3.24 FISH VALUES

3.24.1 Action Alternative 1 – Applicant's Proposed Action

3.24.1.1 Aquatic Habitat

Mine Site

The mine site would be located in the Koktuli River and Upper Talarik Creek (UTC) watersheds.

The 36-mile North Fork Koktuli (NFK) and 40-mile South Fork Koktuli (SFK) rivers join to form the Koktuli River (KR), 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 KR 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 within the NFK watershed, including the most of the tailings storage facility (TSF), pyritic TSF, water management ponds (main and open pit), mill site/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 represents 0.3 percent of Bristol Bay's 39,184-square-mile watershed area. Approximately 23 percent of the NFK basin area and 15 miles of mainstem channel are upstream of the mine site footprint. The Alaska Department of Fish and Game (ADF&G) Anadromous Waters Catalog (AWC) (ADF&G 2018) lists 12 anadromous fish-bearing tributaries entering the NFK, including Tributary 1.19, which would contain the majority of the mine site footprint.

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. 2011). 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. 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).

Comment [A1]: NPS staff with significant field time in this region respond to this description with the following: "the North Fork Koktuli is not a single-thread channel, rather it is a highly diverse system containing braided sections, wetlands, floodplains, beaver complexes, and during spring and fall, when it floods, this system joins with the Upper Talarik system headwaters."

Beaver ponds and other off-channel habitats are widely distributed 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

Comment [A2]: This supports the fact that the the NFK is not a single channel.

Schlumberger 2011). See Section 3.22, Wetlands, 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. 2011). 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 UT 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.

Comment [A3]: Fish, particularly age 1 and 2 Chinook Salmon, rear throughout the mainstem NFK as well as in the abundant off channel ponds and tributaries that were not studied.

Chinook salmon spawning habitat occurs throughout the lower 20 miles of the NFK below the mine site, 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 approximately 20 miles downstream from the mine site (R2 et al. 2011). 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, 5 miles above the SFK confluence; 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.

Comment [A4]: The study conducted by R2 was not sufficiently rigorous or quantitative to determine where the majority of location by species. Their studies only focused on the mainstem away from the mine site, excluded all tributaries and off channel habitats, used varying methodology, does not provide a clear picture of salmon and therefore subsistence species use of the habitats in that area. Their biological models were based on very few observations.

Coho salmon 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 based on field observations (R2 et al. 2011).

Comment [A5]: No defensible quantitative habitat "preference" studies were conducted to support such a statement. Studies were conducted on portions of the 3 mainstem rivers well away from the mine impact zone; smaller tributaries that occur throughout the watersheds and extend into the proposed mine site and support Coho, Sockeye, Chum, and Chinook spawning and Coho, Sockeye, and Chinook rearing as well as resident species were not studied.

Sockeye salmon spawning habitat primarily occurs in the lower 10 miles of the NFK, but the run extends upstream to the vicinity of Big Wiggly Lake (R2 et al. 2011). 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. 2011). 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. 2011). 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 2011, 2015).

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. 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 Hydrology.

Comment [A6]: During flood events in spring and fall the NFK, SFK and UTC can all be joined at the headwaters and the wetland complex unites into one very large wetland. This indicates that there can be mixing and potential transference among basins.

Comment [A7]: Groundwater transfers from SFK to UTC; This should be mentioned. See EBD.

Figure 3.24-1: North Fork Koktuli, South Fork Koktuli, and Upper Talarik Creek Basin Map

Table 3.24-1: Proportion of Habitat Types within 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	-
	B	0.65	0.34	0.01	0.00	-
	C	0.56	0.42	0.02	0.00	-
	D	0.46	0.45	0.01	0.08	-
	E	0.30	0.28	0.02	0.40	-
	Off-Channel	-	-	-	0.85	0.15
SFK	A	0.65	0.32	0.03	0.00	-
	B	0.44	0.54	0.02	0.00	-
	C	0.27	0.64	0.05	0.04	-
	D	0.55	0.24	0.03	0.18	-
	Off-Channel	-	-	-	0.91	0.09
UTC	A	0.54	0.45	0.01	0.00	-
	B	0.53	0.44	0.03	0.00	-
	C	0.24	0.74	0.02	0.00	-
	D	0.16	0.77	0.07	0.00	-
	E	0.19	0.69	0.12	0.00	-
	F	0.20	0.51	0.22	0.07	-
	G	0.76	0.23	0.01	0.00	-
	Off-Channel	-	-	-	0.93	0.07

[1] Includes mainstem reaches and off-channel habitats outside of the mine site analysis area or in the transportation analysis area

[2] Other off-channel habitats include beaver pond outlets, alcoves, isolated ponds, side channels, and percolation channels

Source: R2 et al. 2011

Comment [A8]: How was this estimated and where can the data be found? NPS was unable to locate the reference.

