals that live in ocean floor sediments) studies were conducted at multiple intertidal stations between 2004 and 2008 (Figure 3.24-6).

Intertidal infauna study results indicate that all animals identified at the genus level are abundant in marine assemblages elsewhere in Alaska (Blanchard et al. 2003). Between 2004 and 2008, differences in abundance, biomass, and diversity were found in the infauna sampling results. These differences reflect small-scale spatial and temporal occurrences, and illustrate the constantly shifting baseline conditions in the intertidal infauna assemblage.

Intertidal studies found that the average number of infaunal taxa observed per square meter ranged from 1.6 to 8.0 in 2004, and ranged from 1.6 to 14.2 in 2008.

Subtidal study results indicate stability in subtidal ecology through time. The variability of the results of subtidal faunal measures was considerable, but is comparable to the results of studies of similar marine assemblages elsewhere (Feder et al. 2005). Communities are dominated by a few taxa with high abundance, and there is a moderately diverse assemblage of taxa within sites.

Subtidal infauna was, overall, more abundant and more diverse than intertidal infauna. Greater stability and lower stress in subtidal environments lead to more abundance and diversity. Intertidal environments experience increased wave action, large temperature and salinity shifts, and seasonal ice-gouging, which exert more stressful influences not experienced in subtidal habitats. Despite the physical stresses, some areas of the intertidal environment exhibited substantial biomass of large infauna that far exceeded the subtidal biomass. In addition, the infauna at subtidal stations exhibited a higher degree of within-station similarity than did the infauna at intertidal stations—a reflection of the greater diversity of intertidal substrates; again, likely a consequence of the harsher nature of the intertidal environment.

Subtidal studies found that coarse substrates dominated the area, and the biota therefore reflected this habitat type. Attached and burrowing animals, rather than burrowing infauna, dominated the diverse transects. The average abundance of all taxa observed ranged from 2,210 to 5,150 per square meter. Biomass ranged from 25.9 to 298 grams per square meter. The number of taxa observed ranged from 26 to 40 among sites sampled.

### 3.24.2.4 Alternative 2 Variants

**Alternative 2 – Summer-Only Ferry Operations Variant**

Aquatic habitat and fish distribution would be the same for this variant as that described in Alternative 2.

**Alternative 2 – Pile Supported Dock Variant**

Aquatic habitat and fish distribution would be the same for this variant as that described in Alternative 2.

## 3.24.3 Alternative 3 – North Road Only

**Mine Site**

The affected environment as described under Alternative 1 is applicable to Alternative 3.

### 3.24.3.1 Aquatic Habitat

**Transportation and Natural Gas Pipeline Corridors**

The north access road and natural gas pipeline route would include an 82.3-mile-long corridor that would skirt the eastern edge of Iliamna Lake, thereby avoiding a ferry crossing of Iliamna Lake (Figure 3.24-5). The natural gas pipeline would be buried adjacent to the road alignment to Diamond Point, then would cross Cook Inlet to the Kenai Peninsula, as described above.

The affected environment associated with the natural gas pipeline described under Alternative 2 is applicable to the transportation and pipeline route in Alternative 3. The number of road and pipeline crossings for Alternative 3 is very similar to Alternative 2 (Table 3.24-5), with one fewer crossing of an anadromous channel. Alternative 2 crosses Eagle Bay Creek in two locations (one for the road, one for the natural gas pipeline), whereas the Alternative 3 road and adjacent natural gas pipeline crosses it in a single location.

**Diamond Point Port**

The affected environment as described under Alternative 2 is applicable to Alternative 3.

### 3.24.3.2 Resident and Anadromous Fish

**Transportation and Natural Gas Pipeline Corridors**

As described above, the transportation and natural gas pipeline corridors would cross numerous rivers, lakes, streams, and lake outlets in several different watersheds. Most of these watersheds drain into Iliamna Lake, with the exception of the Isolated Watershed Group, where precipitation, evaporation, and groundwater exchange appear to be the dominant hydrologic process.

See Table 3.24-2 for a description of fish species found in the UTC and Newhalen watershed groups. No fish were found in the Isolated Watershed survey sites during the October 2007 sampling. Four fish species were documented at the primary survey sites in the Roadhouse/Northeast Bay/Eagle Bay Watershed Group: slimy sculpin, Dolly Varden, rainbow trout, and ninespine stickleback. Coho salmon, sockeye salmon, and Arctic char are also known to occur in this watershed group. Sockeye salmon, rainbow trout, Dolly Varden, and slimy sculpin were found at sites in the Youngs/Chekok/Canyon Watershed Group. Other fish known in this group include coho salmon and Arctic char. In the Knutson Bay/Pedro Bay Watershed Group, sockeye salmon, Dolly Varden, and slimy sculpin were documented at several sites, and Arctic char are also known to be present in this watershed. Slimy sculpin and threespine stickleback were documented in primary and support survey sites in the Pile Bay/Lonesome Bay Watershed Group. Although no salmon were observed during the fish surveys, sockeye salmon and Arctic char are known to be present. Sockeye salmon, Dolly Varden, and slimy sculpin were observed in the Iliamna River Watershed Group. Approximately 3,000 adult sockeye salmon were observed at two support survey sites in August 2004. Williams Creek, which drains into Cook Inlet at Williamsport, contained Dolly Varden when sampled in 2004.

**Diamond Point Port**

See description of fish resources at Diamond Point under Alternative 2.

**Alternative 3 – Concentrate Pipeline Variant**

The habitat and fishery attributes associated with this variant are expected to be similar to Alternative 3, except the road footprint would typically be widened by less than 10 percent to place the 6.25-inch-diameter concentrate pipe alongside the natural gas pipeline. A slight increase in the footprint of the port facility would be required to store concentrate and to treat and discharge the filtrate water. If the filtrate water is pumped to the mine site rather than discharged at the port site, an 8-inch return-water pipe would be placed in the concentrate/natural gas pipeline trench, which would widen the road corridor by a few additional feet.

## 3.24.4 Alternatives Fish Stream Crossing Summary Table

A comparison of number of stream crossings, fish streams, anadromous streams, and resident fish is given in Table 3.24-6.

**Table 3.24-6: Fish Stream Summary Table**

| Alternative | Stream Crossings | Fish Streams | Anadromous[1] | Resident[2] |
|---|---|---|---|---|
| Alternative 1 – Mine Access Corridor | 30 | 10 | 6 | 4 |
| Alternative 1 – Port Access Corridor | 65 | 39 | 10 | 29 |
| Alternative 1 – Port Access Corridor – East Kokhanok Variant | 55 | 34 | 6 | 28 |
| Alternative 2 – Road Sections | 35 | 22 | 9 | 13 |
| Alternative 2 – Pipeline Sections | 82 | 34 | 15 | 19 |
| Alternative 3 – Road and Pipeline Sections | 116 | 55 | 23 | 32 |

Notes:
[1] Data from AWC catalog
[2] Resident fish stream data from EBD, RFI 85 2018 fish survey data
AWC = Anadromous Waters Catalog

## 3.24.5 Climate Change

Detailed analysis of long-term climate change and how it relates to aquatic habitats is discussed in Sections 3.16 and 4.16, Surface Water Hydrology.