Comment [A9]: Please provide source, unavailable to verify.

The observed water temperatures in the NFK ranged from a low of 0.3 to a maximum of 21.9 degrees Celsius (°C) (R2 et al. 2011). 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 2009) 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 1.19 and Sub-tributaries

Tributary 1.19 and sub-tributaries to the NFK would contain the majority of the mine site footprint. A summary of the aquatic habitat in Tributary 1.19 is provided below.

Tributary 1.19 is 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 (*Oncorhynchus tshawytscha*), and rearing and spawning for coho salmon (O. kisutch). Resident fish species include Arctic grayling (*Thymallus arcticus*), Dolly Varden (*Salvelinus malma*), rainbow trout (O. mykiss) and slimy sculpin (*Cottus cognatus*).

Stream 1.19b is an incised, coarse gravel and cobble bed stream flowing through glacial drift deposits with heavily vegetated banks, and a slope of 1 percent that drains approximately 4 square miles. The channel goes dry during winter and summer low-flow periods due to the small drainage area, steep terrain, and lack of ponds or other storage features. The stream also loses groundwater to the upper mainstem of the NFK, which contributes to dry channel conditions during low-flow periods. Coho salmon have been documented using this stream as rearing habitat.

South Fork Koktuli River

The SFK River extends approximately 40 miles upstream from the confluence with the NFK to the headwaters, including over 60 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 3.24-2). 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.

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. 2011), 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 is 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 intermittent reach from 2 miles below Frying Pan Lake to SFK Tributary 1.19 (R2 et al. 2011). This reach has been observed dry during summer and/or winter low-flow periods from 2004 to 2008 (Knight Piésold et al. 2011). 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 re-emerges at the downstream end of the dry reach 20 miles above the NFK confluence (Knight Piésold et al. 2011).

Comment [A10]: However, fish move among available habitats during spring and fall especially, when floods occur and connect all three basins.

Chinook salmon spawning habitat has been documented from the SFK/NFK confluence upstream to Frying Pan Lake (Table 3.24-2), although more recent sampling indicated preferred spawning habitat occurs in the lower 20 miles of the SFK (R2 et al. 2011). As noted above, the mainstem SFK from SFK Tributary 1.19 to 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.

Comment [A11]: If more rigorous spawning preference studies have been conducted for this region please share with cooperating agencies.

Comment [A12]: Chinook Salmon are documented in the mine footprint, see the AWC.

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, and in two tributaries: SFK 1.13 and SFK 1.19 (R2 et al. 2011). 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 the reaches SFK-A and SFK-B (Figure 3.24-3).

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).

Chum 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, where accretion of groundwater is most evident (R2 et al. 2011). Rainbow trout habitat occurs in several reaches of the SFK, including upstream of Frying Pan Lake and tributaries, but densities of this species were lower than for other resident salmonids (R2 et al. 2011).

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. 2011). 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 2009) at several water quality stations in the upper SFK.

Upper Talarik Creek

UTC flows south about 39 miles from its headwaters on the eastern edge of the mine site downstream into Iliamna Lake near the town of Iliamna (Figure 3.24-1). The UTC watershed is approximately 135 square miles, representing 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 (Figure 3.24-2). 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. 2011). 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;

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. 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. 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 2011); 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 UT.

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. 2011). 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. Although summer water temperatures did sometimes exceed the ADEC 15° C criteria for aquatic life and fish life-stages (ADEC 2009), 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.

Figure 3.24-2: Map of North Fork Koktuli Watershed

Figure 3.24-3: Map of South Fork Koktuli Watershed

Figure 3.24-4: Map of Upper Talarik Creek Watershed

Table 3.24-2: Estimated Mileage[1] of Habitat for Pacific Salmon and Rainbow Trout in Tributaries Draining the Mine Site

Subbasin	Species	Spawning (mi)[2]	Rearing (mi)[2]	Present (mi)[3]
NFK	Chinook salmon	23	34	8
NFK	Coho salmon	34	50	8
NFK	Sockeye salmon	28	18	2
NFK	Chum salmon	20	5	0
NFK	Pink salmon	0	0	0
NFK	Rainbow trout[4]	-	-	27
SFK	Chinook salmon	28	33	2
SFK	Coho salmon	34	54	6
SFK	Sockeye salmon	20	25	14
SFK	Chum salmon	19	2	4
SFK	Pink salmon	0	0	0
SFK	Rainbow trout[4]	-	-	19
UT	Chinook salmon	31	25	7
UT	Coho salmon	61	63	3
UT	Sockeye salmon	47	31	1
UT	Chum salmon	28	0	2
UT	Pink salmon	-	-	4
UT	Rainbow trout[4]	-	-	42

[1] Includes mileage from mainstem and tributary reaches outside of the mine site analysis area or within the transportation analysis area

[2] Includes AWC (ADF&G 2018) listing as “spawning” or “rearing”; lakes not included

[3] Additional waters listed as species “present,” but not specified by life stage

[4] Stream mileage based on highest reported rainbow trout observation in AWC (ADF&G 2018) (life-stages not specified)

Transportation and Natural Gas Pipeline Corridors

The analysis area where effects would occur from road and pipeline construction and operations is defined in Figure 3.24-5. The corridor, including access roads, would cross a total of which 44 rivers and streams documented to support fish. Due to the wide geographic area and numerous waterbody crossings, it is reasonable to assume additional fish habitat occurs than is currently documented. [NOTE: Fish distribution data is pending review of 2018 field data and will be included in the DEIS].

Table 3.24-3 summarizes the length of stream channels occupied by Pacific salmon and rainbow trout of the transportation and natural gas pipeline corridor. Table 3.24-4 lists anadromous streams that would be crossed by the access roads from the mine site to Amakdedori port. A total of seven anadromous streams would be crossed by the transportation corridor.

Table 3.24-3: Estimated Mileage of Habitat for Pacific Salmon and Rainbow Trout within Streams Crossed by the Transportation and Natural Gas Pipeline Corridor[1]

Transportation Corridor	Species	Spawning (mi)[2]	Rearing (mi)[2]	Present (mi)[3]
South Access Road	Chinook salmon	0	0	0
South Access Road	Coho salmon	2	4	13
South Access Road	Sockeye salmon	41	0	2
South Access Road	Chum salmon	8	0	0
South Access Road	Pink salmon	2	-	0

[1] Mileages associated with the north access road and UTC are shown in Table 3.24-2

[2] Includes AWC (ADF&G 2018) listing as "spawning" or "rearing"; lakes not included

[3] Additional waters listed as species "present," but not specified by life stage

North Access Road

The north access road, including the Iliamna spur road, would cross 32 waterbodies. Of these, nine are documented fish bearing streams, five of which are anadromous fish habitat (Figure 3.24-5). The road would cross the major drainages of UTC and the Newhalen River. As noted in Table 3.24-3 and described above, 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 proposed 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 are also known to inhabit the Newhalen River between Sixmile Lake and Iliamna Lake.

Comment [A13]: Arctic Grayling, Lake Trout, Northern Pike, Humpback Whitefish and many other species used for subsistence also occur in this region.

Table 3.24-4. Anadromous Waters Crossed by Access Roads and Pipeline along the Transportation and Natural Gas Pipeline Corridor

Tributary [1]	AWC Code	R.M. [2]	Feature	Species/Life-stage [3]
UTC 1.36	324-10-10150-2183-3057	0.4	culvert	COr
UTC mainstem	324-10-10150-2183	17	bridge	Ks, Kr, Ss, Sr, COs, COr, CHs, Ps
UTC 1.34	324-10-10150-2183-3050	0.1	culvert	COr
UTC 1.60	324-10-10150-2183-3010	14	bridge	COs
Newhalen River	324-10-10150-2207	9	bridge	Kp, Ss, COp
Gibraltar River	324-10-10150-2196	1.2	bridge	Ss, COp, CHs, ACp
n/a	243-40-10010-2008	2.2	bridge	Ss, COs

1 Tributary name from EBD 2011, if available

2 R.M. = river miles at crossing above mouth or confluence of tributary (approx.)

3 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)

Iliamna Lake

Iliamna Lake is a large, oligotrophic 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.

Juveniles and adults of all five salmon species use the lake habitat as a migration corridor between Bristol Bay and Iliamna Lake, via the Kvichak River. Of the anadromous salmonids, sockeye are 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 adfluvial rainbow trout, which use both littoral and limnetic lake habitats for summer foraging (SEBD 2015; Minard et al. 1992).

Comment [A14]: Should Lake Clark be included here? A significant proportion of the Kvichak run returns to Lake Clark National Park and also uses Iliamna Lake as a migration corridor (and may even rear there).

The lake margin in the vicinity of the north ferry terminal is gently sloped and dominated by fine sediments, whereas margin habitat at the south ferry terminal is steeper and rocky. Physical characteristics of Iliamna Lake are described in Section 3.16, Surface Water Hydrology.

South Access Road

Comment [A15]: It is highly probable that more streams are anadromous along this proposed road corridor. Should this alternative be selected further identification of anadromous bodies of water would need to occur.

The south access Road would cross 65 waterbodies. Thirty-three are documented fish-bearing streams, two of which are anadromous fish habitat (Figure 3.24-3). The south 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 road would cross two anadromous streams, per AWC (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. The second anadromous crossing would be a bridge over a tributary that meets Amakdedori Creek approximately 2.5 miles above the Cook Inlet. No stream crossings would occur on the 1.4-mile spur road that connects the south access road to the town of Kokhanok.

Kokhanok East Ferry Terminal Variant

[Note: Section will be updated for the Draft EIS].

Cook Inlet Portion of Natural Gas Pipeline Corridor

Cook Inlet is in southcentral Alaska, and extends approximately 180 miles from the Gulf of Alaska to Anchorage. The natural areas of Cook Inlet most likely to be affected by the project are the Lower Cook Inlet central zone and Kamishak Bay (NMFS 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 (NMFS 1977). Approximately half of the 95-mile pipeline route would traverse depths of 200 feet or more, with a substrate largely composed of sand, shells, and pebbles.

Amakdedori Port

The Amakdedori port would be in the central portion of Kamishak Bay, which is a relatively shallow, rocky bay with low-energy tidal circulation (NMFS 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 (NMFS 1977). According to the ShoreZone tool from NOAA-Fisheries (2018), the nearest eelgrass to the Amakdedori port location is in a small cove about 4.4 miles south.

The coastal habitat in the immediate area of Amakdedori port is classified as exposed mobile or partially mobile sediment, or rock and sediment; 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 2018).

3.24.1.2 Resident and Anadromous Fishes

This section describes fish species that have the potential to occur in the EIS analysis area. Fish life history characteristics are available through the ADF&G fish webpages (ADF&G 2018h). For a description of Bristol Bay and Cook Inlet commercial fisheries, refer to Section 3.6, Commercial and Recreational Fisheries.

Mine Site

North Fork Koktuli River

Chinook salmon, coho salmon, sockeye salmon, and chum salmon ~~have been~~are documented in the NFK watershed (ADF&G 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, lamprey (*Lampetra* spp.), including species such as brook lamprey (*P. planeri*), 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 (ADF&G 2018) for anadromous species and rainbow trout in the NFK by life-stage is given in Table 3.24-5. The relative distribution and abundance of anadromous and resident salmonid species, based on AWC data (ADF&G 2018) and 2004-2008 EBD (R2 et al. 2011), are shown on Figure 3.24-2.

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.

Comment [A16]: Relative to the Mine Site itself, there is abundant fish survey data (ADFG Anadromous Waters Catalog and Fresh Water Fish Information Database) indicating subsistence species that occur in the potential mine impact zone. This information can be downloaded from ADFG and published in this document to better inform the public of subsistence fishery trade-offs. For example, Chinook, Coho, Sockeye and Chum Salmon all occur in the proposed mine impact area, both spawning and rearing. A GIS map showing the known distribution of these species would assist subsistence users in understanding potential trade-offs.

Comment [A17]: Recommend changing to "are not documented" since observations are too limited to say Pink Salmon actually don't occur.

Comment [A18]: Run timing into Bristol Bay as well as mainstem rivers and tributaries has changed over the years since the EBD studies were conducted almost a decade ago. These run timing studies should be repeated to verify what the new range of run timing is relative to both changing salmon densities and thermal regimes as it combined with mining can impact subsistece users.

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. 2011). Other resident fish are distributed in low abundance in the lower reaches of the NFK, with Dolly Varden and slimy sculpin being distributed throughout the drainage.

Figure 3.24-5: Transportation and Natural Gas Pipeline Corridor

Table 3.24-5: Estimated Life Stage Periodicities of Select Fish Species within NFK, SFK and UTC Waterbodies

Comment [A19]: Because the original pebble EBD is so limited e.g. to primarily mainstem sections of 3 tributaries away from the proposed mine impact zones, this data chart should be proofed against ADFG databases for accuracy.

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

Table 3.24-5: Estimated Life Stage Periodicities of Select Fish Species within 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

[2] Periodicities estimated from Morrow 1980.

Comment [A19]: Because the original pebble EBD is so limited e.g. to primarily mainstem sections of 3 tributaries away from the proposed mine impact zones, this data chart should be proofed against ADFG databases for accuracy.

South Fork Koktuli River

Chinook, coho, sockeye, and chum salmon have been documented in the SFK watershed (ADF&G 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. Arctic char have also been documented in the SFK; however, fish surveys did not encounter this species (R2 et al. 2011). Overall, the SFK supports more fish species than either the NFK or UTC. The approximate stream mileage listed in the AWC (ADF&G 2018) for anadromous species and rainbow trout in the SFK by life-stage is given in Table 3.24-5. The relative distribution and abundance of anadromous and resident salmonid species, based on AWC (ADFG 2018) and EBD data (R2 et al. 2011), are shown on Figure 3.24-3.

The mine pit and associated sediment pond embankment would be expected to capture or block approximately 1.4 miles of stream channel known to support resident fish (arctic grayling, sculpin, and stickleback) in the upper SFK watershed. No anadromous fish were documented in this reach 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 (ADF&G 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. 2011). 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 4 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 proposed 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. 2011).

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. 2011). The approximate stream mileage listed in the AWC (ADF&G 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 (ADF&G 2018) and EBD surveys (R2 et al. 2011), are shown on Figure 3.24-4.

Pink salmon have been documented in the lower 4 miles of the UTC, where more than 300 adult pink salmon were observed in 2006, but only 5 in 2007, and zero in 2004-2005 and 2008-2009 (SEBD 2018). 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. 2011). Chum salmon occur in the mainstem UTC up to Tributary 1.35, about 25 miles above the UTC mouth (Table 3.24-2) (ADF&G 2018). Chum salmon were the least-abundant salmonid species in the UTC basin (R2 et al. 2011), 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. 2011). 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 UT 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 UT 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 UT, suggesting typical downstream migration to lake-rearing habitat soon after emergence.

Comment [A20]: This statement does not make sense, if they are migrating downstream after emergence, then you would not have two age classes. Also, river populations of Sockeye Salmon will rear in sloughs and off channels.

Adult coho salmon have been documented entering the UT 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 UT 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 juvenile have been observed in the UT, consistent with the species life history of abbreviated river residence time after emergence.

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. 2011). 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 (SEBD Chapter 15 2018). 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), 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

North 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 (ADF&G 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. 2011).

As noted in Table 3.24-2, the north 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 proposed 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 proposed 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, rainbow trout, and slimy sculpin (Frissel 2014).

Iliamna Lake

Eleven 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) and Arctic char, five non-anadromous salmonids (adfluvial populations of rainbow trout, Dolly Varden, lake trout, Arctic grayling, and humpback and/or round whitefish), and several resident species (e.g., northern pike, slimy sculpin, ninespine stickleback). 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. 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. 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.

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 (SEBD 2018). 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), 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.

South Access Road

Four anadromous species/life-stages are listed in the AWC (ADF&G 2018) for the lower Gibraltar River (Table 3.24-3): coho present, chum spawning, sockeye spawning, and Arctic char present. 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 proposed crossing location, and chum spawning is listed downstream of the location. Dolly Varden; slimy sculpin are also present in this tributary. Resident fish species also inhabit 32 other stream channels that would be crossed by the south access road.

Kokhanok East Ferry Terminal Variant

[Note: Section will be updated for the Draft EIS].

Cook Inlet Portion of Natural Gas Pipeline Corridor

All 5 species of Pacific salmon, Pacific herring (*Clupea pallasii*) and pond smelt (*Hypomesus olidus*) are found in the Cook Inlet management area (ADF&G 2018h). 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 the 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.

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*), which are prolific in Kachemak Bay (Szarzi et al. 2007). Several species of crab are found in the Cook Inlet area, including Tanner (*Chionoecetes bairdi* and *C. opilio*), red king (*Paralithodes camtschaticus*), golden king (*Lithodes aequispinus*), 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, sea cucumber, and scallops. 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 River and in Mikfik and Chenik lakes, and in Amakdedori Creek near the proposed port site. Amakdedori Creek had average annual sockeye salmon runs of 1,200 fish between 1970 and 1980, which increased to 2,700 fish annually from 1981 to 2010 (Hollowell et al. 2016). The estimated escapement of pink salmon in Amakdedori Creek in 2015, measured by aerial survey using area under the curve estimation, was 25,945 fish. 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 Kamishak and Little Kamishak rivers and Cottonwood Creek. Pacific herring may be harvested in the Kamishak Bay district when biomass allows, although this fishery was closed for the 14th consecutive year as of 2015 (Hollowell et al. 2016).

3.24.1.3 Aquatic Invertebrates

Mine Site

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 life cycle, 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 established important macroinvertebrate community response to disturbance intensity in the region. Metrics such as number of taxa, percent EPT genera, and Shannon's Diversity Index (SDI) were found to decrease at sites with increased disturbance intensity, while other metrics such as percent 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 Upper Talarik Creek 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 with 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. 2011). 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 and Barbour 2001), were calculated from macroinvertebrate data collected using the ASCI method and the Surber method (R2 et al. 2011). These metrics are indicators of habitat change (Major and Barbour 2001), and include taxa richness, percent Ephemeroptera, Plecoptera, and Trichoptera genera (together referred to as "EPT genera") taxa; percent Chironomidae family taxa (Chironomidae is within order Diptera); percent other Diptera order taxa; percent 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 and Barbour 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 zero through ten).

Periphyton

A total of 115 periphyton samples 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 percent dominant taxon at all sample locations ranged from 21 to 72 percent. The percent 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 percent 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, percent 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-percent EPT, high-percent Chironomidae, and high-percent dominant taxon, conditions which have been associated with poor stream health in other Alaska-based studies (ADF&G 2007). 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. 2011).

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 Orihocladiinae 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).

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 most of the macroinvertebrate 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 variable, 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 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 percent dominant taxon was much higher for the unnamed creek than for Y Valley Creek (79 percent and 35 percent, respectively). The percent 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 signified 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 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.

Amakdedori Port

Available information is included above in the Cook Inlet Portion of Natural Gas Pipeline section.

Figure 3.24-6: Cook Inlet Aquatic Invertebrates Sampling Sites

3.24.1.4 Fish Tissue Trace Element Analysis

Overall, 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).

Overall, 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.

For a detailed report on fish tissue trace metals analysis, refer to EBD Chapter 10, Section 10.3

Alternatives 1 and 2 Summer Only Ferry Operations Variant

The summer only ferry options variant is described in Chapter 2, Alternatives. Aquatic habitat and fish distribution would be the same for this variant as described in Alternative 1.

Alternative 1 Kokhanok East Ferry Terminal Variant

[NOTE: AQUATIC HABITAT AND FISH DISTRIBUTION FOR THIS VARIANT WILL BE UPDATED FOR THE DRAFT EIS.]

The proposed Kokhanok East route crosses eight streams, one of which is classified as anadromous. This stream has been documented to support spawning and rearing habitat for sockeye salmon and arctic char. The shoreline of the proposed ferry terminal location is generally rocky and deepens rapidly, suggesting that it is unlikely to be preferred spawning habitat (RFI 078).

Alternative 1 and 2 Pile Supported Dock Variant

The pile supported dock variant is described in Chapter 2, Alternatives. Aquatic habitat and fish distribution would be the same for this variant as described in Alternative 1.

3.24.2 Action Alternative 2 – North Road and Ferry

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 transportation corridor includes the mine site road, two spur roads to ferry terminals on Iliamna Lake, and the natural gas pipeline corridor from the mine site to Diamond Point. The transportation corridor under Alternative 2 would crosses 116 waterbodies, including 23 anadromous fish streams and 28 resident fish streams. The natural gas pipeline from Eagle Bay Creek to Ursus Cove would cross 89 total drainages, including 37 fish streams, of which 13 are anadromous.

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

Access Corridor – Mine Site to Ferry Terminal

The access corridor follows the Alternative 1 route from the mine site to 1 mile south of the bridge crossing the mainstem UTC (Figure 3.24-6). Along this route, the road and pipeline would cross 21 stream channels, 8 of which are listed in the AWC as anadromous streams (Table 3.24-6), with another 6 channels inhabited by resident fish species, and 12 channels believed to be fishless (see Appendix K3.24) 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.

Table 3.24-6. Anadromous waters crossed by access roads along the Alternate 2 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	324-10-10150-2239	0.8	n/a	COr, Ss, ACp
Iliamna River	324-10-10150-2402	4.1	bridge	CHp, COp, Kp, Pp, Ss
Browns Peak Creek	248-10-10040		n/a	COr
Un-named	248-20-10030		n/a	CHp

1 Channels that would be crossed by the Alternative 2 natural gas pipeline are shown in Table 3.24-3

2 Tributary name from EBD 2011, 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)

Iliamna Lake

This alternative includes a ferry terminal site at Eagle Bay, approximately 20 miles east of the terminal for Alternative 1, with the other ferry terminal site in Pile Bay (Figure 3.24-6). The ferry route would pass to the south of the Triangle, Flat, and Porcupine Island clusters. Although the islands contain extensive littoral shoal habitat, the ferry route would remain well offshore, where depths range from 200 to over 900 feet. Physical characteristics of Iliamna Lake are described above in this section. 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.

Access Corridor – Ferry Terminal to Port

The Pile Bay ferry terminal site would connect to the existing Williamsport-Pile Bay Road via a short spur road. Realignments and improvements would be made to the existing road. From the town of Williamsport, a new 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 3.24-6). Three other bridges and two culverts cross resident fish streams, with six culverts crossing fishless streams.

Diamond Point Port

The proposed port site at Diamond Point is at the intersection of Iliamna and Cottonwood Bays. Both bays are relatively shallow (mostly less than 40 feet in depth), with sand and pebble substrates interspersed by rocky reefs and extensive mud-dominated intertidal flats at the heads of each bay. 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.

3.24.2.2 Resident and Anadromous Fish

Transportation Corridor and Natural Gas Pipeline Corridor

[NOTE: Fish data for this section is pending review of 2018 field data and will be included in the DEIS].

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

Access Corridor – Mine Site to Ferry Terminal

The eight anadromous streams that would be crossed by this portion of the access corridor have been documented to contain Chinook, coho, sockeye salmon, and Arctic char. Resident species include slimy sculpin, rainbow trout, Dolly Varden, longnose suckers (*Catostomus catostomus*), and ninespine stickleback.

Iliamna Lake

See above sections for general information on fish resources in Iliamna Lake. The ferry route for this alternative traverses the eastern basin of Iliamna Lake, including the vicinity of Eagle Bay and Eagle Islands, as well as the full length of Pile Bay.

Access Corridor – Ferry Terminal to Port

This portion of the access corridor would cross the Iliamna River approximately 4 miles above its mouth. The Iliamna River supports all five species of Pacific salmon, including important spawning habitat for sockeye salmon.

Diamond Point

Marine fish and invertebrates were sampled in the Iniskin-Iliamna Bay Estuary (IIE) by beach seining, otter trawling, and gill or trammel netting in two different time periods (2004-2008, and 2010-2012) to establish baseline conditions and temporal variations in species composition and abundance in the marine habitat (Pentec Environmental and Hart Crowser 2005). 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. The use of multiple sampling gears provided a better coverage of several habitat types, potential spawning area, nursery areas, species distribution, and use within 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 (*Hypomesus pretiosus*), and Pacific sand lance (*Ammodytes hexapterus*) 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 (*Platichthys stellatus*), 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 (*Hexagrammos stelleri*).

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 level (ADF&G 2009). Young salmonids also use the bays for rearing, as do the adults for migration into nearby tributaries. Adult salmonids provide commercial, subsistence, and recreational fishery. Seining in three tidal lagoons in Iliamna and Cottonwood Bays indicated that threespine stickleback was the most abundant species, followed by juvenile chum salmon and pink salmon.

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 consisted of 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 the in 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 variable, 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 is 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 varied 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 and Barbour 2001). The concentration of dissolved oxygen (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.

3.24.3 Action 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 access route would include an 82.3-mile-long north road corridor and natural gas pipeline that would skirt the eastern edge of Iliamna Lake, thereby avoiding a 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 follow the route into Cook Inlet to the Kenai Peninsula, as described above.

The affected environment as described under Alternative 1 for the Cook Inlet portion of the natural gas pipeline is applicable to Alternative 3.

Along this corridor, there are numerous watersheds ranging in size from large rivers to very small seasonally flowing channels containing anadromous and resident fish species. As part of the environmental baseline documentation, multiple sites were surveyed along the Alternative 3 transportation and natural gas pipeline corridor from 2004 to 2008 for fish and aquatic habit. Primary survey sites were directly on or near the representative road and pipeline alignment. In addition, support survey sites were upstream or downstream of the primary sites or on nearby tributaries. There were 61 primary survey sites and 44 support sites surveyed during this period. The survey sites were grouped into the watershed groups: Upper Talarik, Newhalen, Isolated watersheds, Roadhouse/Northeast Bay/Eagle Bay, Youngs/Chekok/Canyon, Knutson Bay/Pedro Bay, Pile Bay/Lonesome Bay, and Iliamna River; and Williams Creek. All groups except the Williams Creek group are in the Bristol Bay drainage. Overall, this alternative would involve 118 stream crossings, with 23 listed as anadromous waters (Table 3.24-7), 28 containing resident fish species only, and 67 small channels designated as fishless (K3.24). Nine of the anadromous streams that would be crossed by the Alternative 3 transportation and natural gas pipeline corridor are listed in Table 3.24-6.

Table 3.24-7. Anadromous Waters Crossed by Access Road and Pipeline Along the Alternate 3 Transportation and Natural Gas Pipeline Corridor[1]

Tributary [2]	AWC Code	R.M. [3]	Feature	Species/Life-stage [4]
n/a (tributary to Eagle Bay Creek)	324-10-10150-2239-3005	2.4	bridge	Ss, ACp
n/a (tributary to Chekok Bay)	324-10-10150-2261	5.6	bridge	COp, Ss, ACp
n/a (tributary to Chekok Bay)	324-10-10150-2261-3006	1.0	bridge	COp, Ss, ACp
n/a (tributary to Chekok Bay)	324-10-10150-2267-3001	2.7	culvert	COp, Ss, ACp
Chekok Creek	324-10-10150-2267	3.3	bridge	COp, Ss, ACp
Knutson Creek	324-10-10150-2301	1.6	bridge	Ss, ACp
n/a (tributary to Lonesome Bay)	324-10-10150-2333	0.9	bridge	Ss
Pile River	324-10-10150-2341	1.6	bridge	Ss, ACp
Long Lake outlet	324-10-10150-2343	1.8	bridge	Kp, Sp
n/a (3 crossings)	324-10-10150-2343-3006	0.4, 0.7, 0.9	Culvert, bridge, culvert	Sp

1 Not including 9 anadromous streams that would be crossed by this alternative listed in Table 3.24-2. Note this alternative would cross Eagle Bay Creek approximately 4 miles above its mouth.

2 Tributary name from EBD 2011, 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)

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.

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 Natural Gas Pipeline Corridors

As described above, the transportation and natural gas pipeline corridors would cross several rivers, lakes, streams and lake outlets within 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.

Isolated Watershed Group. No fish were found in these survey sites during the October 2007 sampling.

Roadhouse/Northeast Bay/Eagle Bay Watershed Group. Four fish species were documented at the primary survey sites: 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.

Youngs/Chekok/Canyon Watershed Group. Sockeye salmon, rainbow trout, Dolly Varden, and slimy sculpin were found at sites in this watershed group. Other fish known in this group include coho salmon and Arctic char.

Knutson Bay/Pedro Bay Watershed Group. Sockeye salmon, Dolly Varden, and slimy sculpin were documented at sites in this watershed group, but Arctic char are also known to be present in this watershed.

Pile Bay/Lonesome Bay Watershed Group. Slimy sculpin and threespine stickleback were documented in primary and support survey sites. Although no salmon were observed during the fish surveys, sockeye salmon and Arctic char are known to be present.

Iliamna River Watershed Group. Sockeye salmon, Dolly Varden, and slimy sculpin were observed in this watershed group. Approximately 3,000 adult sockeye salmon were observed at two support survey sites in August 2004.

Williams Creek Watershed. Williams Creek, which drains into the 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.

3.24.3.3 Aquatic Invertebrates

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 relative 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, the 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 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.

Alternative 3 Concentrate Pipeline Variant

The concentrate pipeline variant is described in Chapter 2, Alternatives. Aquatic habitat and fish distribution would be the same as described under Alternative 3- Transportation Corridor.

3.24.3.4 Alternatives Fish Stream Summary Table

A comparison of number of stream crossings, fish streams, anadromous streams, and resident fish is given in Table 3.24-8.

Table 3.24-8: Fish Stream Summary Table

Alternative	Stream Crossings	Fish Streams	Anadromous*	Resident**
Alternative 1 North Access Corridor	32	11	6	5
Alternative 1 South Access Corridor	65	33	2	31
Alternative 2 Road Sections	21	14	8	6
Alternative 2 Pipeline Sections	118	51	23	28
Alternative 3 Road and Pipeline Sections	116	51	23	28

*Data from AWC catalog

** Resident fish stream data from EBD, RFI 85 2018 fish survey [will be updated for DEIS]

3.24.3.5 Climate Change

There are likely to be hydrological impacts associated with projected changes in temperature, precipitation, and evapotranspiration in the Bristol Bay watershed, including changes in the magnitude and timing of streamflow that are likely to affect salmon habitat and populations. Changes in hydrology are likely to affect existing habitat via changes in water volume and velocity along with channel forms, which may lead to declines in habitat availability for spawning and rearing salmon populations.

Both hydrology and water temperature of freshwater systems affect critical life stages of salmonid species. These hydrological changes are likely to have different effects on salmon populations depending on the amount of time they spend rearing in freshwater habitats, their life stage, and their ability to adapt to changes in environmental conditions.

Populations of Pacific salmon species are likely to adapt to changes in temperature, precipitation, and hydrology in different ways; the geographic location of populations is likely to affect their ability to adapt to these changes. The genetic and life history diversity within and among the Bristol Bay Pacific salmon populations will likely be crucial for maintaining the resiliency of the regions salmon stocks under a future environment characterized by climate change and increased anthropogenic stressors (Hilborn et al. 2003, Schindler et al. 2010, Rogers and Schindler 2011).

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